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SPEECH OF RECTOR

Assalamualaikum Wr. Wb.

Ladies and Gentlemen, may I take this opportunity to welcome everyone of you to this conference by praying to the Almighty God for all His blessings, His grace, and His mercies that have made us possible to gather here in excellent condition and good health.

Dear keynote speakers, distinguished guests and participants of the SENTA 2016 with the main topic theme on “Marine Technology for Fulfilling Global Maritime Axis”. It's a pleasant duty for Institut Teknologi Sepuluh Nopember (ITS) to bid you all a genial welcome and host this conference.

Indonesia, where two-thirds of its territory is water, depends heavily on maritime transportation for domestic and international trade. It is necessary to master the maritime technology these days accompanied by other essential knowledges in order to utilize the maritime’s natural resources.

Maritime as a part of the vision of ITS has redefined the importance of maritime technology in the four most outstanding research field in this institute. By having this conference and gathering all research institutions, industries and academicians it is expected that new ideas and concepts could be conceived for the future of maritime technology.

The internationalization of SENTA is a response to the need of ITS to be a world – class research university as well as Indonesia as a global maritime axis. Hopefully, we all can significantly give more contributions to the nation advancement in the near future. To all of our distinguished guests and participants, thank you for being here, welcome, and enjoy the conference!

Wassalamualaikum Wr. Wb.

Prof. Ir. Joni Hermana, M.Sc.Es, PhD
Rector of ITS, Surabaya, Indonesia

SPEECH OF DEAN FACULTY OF MARINE TECHNOLOGY

Bismillahirrahmaanirrahiim

Assalamu'alaikum Warahmatullaahi Wabarakaatuh,

I would like to praise God for His blessings and mercies which allow all of us to be part of this international seminar of marine technology, SENTA 2016 that is an annual International Seminar on Marine Technology organized by the Faculty of Marine Technology, Institut Teknologi Sepuluh Nopember (ITS) Surabaya with the theme of Marine Technology for Fulfilling Global Maritime Axis.

On behalf of SENTA 2016, All the academicians of Faculty of Marine Technology Institut Teknologi Sepuluh Nopember and I would like to welcome the honourable keynote speakers, authors, participants. I wish to express our deepest appreciation to all the people who have been kindly encouraged to contribute to this conference through submissions of their research papers. This would be our great pleasure to welcome all of you.

I especially would like to express my gratitude and highest appreciation to the organizing committee on the hard work, perseverance and patience in preparing and organizing this seminar, so it can run well and successfully.

Allow me to wish all of you a meaningful and rewarding seminar for the internationalization of SENTA that is a response to the need of ITS to be an international institute as well as Indonesia as a global maritime axis. Hopefully, we all can significantly give more contributions to the nation advancement in the near future. Thank you and I hope to see you again at the SENTA 2017.

Wassalamualaikum Wr. Wb.

Prof. Ir. Daniel Mohammad Rosyid, Ph.D.
Dean of Faculty of Marine Technology

SPEECH OF CHAIRMAN EVENT

Honourable Rector of Institut Teknologi Sepuluh Nopember (ITS), Prof. Ir. Joni Hermana, MSc.Es, PhD,
Honourable Dean of Faculty of Marine Technology, Prof. Ir. Daniel Mohammad Rosyid, Ph.D.

Assalamualaikum. Wr. Wb.

At this precious moment, let me first express our sincere gratitude to God, who has granted us with blessings and grace that we could gather here today to attend the annual International Seminar on Marine Technology. I'm truly delighted to welcome all keynote speakers and participants to SENTA 2016.

This seminar, organized by Naval Architecture and Shipbuilding Engineering Department of ITS, was initially a national seminar that was held back in 2001, and the internationalization of SENTA is a response to the need of ITS to be an international institute as well as Indonesia as a global maritime axis. SENTA 2016 will be held at Department of Naval Architecture and Shipbuilding Engineering, ITS, Surabaya, on 15-16 December 2016. In accordance to this year's theme, which is **Marine Technology for Fulfilling Global Maritime Axis** SENTA 2016 invites original contributions on the following topics, but not limited to: Ship and Offshore Structure, Marine System, Maritime Manufacturing Industry, Marine System and Maritime Logistic, Maritime Transportation and Logistic, Marine Energy Exploration and Exploitation, Coastal and Natural Resources Management.

Participants in this seminar who originated from graduate students, faculty members, researchers, and academia from various universities and research institutions, and also professional associations and other related organization in infrastructure area have been registered in SENTA 2016.

My deepest thankfulness to all of our speakers, participants and contributors who have given this seminar their generous supports. I would like to express our gratitude and thanks again to all the keynote speakers who have volunteered and spared their busy schedule to contribute to this special event. Many thanks are due to all our Organizing Committee members for their dedication and continuous efforts and hard work in preparing and organizing this seminar. To our lead and supporting sponsors, our most gratitude and thanks for their generous contributions to make this seminar happened. We also owe our success to the full support of the Rector of Institut Teknologi Sepuluh Nopember and the Dean of Faculty of Marine Technology.

Allow me to wish all of you a meaningful and rewarding seminar. Thank you.

Wassalamualaikum Wr. Wb.

Aries Sulisetyono, ST, MASc, PhD.
Chairman Event

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COASTAL AND NATURAL RESOURCES MANAGEMENT

Selection Concept of Priority Sector for Blue Economy Implementation in Sumenep using Analytical Hierarchy Process

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Keywords: Blue economy, AHP, sustainable economy, valuation.

Abstract. In the forum of the Conference Rio + 20 in Brazil 2012, the President in his speech campaigns for blue Economy, where the sea becomes a part of the sustainable development goals. To actualize sustainable development, there are three aspects that must be valuated: economy, environment, and social aspect. One that can be implemented of blue economy is in Sumenep. Referring to Produk Domestik Regional Bruto (PDRB), in this study will conducted valuation of three sectors, fisheries, mining, and agricultures. Valuation will be done using Analytical Hierarchy Process (AHP), a method that used to help draw up a priority from the various alternatives. Based on AHP, fisheries is a priority sector that will be developed and have a sustainability development.

Introduction

The policies of National Ocean Development were built from 5 main pillars consisting of ocean culture, ocean governance, maritime security, ocean economy, and marine environment. Both economic and environmental pillars are the core component in the blue economy concept. In the forum of the Conference Rio + 20 in Brazil the end of June 2012, the President in his speech not only invites the world to jointly implement the green economy in national development, but also campaign for economic blue (Blue economy), where the sea becomes an integral part of the Sustainable Development Goals. Therefore, the blue economy concept needs to be part of the grand design of the national marine development [1].

To actualize the sustainable development based on blue economy is not as easy as envisioned. Policies and the roles of government and society are needs to realize their potential for marine as well as the role of decision-makers and stakeholders. Not only needs the role, but also need a valuation to determine at what sector that have a highest potential to be developed viewed from various aspects. The desire to valuate the blue economy is driven by the effects this large segment has on the entire economy of country [2].

Can be seen in Table 1, referring to Produk Domestik Regional Bruto (PDRB) of Sumenep, there are 2 main sector which is have a highest value if it's based on blue economy concept, fisheries and mining. However, some tourism potential in Sumenep is necessary to be an alternative sector. So, the sectors as alternatives are:

1. The fisheries sector
2. The mining sector
3. Agricultures of seaweed

Not only knowing what sectors that have the best potential to be developed, but also must consider the circumstances or fundamental of the sector can be maintained sustainable

development. Sustainability development divided into three aspects that will be used as indicators, consist of:

1. Environmental Aspect
2. Economic Aspect
3. Social Aspect

The method that used for evaluation approach is Analytical Hierarchy Process (AHP), the method which will further described in the methodology. With this AHP approach will be obtained by a decision of what the sector with the most potential to be developed as a sustainable economy with pre-determined criteria.

Table 1. Gross regional domestic product (PDRB).

No	Lapangan Usaha (Sector)	Tahun (year)	
		2013	2014
	(1)	(2)	(3)
01.	Pertanian, Kehutanan, dan Perikanan	8.295.748,2	9.438.503,4
02	Pertambangan dan Penggalian	8.982.802,6	9.917.558,3
03	Industri Pengolahan	1.061.849,7	1.200.441,0
04	Pengadaan Listrik dan Gas	6.226,0	6.401,3
05	Pengadaan Air, Pengelolaan Sampah, Limbah	10.103,1	10.499,1
06	Konstruksi	1.399.850,8	1.568.935,2
07	Perdagangan Besar dan Eceran, Reparasi Mobil dan Sepeda Motor	2.295.951,5	2.516.123,1
08	Transportasi dan Pegudangan	196.244,3	225.060,2
09	Penyediaan Akomodasi dan Makan Minum	126.030,0	141.110,9
10	Informasi dan Komunikasi	929.840,8	1.048.299,6
11	Jasa Keuangan dan Asuransi	375.689,4	426.865,8
12	Real Estate	196.682,1	216.581,9
13	Jasa Perusahaan	40.105,4	44.413,1
14	Administrasi Pemerintahan, Pertahanan, dan Jaminan Sosial Wajib	732.097,2	772.074,5
15	Jasa Pendidikan	506.815,3	575.986,5
16	Jasa Kesehatan dan Kegiatan Sosial	68.298,2	78.167,0
17	Jasa Lainnya	136.928,5	153.006,8
	PDRB	**25.361.262,8**	**28.340.027,6**
	PDRB Tanpa MIGAS	**16.915.255,0**	**19.017.111,0**

(Source: *Badan Pusat Statistik Kabupaten Sumenep)*

Literature Review

Principal of Blue Economy

Gunter Pauli said that blue economy means “Ocean Blue-Blue Sky”, it is understood that the blue economy model approach will be able to generate economic growth and welfare of the people, but the sea and the sky remained blue [3]. Thus, blue economy can be interpreted as a new concept that aims to generate economic growth of marine and [4]fisheries sector, while ensuring resources sustainability and coastal and marine environment.

Sustainability of Blue Economy

In a book written by Serageldin and Steer in 1994, a sustainable economy must meet the three pillars of sustainable development. Thus, sustainability development divided into three aspects or pillars that will be used as indicators [5].

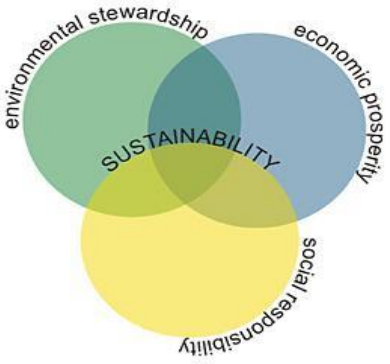

Figure 1. Pillars of sustainable development.
(Source: www.ladstudios.com/ladsites/sustainability)

Can be seen in Fig. 1 of each pillar, that for actualize sustainable development must contain 3 aspects. Then, the main criteria are based on main pillars of Sustainable Development Goals consist of:

1. Social Aspect
   - Level of education

     The level of education is one of the sub-criteria that will be affected by the existence of a sector development. On the other hand, education is very influential on the wisdom of local communities.
   - Local empowerment

     Empowerment of local communities in the mean that is how big the community can play a role in using and managing natural resources based on the selected sectors.
   - Local support

     Local support is how much support to their local communities will be selected sectors, the most important support that helped keep the balance of nature. A balance needs to be maintained to avoid damage caused by the construction of the selected sectors.
2. Environment Aspect
   - Water pollution

     Water pollution either sea water or water from surrounding communities will be greatly detracted from the development of the sector. Thus, sub-criteria is very important to consider because it will affect the health of local communities.
   - Global warming

     Along with the development of maritime sector, then global warming will occur. But, it must be considered how big the global warming of each sector that has the potential to be developed.
   - Conversion of coastal area

     One sub criterion highly skilled directly from their development maritime sector is which over the function of the coastal area.
   - Hazardous and toxic waste

     With the development of the maritime sector, the negative impacts will emerge as hazardous and toxic waste. An example is the seaweed farming sector, there will be substances that are used for the cultivation process.

3. Economic Aspect
   - Investment

     Investment is a very important point of their maritime development. In this sub-criterion will be seen how much the value of investments that will be given to the development of each sector.
   - Local workforce

     Local workforce needs to be a very important part to note. Because by providing jobs, it can improve the local economy around. Thus, in this sub-criterion need to be considered for each sector.
   - Export-import

     Export-import activities will occur on the existence of a development of the maritime sector. An example is the fisheries sector, the catches can be for export. From the results of these exports, it can add to the local economy around.
   - Government and Local Income

     Local and government income will be severely affected from the construction of the maritime sector. In this sub-criterion will be evaluated against the inclusion eg in exports in the fisheries sector.

Sectors that can be developed

1. The fisheries sector
   Indonesia is the country's largest aquaculture producer to 4th in the world with production in 2012 reached 3.06766 million tons, or 4.6% of world fisheries production [6]. The potential of fisheries in coastal areas should be managed properly by considering economy, environment, and social aspect so it can be sustainable sector. It should be managed properly because there are many problems that would be happen such as illegal fishing. Exploitation of fisheries that not environmental-friendly (illegal fishing) should be anticipated, so such damage would not occurs in various regions [7]. By developing fisheries sector, it can be improving and increasing food security of local people and can provide regional and government income through export activities.
2. The mining sector
   Indonesia is one country that has a rich in mining but is not widely used because of the lack of technology. But mining is a sector that is expected to have a positive impact, from the aspect of foreign exchange and local revenues, the presence of mining companies is very helpful in the development of national and regional [8].
3. Agricultures of seaweed
   Seaweed is one of the important marine commodities, in addition to the many potential uses, seaweed earns increasing every year [9]. The potential sites for the development of seaweed agriculture in East Java are Pacitan, Banyuwangi, and Sumenep [10].

Analytical Hierarchy Process

The Analytical Hierarchy Process (AHP) is an approach based on multi-criteria decision-making introduced by [11, 12]. Since the establishment of AHP, this method has attracted the interest of many researchers mainly because this method employs simple mathematical properties for easiness of calculation and data required is relatively easy to obtain. Behind its simple mathematical properties, AHP is considered as a decision support tool that can solved complex problems that sometimes accompany with qualitative parameter. AHP has been utilizing for various fields not limited to solve problems in engineering field but also can be used in the fields of social science, economics, etc. Various applications of AHP in engineering application have been reported by [13]. In procedure of calculation, AHP uses multi-level

hierarchical structure and each structure consists of homogeneous element. The hierarchical structure may consist of the objectives, criteria, sub-criteria and alternatives to be include in selection. Data needed in the analysis of AHP are derived by using pairwise comparisons. These pairwise comparisons are used to obtain the weights of the interest or the importance of the decision criteria. The comparisons are also used to obtain measure of relative performance of each individual decision criteria. Mechanism to improve consistency of comparison should be introduced in condition that the ration obtained from pairwise comparison procedures is inconsistent. The procedure of AHP can be found on a variety of sources that include [14-16].

Methodology

Meanwhile, for the sub criteria are based on impact from each criteria/ aspect. The sub criteria can be seen in with the hierarchy diagram in Fig. 2.

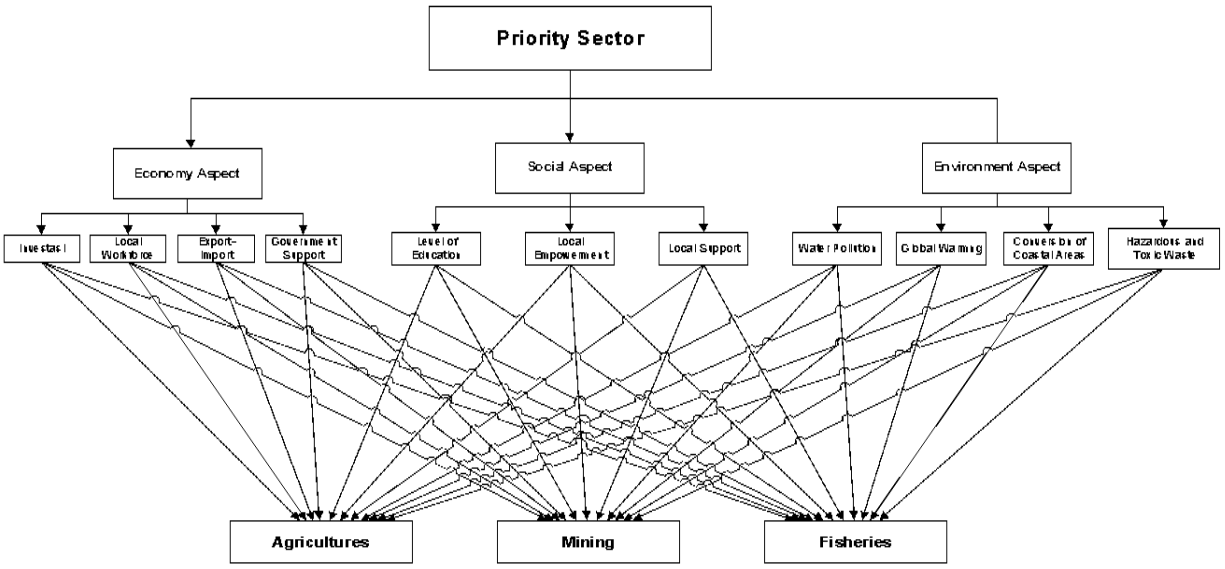

Figure 2. Hierarchy of criteria and sub criteria for choosing sector priority.

From some alternatives consist of agriculture, mining, and fisheries, valuation will be performed. The method that used for the valuation is approaches using Analytical Hierarchy Process (AHP). With this AHP approach will be obtained by a decision of what sector with the most potential to be developed as a sustainable economy with the multi criteria.

The AHP will be done with relies on the judgments of experts to derive priority scales [16], and the respondents as judgments are from local communities in Sumenep.

Results and Conclusion

Aspects used as an indicator is weighted in advance, so that it can be seen by the respondents, what aspects is necessary to be considered. Results weighting criteria and sub-criteria can be seen in Fig. 3.

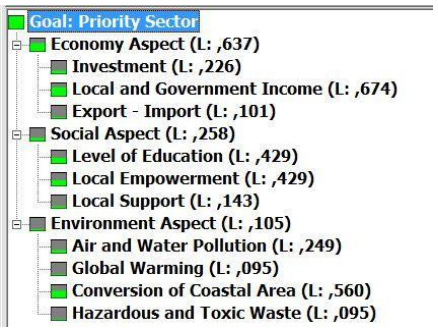

Figure 3. Weighted of criteria and sub criteria.

Based on the purpose in this study, to do a selection of sectors to comply the aspects of sustainable development using AHP, fisheries is the selected priority sector. Priority has been based on several criteria and sub-criteria that have been determined.

Figure 4. Result from AHP approach.

Can be seen in Fig. 4 that from AHP approach, that fisheries have a high value. So, it can be concluded that fisheries have a good opportunity to be developed based on 3 pillars sustainability development goals, which are economy, environment, and social aspect.

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Junior Birdwatching as an Environmental Education Program Based on Ecological Vision for Supporting Coastal Areas Management in Surabaya

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Keywords: Environmental education, ecological vision-based, elementary student, coastal area management.

Abstract. Implementation of ecological vision-based education in schools is to empower the learning environment, among others, by using the environment as a learning resource, and develop a critical attitude and caring environment to students. Thus, it is important to applied the ecological vision-based learning media that promotes animal-plant interactions in mangrove forest, such as Junior Birdwatching Program. JB program is derived from Eco-adventure tour that focuses on the observation of birds in nature, which combined with various games and drawing/coloring competitions. The preparatory step was conducted by introduction of mangrove birds and birdwatching in the classroom, sketch techniques of birds and introduction of birdwatching equipments. The observation step was also conducted by direct observation in the mangrove habitat with bird illustrated pocket book. Evaluation of the understanding level of students was conducted by prize quizes and coloring competition of mangrove bird pictures to visualize the bird species. We expected that the development of biodiversity conservation through an integrated adventure management in nature can raise awareness in elementary school students on the importance of mangrove habitat maintenance for birds in coastal areas. Elementary students will be expected as environment cadre that capable of simply implementing for conserving and protecting birds diversity and mangrove habitats in their environment.

Introduction

Various environmental problems began to appear, such as reduced lands, decreased quality of lands, scarcity of resources, as well as various environmental disasters, are the result of overexploitation of natural resources. Mangrove forests and fauna associations is one of coastal resources began distractions due to land conversion and overexploitation. A lot of damage to mangrove forests in the coastal largely caused by human pressure in the open lands and conversion of mangrove areas for the aquaculture, industrial, agricultural, residential, and recreational areas, as well as a small part due to natural disasters (floods, droughts, storms, tsunami) and pest attack [5].

To generate the generation which care about environmental issues is necessary to environmental education which leads to understanding and discussing education seen in the ecological perspective (based on ecological vision), which takes into consideration four principles: holistic, sustainability, diversity, and balance [3]. Implementation of ecological vision-based education in schools is to empower the learning environment, among others : applying the model "learning environment", filling the school curriculum with the vision of educational competency ecology, developing a critical attitude and caring environment to students, maintaining environment, and using the environment as a learning resource [7, 8].

Limitations of educational facilities, such as learning materials and media that appropriate to elementary school level, causing the students do not know how important the role and conserve the nature of coastal environment. It is necessary that the learning process in environmental education will conduct in optimal condition. Thus it is important to applied ecological vision-based learning media that promotes interaction in the mangrove forest with a variety of fauna and flora, such as Junior Birdwatching Program. JB program is derived from Eco-adventure tour that focuses on the observation of birds in nature, which combined with various games and drawing/coloring competitions. JB is a popular activity for people of all ages can participate [4], so that this concept can be used as a children's adventure tour fun as well instilling the basics of conservation [6].

Methods

Methods and strategies of environmental education activities through an integrated management adventure Junior birdwatching program, which is addressed to elementary school students in coastal areas around the ITS campus were indicated by the flowchart below:

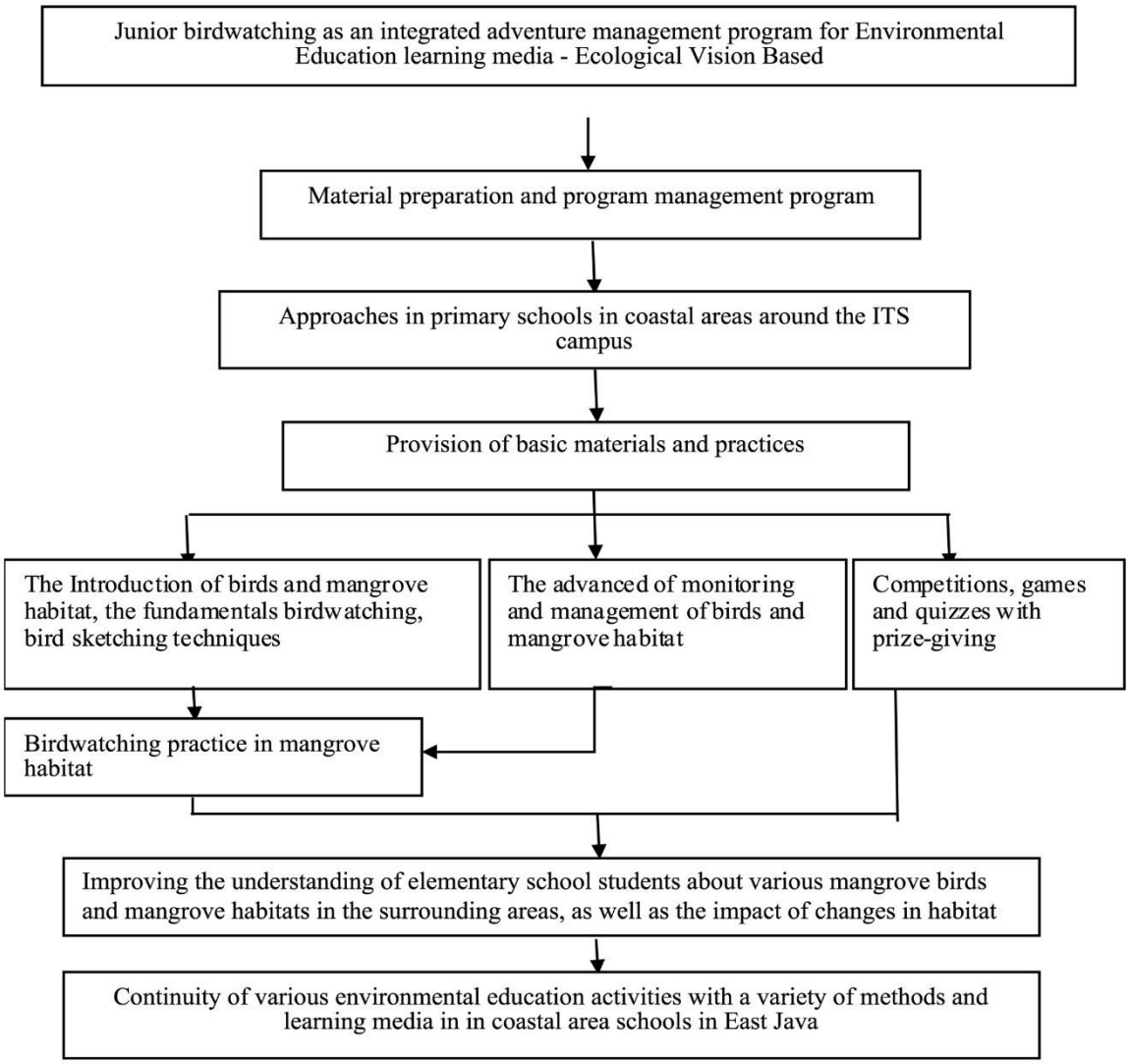

Figure 1. Flowchart of strategies and methods of Junior Birdwatching as an integrated adventure management program.

Methods and strategies of environmental education activities through an integrated management adventure Junior Birdwatching program, is addressed to elementary school students in coastal areas around the ITS campus. Strategy of Junior Birdwatching activities is a basic learning process as well as the advance lectures about monitoring and management of mangrove birds and habitat, drawing and coloring of mangrove birds pictures in the laboratory of Biology ITS. These activities were continued to the direct observation of birds in nature by illustrated pocket book, as well as games and quizzes in the Mangrove Ecotourism Wonorejo, which overall take up to 2 days.

Result and Discussions

Debriefing and preparatory step

Debriefing and preparatory step is the provision of fundamental conservation materials of birds and mangrove habitat, provision of advanced material about monitoring and management of birds in their habitats, which comes with prize quizes, as well as drawing and coloring pictures of mangrove birds in the classroom.

- Giving basic lecture of mangrove birds and habitat conservation in the classroom, including: what is the mangrove, mangrove species, environment surrounding the mangrove forests, birds types that are often found in mangrove forests, and roles of birds in the mangrove ecosystem.
- Giving the advances material about monitoring and management of mangrove birds and habitat by birdwatching illustrated pocket book in the classroom, including: the basics of bird identification, illustrating birds (bird sketching), the use of binoculars and bird observation techniques in the field
- Drawing and coloring contest of mangrove birds pictures.

Figure 2. Debriefing and preparatory step: a) basic lecture of mangrove bird and habitat conservation; b) the advanced of monitoring and management of mangrove birds and habitat; c) slideshow samples of fundamentals birdwatching; along with d) the introduction of birdwatching tools.

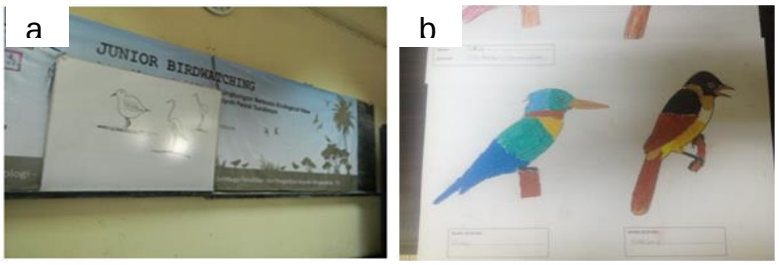

Figure 3. Debriefing and preparatory step by providing lectures : a) technique and skill to sketch birds to support the basic and advanced lectures; b) a coloring contest of mangrove bird image patterns.

In this step, the results such as increased understanding of students to birds and mangrove habitat through evaluation quiz parameters. Besides the increasing of students understanding to be able to do birdwatching and appropriate techniques, knowing the tools used, sketch birds with simple techniques and knowing the color of mangrove bird according to its species.

Direct Observation Step

The introduction of mangrove habitat birds were performed through direct observation in nature (mangrove ecotourism in Wonorejo) by bringing the illustrated pocket book, continued with the strengthening student understanding of the material provided through various games and quizes with prize-giving.

During the direct observation in the fields, students learn to practice birdwatching ethics, such as dressing not in glaring colour, walk slowly and not noisy, patient in observing nature, not disturb the birds, not damage the nature and fouled the environment, until how to make field notes [1, 2]. Results of direct observation showed that birdwatchers students demonstrated a positive environmental attitude by trying not to make noise, walking slowly, be patient waiting for the observation object and does not damage and pollute the surrounding environment. This is shown also by more enthusiasm of the students in answering quiz given by the field instructor, as well as considering the bird along with their characteristics. The birdwatcher students tend to be motivated by prizes quiz by the instructor, so willing to be patient to wait for the birds observed, many questions about characteristics of the birds to field instructors and tend to be enjoyed birdwatching activities and interacted with other students.

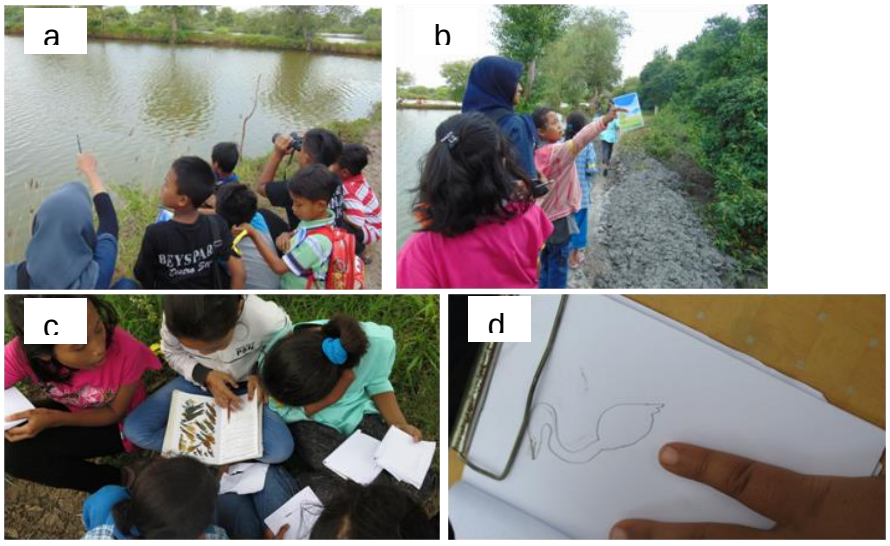

Figure 4. Direct observation step in mangrove habitat: a) birdwatchers students practiced use binoculars tool; b) students make observations with walk one by one in rows; c) identifying birds encountered using book; d) try sketching birds for the purposes of field notes.

Figure 5. a) Design of the front cover of illustrated pocket book "Birdwatching for Children"; b) Design of the content of the book, complete with bird pictures and descriptions of the birds morphology and their habitats.

Conclusions

Debriefing and preparatory step of Junior Birdwatching activities are going well, the students are interested in and able to understand the lecture of fundamental of birds and mangrove habitat, as well as the fundamentals of birdwatching skills and techniques through images, drawings technique and sketching mangrove birds, and coloring contest of mangrove bird image patterns. During the direct observation step, birdwatcher students showed positive environmental attittude, tend to be motivated by prizes quizzed instructor, tend to enjoyed birdwatching and interacted with other students, as well as being able to recognize the birds that encountered through the evaluation quizzes and the results of field notes, to do the practical use of birdwatching tools in the field (Wonorejo mangrove ecotourism area, Surabaya).

Acknowledgement

We thank the fish farmers Trunodjoyo, Wonorejo, involved in this program for their willingness to host this activities and for assistance the field activities. We also thank Ory K. Ayu and Mirza F. Firmansyah for their help with data collection and documentations, and all those who have helped the author in completing this program.

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Identification of Potential Location for Ocean Currents Power Plant in Madura Strait, East Java Indonesia

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Keywords: Madura Strait, ocean currents, energy, power plant, OSCAR.

Abstract. Energy supply has become the most important need in human life. Lately, the conversion of energy supply still dominated by fossil energy. But, the existence of fossil energy is getting decrease as the increase of world population, especially in East Java Indonesia. Furthermore, alternative and sustainable energy source besides of fossil energy is highly needed. Ocean currents within the ocean is potentially converted by using the conversion turbine as an alternative and sustainable energy source. Purposes of this study are to determine characteristics of ocean surface currents and to identificate potential locations for Ocean Currents Power Plant in Madura Strait. Ocean surface currents data is using OSCAR data (*Ocean Surface Current Analysis Real-time).* From analyses results of potential locations for ocean currents power plant in Madura Strait, the most potensial water is in southern part of Madura Strait. They are waters around Sumenep, Sapudi Island and Raas Island; with ocean currents velocity ranging in between 0.5 m/s to 1.2 m/s. The dominant currents direction is toward northeast.

Introduction

Ocean currents is the energy potential as a renewable energy. With the power generated, ocean currents can generate electrical energy. However, the utilization of ocean currents to produce electricity it is still not optimal developed and need to study in more depth. The energy from ocean currents, as a renewable energy, is the potential energy in coastal areas, especially with small islands and straits [1]. Ocean current energy in strait is very potential for a power plant location [2]. Based on the territorial water profile, East Java is one of the provinces that has great potential for the utilization of ocean currents power plants. Madura Strait as the territorial waters of the East Java has the potential for tremendous ocean currents for power plants. Although it has a tendency that ocean currents are not too large, but in some parts of the waters potentially ocean current energy. Until now there has not been much researches on analysis of the potential energy of ocean currents, especially in the waters around East Java. So it is necessary to study in more detail on identification of potential energy from ocean currents; and analysis of the potential location of Madura Strait for ocean currents power plants. Energy from ocean currents can be used to supply power to the regions which are not get electricity supply, especially for coastal communities in coastal area and small island around Madura Island. The aims of this study are to analyze the pattern of ocean currents in the waters around

Madura Strait, mapping the ocean currents energy potential, and to analyze the potential location of the territorial waters of Madura Strait as the location of sea power plants.

Method

The method used in this research is descriptive analytic, which to analysis of the ocean currents characteristics and to mapping potential energy location of ocean currents of Madura Strait Water. These activities are arranged matrix and map potential that describes the condition and the pattern of ocean currents, and create a map of the potential energy of ocean currents. In this study, it will produce an image pattern of movement of currents in the waters of Madura Strait in order to describe the incidence of direction and movement patterns of currents in this region. The analytical approach used to describe the pattern of movement of currents in these regions using image maps of ocean currents analysis of OSCAR (*Ocean Surface Current Analysis Real-time*).

OSCAR data were obtained from JPL Physical Oceanography DAAC and developed by ESR. The data is open access data of ocean surface currents that can be downloaded from portal podaac-ftp.jpl.nasa.gov website [3]. This data is the horizontal velocity directly estimated from sea surface height, surface vector wind and sea surface temperature. These data were collected from various satellites and in situ instruments. The resolution is 1/3° in each direction, and the time resolution within each file is 1/72 year ≈ 5 days. OSCAR data used in this research is for 15 metres in depth. The model formulation combines geostrophic, Ekman and Stommel shear dynamics, and a complementary term from the surface buoyancy gradient [4].

Analyzed OSCAR ocean currents data is ranging from the period 2004 to 2016. The pattern of ocean currents movement is obtained from the average data processing of each year from 2004 to 2016. Then the multiyears ocean currents data is analyzed using averaged 13 years data. The averaged ocean currents velocity data for 13 years (2004-2016), $\bar{v}_{2004\text{-}2016}$, can be obtained from the formulae 1 and 2.

$$\bar{v} = \frac{\sum_{i=1}^{n} v}{n} \quad (1)$$

or

$$\bar{v}_{2004-2016} = \frac{v_{2004}+v_{2005}+v_{2006}+v_{2007}+v_{2008}+v_{2009}+v_{2010}+v_{2011}+v_{2012}+v_{2013}+v_{2014}+v_{2015}+v_{2016}}{13} \quad (2)$$

The ocean currents measurements in the field were carried out in 2 (two) sampling area, i.e in the waters of Camplong Madura and Pasuruan water. Camplong water is as a representative of the Madura Strait northern part, and the Pasuruan water for representatives of the southern part of the Madura Strait. The ocean currents map from data processing results are then verified using the ocean currents data of direct measurements in the field. Analyzed ocean currents data results, is then used to identify the location of the potential energy of ocean currents in Madura Strait.

Results and Discussion

Madura Strait is the strait that separates the island of Java and Madura Island and has an important role in everyday life, especially in the economic, security, and social. A variety of activities such as settlements, ports, industries, and centers is located in the territorial waters of the Madura Strait. Madura Strait is the waters of semi-enclosed type (semi-enclosed sea), in the northwest and east of Madura Strait have open type, in the northwestern part of the Straits of Madura is Java Sea. While in the eastern part of the Strait of Madura is Bali Strait. Madura Strait have potential marine energy large enough to be used, in particular the kinetic energy of ocean currents. According to Nurhayati [5], one of the areas that can be used as a development of non-conventional energy from the sea is the strait. Strait is an area waters narrowed, the strait

is located between two ground surfaces, and connects two parts of a larger waters. The difference in pressure between the ends of the waters of the strait cause currents in the Strait area become stronger.

Current movement patterns are performed data processing on average each year from 2004 to 2016 in Fig. 1.

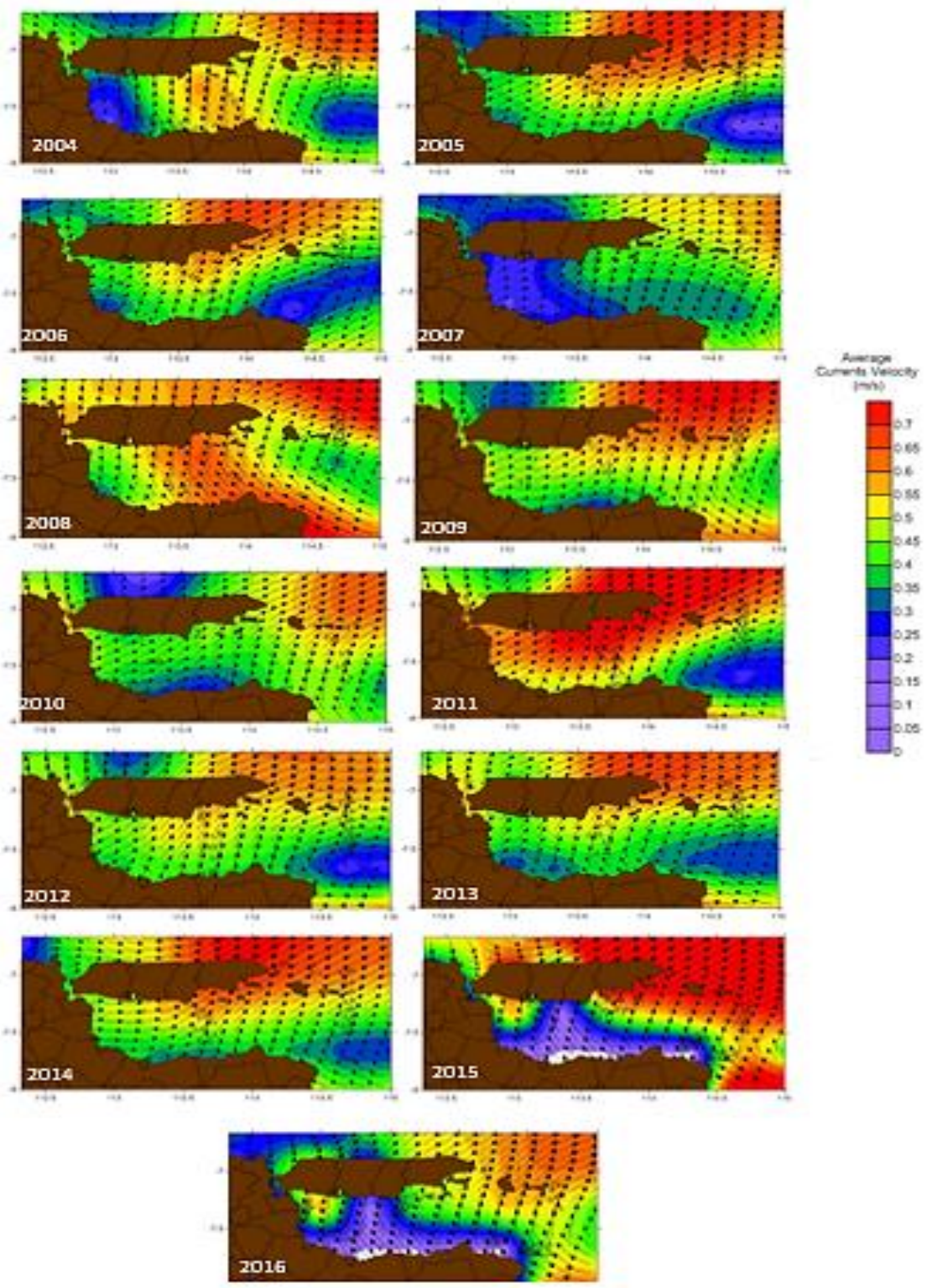

Figure 1. Average ocean currents velocity and direction in Madura Strait for each year from year 2004 to 2016.

From the data year 2004, the highest currents velocity in southern part of Madura Strait is dominated in the area around Sapudi Island and Raas Island. The currents velocity around those islands are in between 0.5 m/s and 0.7 m/s. With the major direction currents toward north east. For the southern part of Madura Strait, the highest of ocean currents velocity around Situbondo water with flow speed betwee 0.3 m/s and 0.55 m/s, and the direction toward north. From all of the ocean currents pattern map for all years from 2004 to 2016, the highest of ocean currents velocity in southern part of Madura Strait in the east part are dominant in water around Sumenep, Sapudi Island and Raas Island. With the dominat direction is toward northeast.

In accordance with Figure 1, the current velocity potential for the area around the power plant in Madura Strait is covers an area of water around Sapudi Island, Raas Islands, and Sumenep. Then to strengthen the analysis of potential areas for regional power generation, performed data processing to find the average value of current speed and direction of currents from all years (2004-2016). From all the year, year 2004 - 2016 shows that the north part of Madura Strait area is an area of highest flow speed, from water around Sapudi Island, Raas Island and Sumenep. The mean of ocean currents velocity, average value from year 2004-2016, is in between 0.2 m/s to 1.2 m/s. For the direction pattern of current velocity, its dominan from west to the east and to northeast.

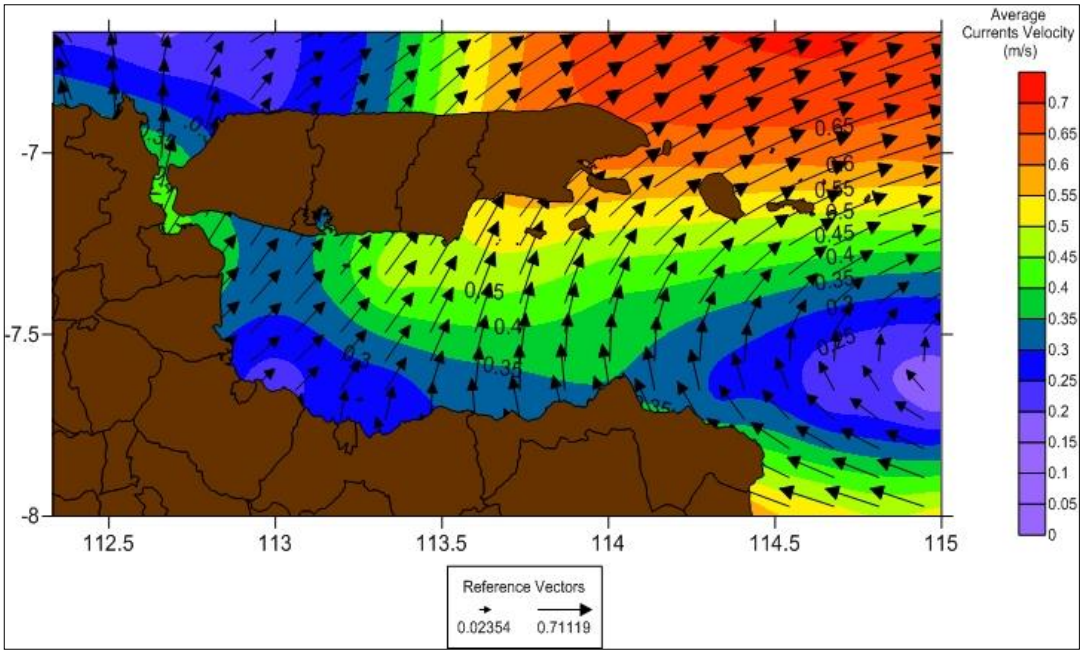

Figure 2. Direction and average currents velocity in Madura Strait for 13 years start from 2004 to 2016.

To verify the data processing ocean currents data using satellite data input (OSCAR), a comparison with the data of direct measurements in the field of observation. Observation and measurement of the flow of data in the field was conducted in August 2015. Ocean currents measurement locations were in: (i) Water of Camplong Madura, this water represent the north part of Madura Strait, and (ii) Pasuruan water, this water represents the south part of the Madura Strait water.

The the measurement of ocean currents velocity in Sampang Water and Pasuruan Water is using current meter and for the direction of currents observed using compass. The data obtained from field observation in detail are as shown in Table 1 and 2.

The data obtained from field measurement in Camplong shows that the ocean currents velocity in this water area in between 0.5389 m/s to 0.9978 m/s. The dominant of ocean currents

direction between 70 degrees and 135 degrees, it means that the dominant direction towards east.

For the data obtained from field measurement in Pasuruan water shows that the ocean currents velocity in this water area in between 0.065 m/s to 0.3556 m/s. The dominant of ocean currents direction are in many variation between 5 degrees and 355 degrees. It means that the dominant direction in Pasuruan water toward west, north and northeast.

Table 1. Ocean currents data of field measurements in Camplong water.

Longitude	Latitude	Ocean Currents Velocity (m/s)	Currents Direction (degrees)
113.3229	-7.2293	0.6667	100
113.3229	-7.226	0.6467	115
113.3178	-7.22	0.5633	90
113.3323	-7.2299	0.7767	123
113.3272	-7.2269	0.8722	100
113.3175	-7.2269	0.9978	98
113.3316	-7.2257	0.9556	135
113.3204	-7.2289	0.7500	125
113.3211	-7.2244	0.5389	86
113.3192	-7.2238	0.6444	75
113.321	-7.2238	0.6944	70
113.3247	-7.2241	0.6833	70

Table 2. Ocean currents data of field measurements in Pasuruan water.

Longitude	Latitude	Ocean Currents Velocity (m/s)	Currents Direction (degrees)
112.925	-7.6118	0.0889	200
112.92	-7.6097	0.0833	285
112.913	-7.6017	0.0889	175
112.908	-7.5956	0.2222	265
112.905	-7.5883	0.1278	60
112.906	-7.5837	0.065	50
112.914	-7.5814	0.1556	20
112.918	-7.5847	0.0944	30
112.922	-7.59	0.1556	15
112.926	-7.5915	0.2778	345
112.929	-7.5974	0.3556	280
112.931	-7.603	0.3556	345
112.936	-7.5995	0.2444	0
112.932	-7.5964	0.2000	10
112.93	-7.594	0.1778	25
112.929	-7.5903	0.2000	5

Longitude	Latitude	Ocean Currents Velocity (m/s)	Currents Direction (degrees)
112.929	-7.5858	0.1722	45
112.928	-7.5829	0.2389	340
112.931	-7.5801	0.2889	5
112.934	-7.5799	0.3111	355

Based on the two data of ocean currents measurements, northern part water of Madura Strait is more potential for ocean currents power plant than the southern part of Madura Strait. The field data of ocean currents is match with the results data based on OSCAR data.

Conclusions

From this research, it can be drawn some conclusions as follows:

1. Ocean currents pattern of Madura Strait from year 2004-2016 with velocity between 0.2 m/s and 1.2 m/s with major direction from west to east and northeast.
2. The potential locations for ocean currents power plant is in northern and eastern part of Madura Strait.The most potential water for power plant are waters around Sumenep, Sapudi Island and Raas Island.

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MARINE ENERGY EXPLORATION AND EXPLOITATION

The Usage of Organic Waste as Nutrition for Algae in Application at Algae's House for Increasing Civilians Prosperity at Poncosari Village, Srandakan, Bantul, Yogyakarta with SWOT Analysis

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Keywords: Algae, Algae's house, biofuel, energy, waste.

Abstract. Based on data obtained from Ministry of Energy and Mineral, Indonesia's oil reserves only remaining 3,6 billion barrels or only survive for 12 years. Another problem underlying this research was the increased of organic waste pollution on Indonesia's beaches especially the south coast of Bantul which has potential algae abundant. From both these phenomena the idea about alternative energy sources research by using an abundance of algae to be biofuel was initiated. This research started by problems seeking, observation related place, literature study and discussion. Application of algae's house in Poncosari village, Srandakan, Bantul, Yogyakarta was designed with open pool, using transparent roof so that the sunlight radiation can used by algae for photosynthesis process and avoid contamination by rains water. Algae's house can be one step to algae cultivation as a substance of biofuel sources.SWOT analysis results showed that proposed strategy by using the power and opportunity to overcome weaknesses and threats. The proposed strategies were improving production capacity, maximizing the utilization of organic household wastes, formulate policies that support small and medium businesses as well as to provide guidance to local communities. Procurement home to algae and algae into biodiesel processing industry has the potential to improve the welfare of the community.

Introduction

Indonesia previously has proven oil reserves up to 27 billion barrels, but it already produced around 22.9 billion barrels. Now the rest only 3.7 billion barrels and expected these reserves can only be used for only 10 years longer. The level of demand for oil in 2013 expected will rise 10% per year. Another issue to consider was the problem of marine pollution by organic waste from coastal communities that resulted the explosion of algae (algal blooming). These algal blooms reduce the levels of DO (dissolve oxygen) in water so oxygen supply for other marine life were hampered, while generally people's livelihood especially at seaside village of Poncosari Srandakan village, Bantul, Yogyakarta were as fishermen.

Biodiesel was one of alternative energy, it was produced by natural ingredients that contain oil such as from palm oil. Therefore, the authors tried to find other materials that do not compete with food needs and easy to get by seaside communities it was Algae. Algae contains about 30-40% vegetable oil and the potential existence quite high in Indonesia, especially in the South Coast Bantul. Based from the challenges and algae's potential, authors attempted to provide the innovation of algae application at home in Poncosari village Srandakan, Bantul, Yogyakarta, which have good algae potential because it was close to South Beach, Bantul.

Method

In this research, we used observation techniques to collected data about kind of algae which have found along south beach of Bantul, we were observe theenvironmental and socio-cultural conditions ofsociety, especially Civilians at Poncosari Village, Srandakan, Bantul, Yogyakarta. Then we made the algae cultivationprogram design with involve local communities. Algae cultivation programdesign isstructured as follows:

a. Organic waste collection system conducted every household
b. Manufacture of organic waste storage pond
c. Made algae's house
d. Growth of algae, during growth algae also followed by maintenance and care with providing additional nutrients from organic waste and addition of sea water.
e. algae harvesting
f. the process of making biodiesel
g. SWOT Analysis

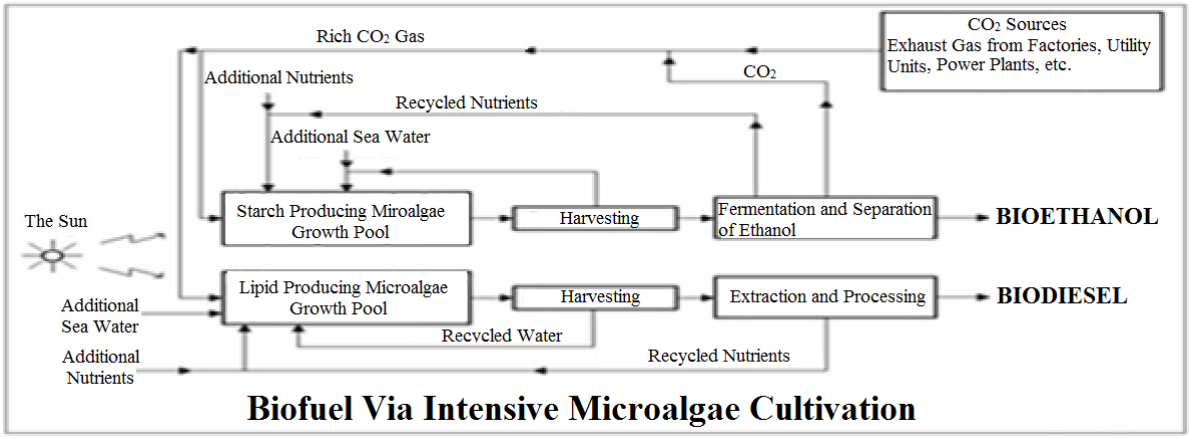

Figure 1.The process of making algae biodiesel (Soerawidjaja,2005).

Results and Discussion

Based on these data the highest dominance of macro algae was Enteromorphaflexuosa with 24.92 value. Besides having highest number of this species,Enteromorphaflexuosawas easy and available in tidal areas that exposed to sunlight, sticking to a hard substrate such asthe dead coral. Of this potential can be seen that the density of algal abundance can be used as material for alternative energy one of which is biodiesel.

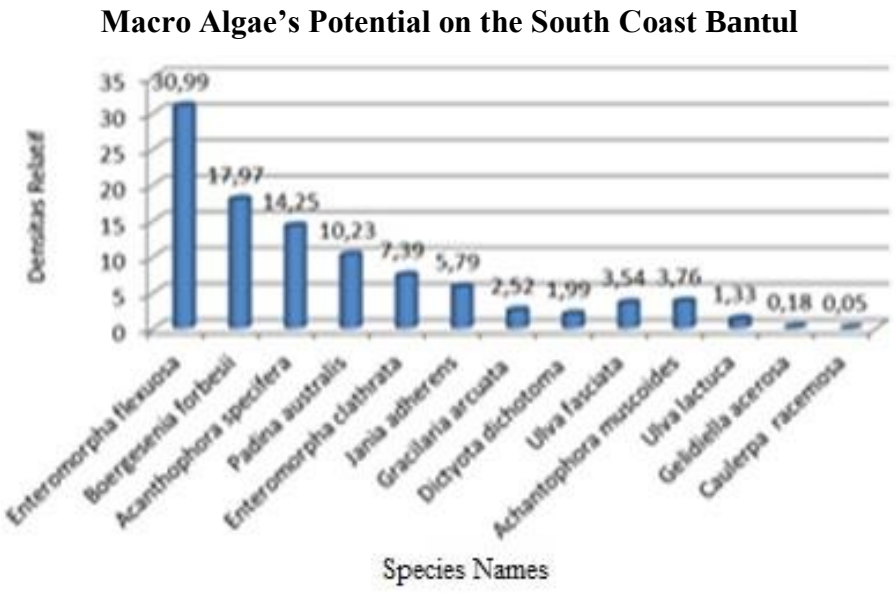

Figure 2. Relative density of macro algae species along the south coast of Bantul [1].

Conversion of Algae Biodiesel Being

Vegetable oil can be made of algae has properties similar to diesel oil by using alcohols such as methanol or ethanol in a process called esterification [2]. Esterification is a process to convert vegetable oils or fats into methyl ester. Methyl ester is called as biodiesel [3-6]
Esterification aims to reduce the viscosity of the feedstock, so that the viscosity of biodiesel produced included in the range was standardized by the National Biodiesel Board[4,7,8,dan 9]. According[4], there are three steps that must be done to change the oil or fat into methyl ester, the process was catalyzing the oil with methanol in order transesterification. Acid catalysis process of oil with methanol in order to esterification. change the oil of fatty acids into methyl ester. In detail, the process was methanol mixed with the catalyst. The catalyst used was sodium hydroxide. This mixture then added to the oil and introduced into the reactor. Heating to a temperature of 150 degrees Fahrenheit carried out for 1 to 8 hours. From this mixture yielded two substances have different densities, the methyl esters and glycerin. This mixture can be separated by centrifugal process. On some systems, the methanol separated after this mixture separately.
Methyl ester then washed with warm water, to clean the rest of the catalyst and soap. There is no wasted material from the processing of biodiesel [10].

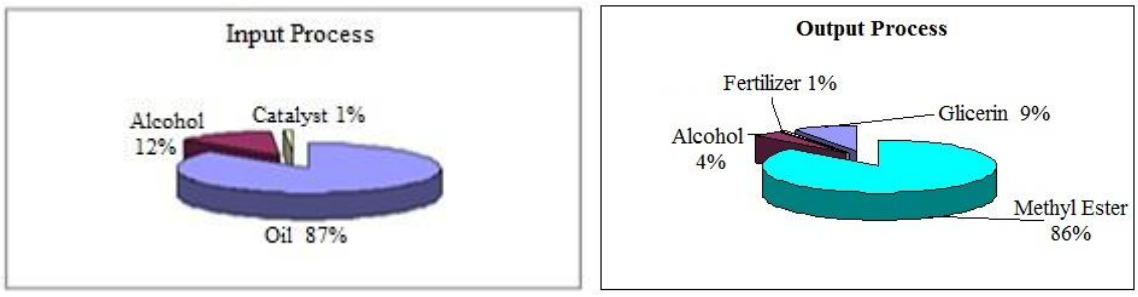

Figure 3. Presentation diagram in input process of macro-algae biodiesel oil.

Results of SWOT analysis

Table 1. SWOT analysis of alga's house program.

No	Internal/external			
	Internal		External	
	Strength	Weakness	Opportunity	Threats
1	There were no transport costs in the procurement of microalgae for farmed	Labor was still a lot less educated	Market opportunity biodiesel was still great	Tough competition not only from within but from outside products
2	More fuel-efficient	High production costs	Infrastructure simple	The location was close to the settlement enterprise
3	The quality of competing products	Small engine capacity	Demographic layout provides natural resources support in plant operations	Price indexes low market
4	Utilization of household organic waste as nutritional microalgae cultivation	Location house making algae require a large area	Distribution easily accessible or easy	Licensing and bureaucracy
5	Cooperation between academia with coastal communities		The new technologies of organic waste processing	Prices can't compete with fossil fuels
6	Housing conditions algae strategic		Renewable energy policy	
7	Availability of raw materials			

SWOT Analysis was a conventional strategy underlying the formulation of strategies adapted to shape of the corporate environment and market conditions. From the SWOT analysis several alternative strategies was formulated, which were:

Strategy S-O (Strength-Opportunity)

SO alternative strategy was a strategy that formulated by considering strength of company/industries to exploit the opportunities that exist as optimally as possible. SO the strategies were formulated, which are:

Increasing production capacity and maximizing the utilization of organic waste biodiesel society by considering the availability of quality raw materials which are competitive, environmentally-friendly and commercially exploited themselves to the welfare of coastal communities at Bantul.

Develop products to make biodiesel mixture, by utilizing availability of raw material, and by the likelihood of government policy about developing biodiesel as an alternative fuel source.

Strategy S-T (Strenght-Threat)

Product of ST Strategy was a strategy which are used to avoid the threats that coming from the external environment by utilizing power by the utilization of organic waste as a nutrient algae cultivation and then the diversify into biodiesel, which will be able to fullfill the needs of diesel fuel the public and increase public revenue. The quality of competing products, which are efficient and environmentally friendly, will raise the price of market index.

Strategy W-O (Weakness-Opportunity)

Alternative WO strategy is a strategy that can be done to mitigate the effects arising of weaknesses in the companyand to take advantage of existing opportunities. W-O strategic alternatives for the company is doing maintenance and repair of the machine regularly and periodically in order to maintain and keep the quality of production. In the marketing, biodiesel made by the contract for a certain period with the government. It is an opportunity society in selling products continuously even if the production capacity is small. Biodiesel production infrastructure maintenance and repairing of production machinery on a regularly in order to produce biodiesel to meet market demand, especially for needs local communities.

Training about how to operating algae cultivation and conversion into biodiesel infrastructure to the local community needs to be done to provide employment opportunities to the community.

Strategy W-T (Weakness-Threats)

WT strategy is a defensive alternative strategy, and the strategies to minimize losses resulting from weaknesses as well as how to avoid the threats that came with:

Produce only on request. With a small production capacity and high production costs, alternative strategies that we can do is work together with the government (contract) which are support small and medium business community. This is done to solve the low price market index so that people who produce biodiesel will not lose money despite the high production costs.

To reduce the cost of production can be done by streamline work procedures. Reducing the production cost by cutting costs that not important and streamline production facilities in order to gain more profit. This is done to overcome the price which can't compete with fossil fuels.

Focus on small segments, namely the local area. With a small production capacity and high production costs, a strategy that can be done is the production of biodiesel made a focus on small segments that serve the public demand and government agencies are already under contract.

Conclusions

Based on observations and discussion of literature in general it can be concluded that the potential of algae on the South Coast Bantul pretty great. This potential can be used as alternative energy sources because the oil content of algae can be used as biodiesel. This potential will be applied through a home management of algae by the villagers PoncosariSrandakan, Bantul, Yogyakarta in an effort to improve people's welfare and it is able to reduce marine pollution by organic waste from the local community. SWOT analysis results showed that proposed strategy by using the power and opportunity to overcome weaknesses and threats. The proposed strategies were improving production capacity, maximizing the utilization of organic household wastes, formulate policies that support small and medium businesses as well as to provide guidance to local communities. Procurement home to algae and algae into biodiesel processing industry has the potential to improve the welfare of the community.

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Numerical Study of Vertical Axis Marine Current Turbine Using Darrieus Savonius Hybrid by Adding Deflector in Front of Returning Blade

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Keywords: Computational fluid dynamics, Darrieus-Savonius hybrid, moving mesh, deflector angle.

Abstract. Numerical simulation uses Computational Fluid Dynamics based on basic equation of fluid acomplished by Finite Volume Method. Unsteady RANS equation and turbulence model (k-ε) which are appropriate for each blade section, were employed. First for experimental data of Darrieus Savonius Hybrid is available then the 2 dimensional numerical analyses had been performed and compared with the experimental data result. The numerical simulation uses the moving mesh for rotating the equipment. The paper will investigate the performance of Darrieus Savonius Hybrid by adding deflector in front of returning blade. The viscous turbulence model uses standard k-epsilon and its descritization uses Second Order Upwind. The changing of Tip Speed Ratio simulated by numerical simulation at TSR 0.871, 1.05, 1.238, 1.3738 and 1.749. Torque coefficient data will be taken on 9^{o} deflector angle. The grid independency of numerical simulation had validated numerical simulation on the experimental data in about 5 % error at TSR 1,238 and error of numerical simulation had increased by increasing TSR about 32% at TSR 1,749.

Introduction

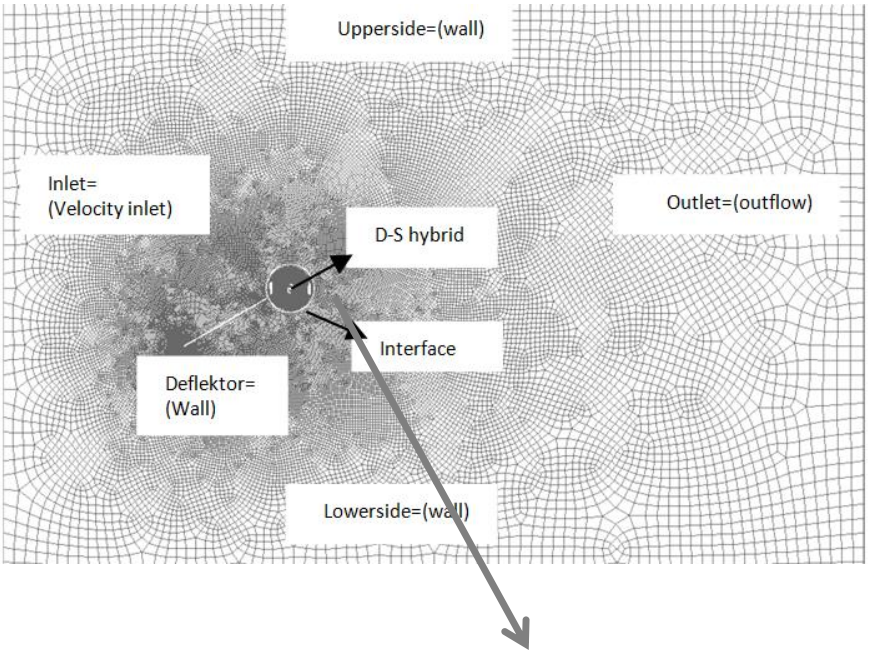
The research aims to increase the performance of savonius turbine by varying the number of bucket blade and gap among the bucket [6]. Savonius turbine was carried out by varying overlaping ratio 0, 0.1 and 0.2. Performance of savonius turbine observed by different velocity to obtain maximum torque at overlaping ratio (e) 0,2 [5]. The similar reasearch done by descripting savonius turbine using deflector in front of turbine of returning blade and beside advancing blade. The deflectors can increase the performance of turbine. Flow phenomenon through advancing blade, will increase the drag force using two deflectors. The flow going to returning blade decreased by flat deflector, however different drag beetwen advancing blade and returning blade will produces maximum torque at savonius rotor[3]. Vertical Axis Marine Current Turbine (VAMCT) has been developed for low current. It uses experimental done in towing tank with double stacking rotors. The method used is experimental at range of overlaping ratio 0,2-0,25 with the best performance at overlaping ratio 0,21[7]. The experiments were carried out in an irrigation channel in Lubuk Linggau, Indonesia. The water velocity of the free stream is constant at 0.71m/s due to the irrigation system of overflow in the main river. Deflector has been increased performance of Darrieus-Savonius turbine [4]. Numerical simulation has been tested to avoid uncertainty however it produces some numerical simulation policy. The one of policy is second order upwind [2]. Comparation beetwen 2-D simulation and 3-D simulation has shown good approaching experiment result. However, The result of 2-D

simulation has power coefficient which is more approaching experiment than 3-D simulation[1].

From the literature review, the deflector effect on the turbine performance had been obtained performance of Darrieus Savonius turbine as function of torque coefficient percycle to changing Tip Speed Ratio (TSR). The paper will observe numerically to the performance of Darrieus-Savonius hybrid turbine using a deflector plate which is represented by torque coefficient percycle. The Darrieus-Savonius Hybrid turbine consists of Darrieus and Savonius turbine in which the Savonius rotor is placed on the middle of Darrieus rotor on the same shaft. Savonius water turbine and cross-flow water turbine can be improved by setting deflector around the rotors because the deflector in front of returning blade of the rotor can increase. In this paper, numerical study analyzes the unsteady flow around the Darrieus-Savonius hybrid by adding deflector in front of returning blade. This study used two kinds of turbines, darrieus turbine use NACA 0015 and savonius. The present study has analyzed the turbine performance by using the 2 dimensional numerical simulation and has verified the result through an experimental data [4].

Method

The research used numerical simulation with Darrieus-Savonius hybrid as model. D-S hybrid model has two blades with the diametre of D = 0.400 m, blade chord of c = 0.125 m, and blade span of H = 0.600 m. This study has used the unsteady incompressible Reynolds-averaged Navier-Stokes equation based on the cell-centered finite volume method and has implemented the rotation by using the moving mesh technique to rotate the space of turbine area. This main study, The structured grid has been employed for all the grid system of rotor and the computational domain reaches to 10D in the inlet direction, 20D in the outlet direction and 20D in the vertical direction, where D denotes the diametre of Darrieus turbine. Most calculations were made based on the 2-dimensional unsteady flow assumption for its relative simplicity. The boundary condition of numerical simulation as shown in Fig 1. The viscous turbulence model uses standard k-epsilon and its descritization uses Second Order Upwind. Torque coefficient data of numerical simulation will be taken on 9o deflector angle percycle and average torque coefficient had been compared by sahim experimental data [4].



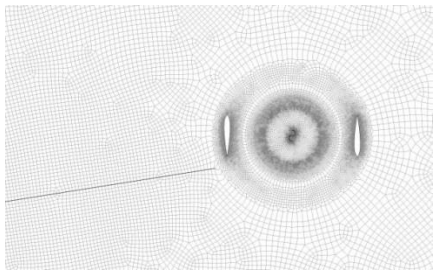


Figure1. Domain of numerical simulation.

Firstly, the numerical simulation have observed Grid Independency to changing size grid from coarse to fine. The objective of grid independency was to determine the meshing of simulation that the numerical simulation did not influence the result of simulation. The grid independency had been done 8 times as shown in Table 1.

Table 1. Grid Independency on 9^{o} Deflector Angle at TSR 1,238

Meshing Type	Torque coefficient (Cm) of Sahim Experimental data	Torque coefficient (Cm) of Numerical Simulation	Error [%]
1	-0,137	-0,0283	79,36
2	-0,137	-0,0432	68,49
3	-0,137	-0,0652	52,40
4	-0,137	-0,0926	32,41
5	-0,137	-0,1068	22,05
6	-0,137	-0,1262	7,90
7	-0,137	-0,1296	5,41
8	-0,137	-0,1301	5,04

Data of Table 1 had shown graph meshing type as the function of Torque Coefficient from coarse to fine meshing as shown in Fig.2. Grid independency had occured at Meshing type 7 and 8 which the simulation did not influence numerical simulation result.

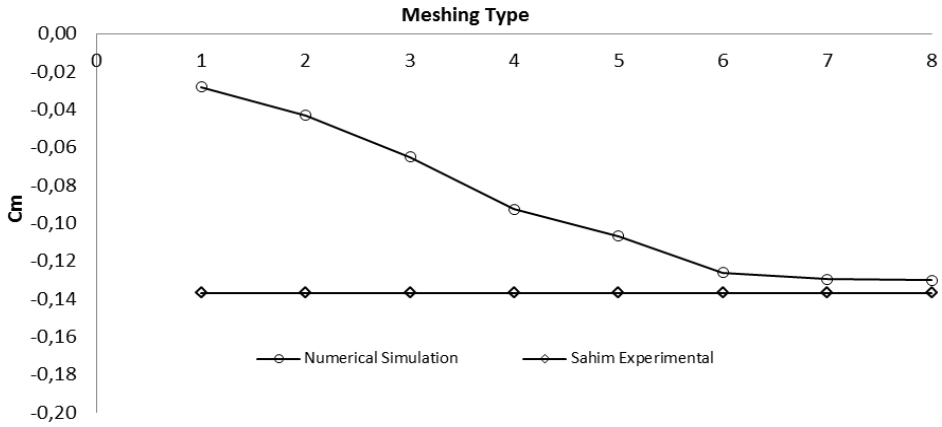


Figure 2. Grid independency of meshing type at TSR 1,238.

Results And Discussion

Comparation of the experimental data and numerical simulation of D-S hybrid turbine was based on the TSR (Tip Speed Ratio) defined as in table 1.

Table 1. Experimental data and numerical simulation result of darrieus savonius hybrid.

TSR	Variable				Error (%)
	Velocity of freestream [m/s]	Angular velocity of Turbine [rad/s]	Torque of Coefficient (Cm) Experimen by Sahim	Torque of Coefficient (Cm) Numerical	
0,871	0,71	3,092	-0,178	-0,169	4,79
1,05	0,71	3,728	-0,158	-0,166	5,06
1,238	0,71	4,395	-0,137	-0,130	5,04
1,3738	0,71	4,877	-0,116	-0,092	20,95
1,749	0,71	6,209	-0,0647	-0,044	32,65

The validation of numerical simulation simulated by experimental data as shown in table 1. The result of numerical simulation was shown in Fig 1. The Changes of Tip Speed Ratio simulated by numerical simulation at TSR 0.871, 1.05, 1.238, 1.3738 and 1.749. The error of numerical simulation showed that the best value in ranges TSR of 0.871 until 1.238 about ± 5% and the error of numerical simulation had increased at TSR of 1.3738 with error 20.95% and TSR 1.749 with 32.65% compared with Sahim experimental data.

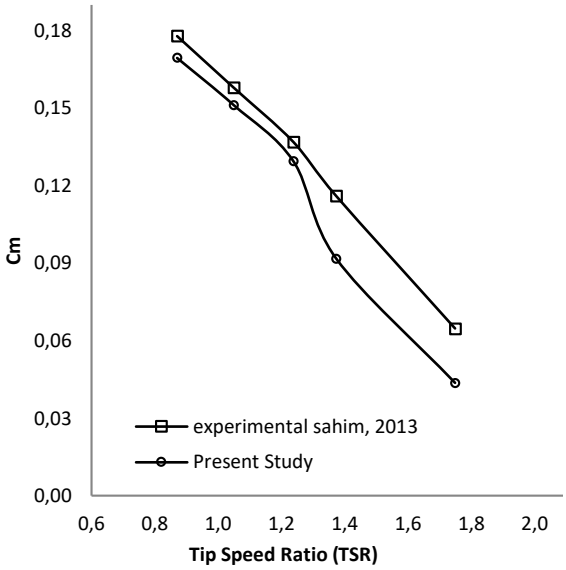


Figure 3 (a) Validation of numerical simulation and experimental data as functions of torque coefficient (C_m).

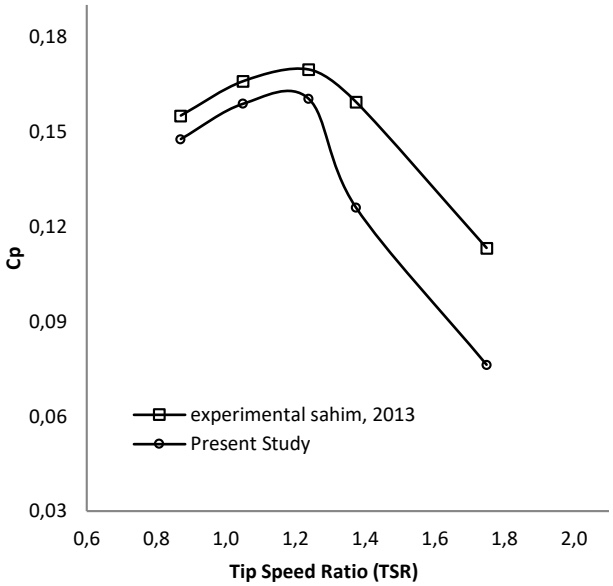


Figure 3 (b) Validation of numerical simulation and experimental data as functions of power coefficient (C_p).

The effect of Tip Speed Ratio to torque coefficient had been shown as in Fig. 3(a). The Tip Speed Ratio had Influenced the result of torque coefficient. Torque coefficient would increase by decreasing TSR and otherwise. And then, The effect of Tip Speed Ratio to torque coefficient had been shown as in Fig. 3(b). The Tip Speed Ratio had Influenced the result of power coefficient, which the power coefficient had increased by increasing TSR and maximum power coefficient at TSR 1,238. But, the power coefficient had decreased by increasing TSR after TSR value 1,238. The numerical study shown the same curve trend to experimental data [4] as shown in Fig. 3(a) and 3(b).

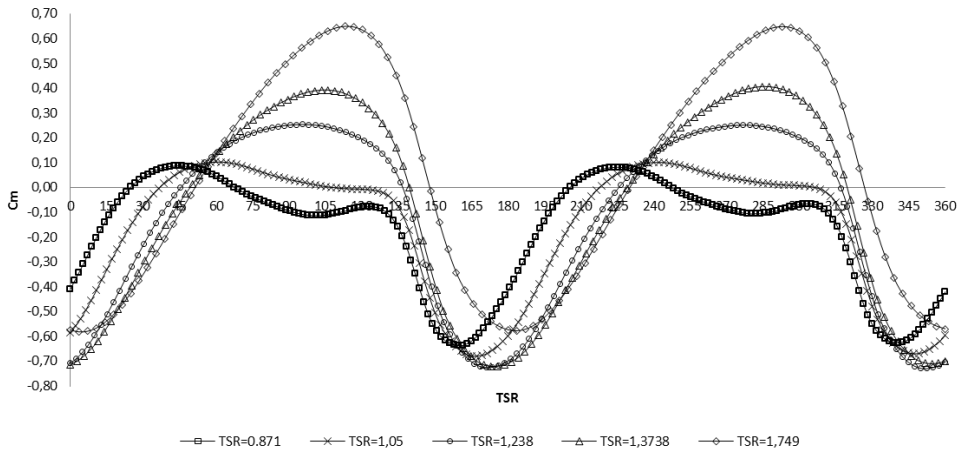


Figure 4. Graph Blade position as the function of Torque Coefficient (Cm) percycle.

The effect of Torque Coefficient (Cm) to changes of Tip Speed Ratio (TSR) had been shown in Fig 3. The TSR had been effected by angular velocity of turbine, which the torque coefficient had increased by decreasing TSR at range of blade position 0-50o. But the torque coefficient has decreased by increasing TSR at range of blade position 50-100o. Average torque had shown that the torque coefficient decreased by increasing TSR.

Conclusion

From the above discussions, grid independency of numerical simulation had validated numerical simulation on the experimental data in about less than 5 % error at TSR 1,238 and error of numerical simulation had increased by increasing TSR about 32%. It is concluded that numerical simulation of Darrieus-Savonius rotor can be used to predict torque coefficient percycle.

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The Potential of Biodiesel from Seaweed as Alternative Fuel for TNI AL Patrol Vessel in Efforts to Maintain Maritime Security

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Keywords: Seaweed biodiesel, renewable energy, maritime security.

Absract. Indonesia is an archipelago which 2/3 are sea territory. It means that growing number of threats to Indonesia maritme security. In an efforts to improve maritime security, Indonesia needs a lot of sea patrol fleet at conflict prone region. However, the availability of fuel oil is still very minimum. Based on this phenomenon, it is necessary to utilize other renewable energy resources that can easily accessible, for example seaweed as biodiesel. Availability of seaweed abundant in Indonesia sea are a potential as renewable energy resource. This research show that potential of biodiesel availability from seaweed to fulfill fuel supply as substitute diesel fuel for TNI AL patrol vessel. Furthermore, this research can be used as a reference in determining renewable energy policy in the fieid of defense.

Introduction

Indonesia as the largest archipelago country with 2/3 sea areas, has a strategic geographical location because it is located at the intersection world that is between two continents and two oceans, so that the geographical location caused the sea between the islands as the sea channel, which is very important for the national and international shipping traffic. Besides that, in addition to having 17,504 islands, with an area of the sea reach 6.32 million km^2 and a coastline of 99 093 km^2 [1], Indonesia sea territory is also one area of tropical sea with high biodiversity, it makes foreign countries have an interesting to enter Indonesia sea territory. Thus, potential of threats in maritime security increase both of traditional and non-traditional. One of the efforts to maintain maritime security, namely maritime security operations TNI AL as a major component in making the country's defense by conducting patrols using patrol vessel. This condition causes the dependence of the patrol vessel's fuel to fuel oil (BBM), which, if it is not fulfilled it would interfere with theirs work in securing the sea.

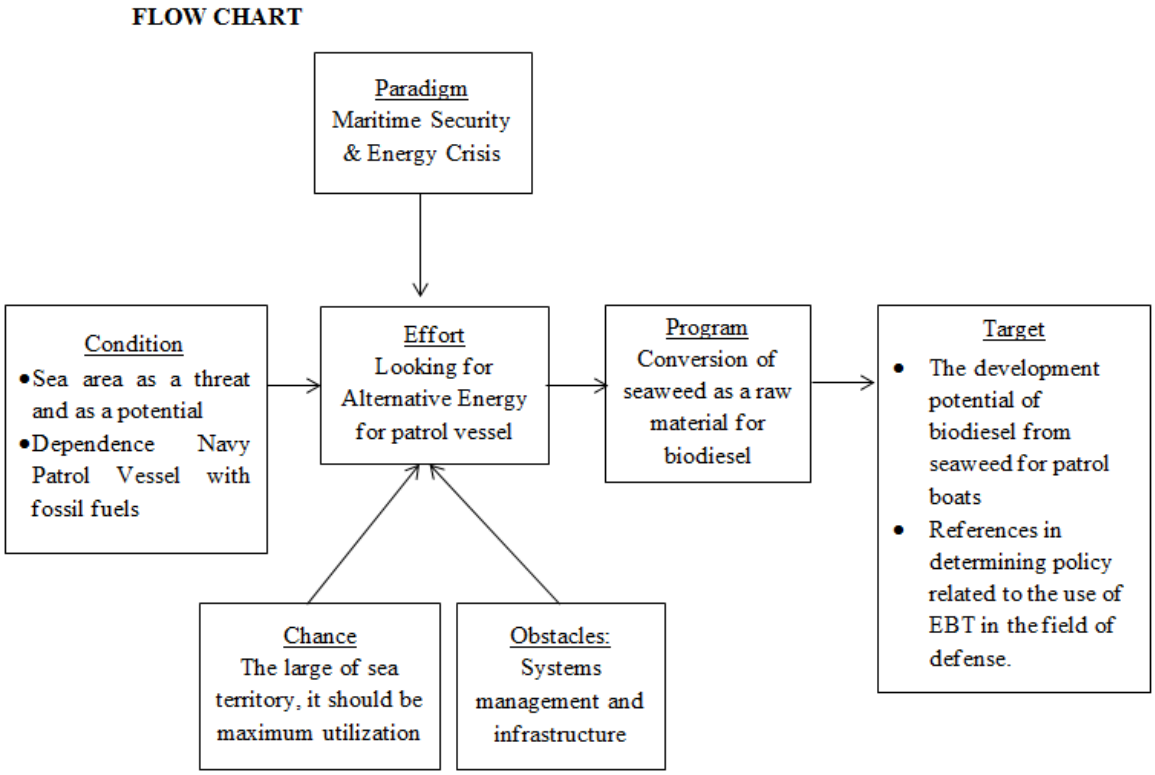
In Indonesia, all of fuel requirements of patrol vessels still dependent on fossil fuels. One essential result of refining oil to fulfilled the needs of the patrol vessel is diesel. Currently the supply of diesel is still supported by domestic production and imports from abroad that have reached half of domestic oil needs. Since 2004, Indonesia has actually become a net importer oil, so that the world oil prices affect to Indonesia energy supply. It is very dangerous when the world oil price increase highly, because Indonesia will be crisis of energy if it is not able to fulfilled a domestic demand. In this case, diesel is the fuel that was instrumental in meeting the transportation needs both of transport goods and people. This scarcity will also have an impact on the transport system of TNI AL patrol vessel, even the vessel fuel is still rely on diesel from Pertamina. Of course this would disrupt the TNI AL patrol system and threaten Indonesia's maritime security. Therefore, it is necessary to find a way to reduce dependence on diesel oil consumption with alternative fuels.

Seaweed is one of the biological resources are very abundant in the waters of Indonesia which is about 8.6% of the total marine biota in [2]. The total area of seaweed habitat in Indonesia reached 1.2 million hectares, the largest in the world [3]. Given the condition of Indonesian waters rich in seaweed species, the potential should be explored and utilized to meet domestic needs, especially the energy sector.

In the energy sector, seaweed can be used as raw material for the production of biodiesel that can be used as an alternative to diesel. Biodiesel can be made from biological materials that are environmentally friendly, such as oil palm, jatropha, etc. However, based on the condition of oil palm plantations are constantly thinning and takes a long time to be replanted, the sea is the area that is ideal as a biodiesel feedstock cultivation. Thus, the large sea territory of Indonesia is a strategic area to take advantage of seaweed as a raw material for biodiesel.

Method

This research using literature study, which follow the mind mapping based on nowdays condition and the future condition step by step. Further, sustainability of development will be analyzed with the SWOT method is based on the assumption that the data has been collected through the study of literature. The formulation is described in the form of a SWOT matrix and strategic obtained is SO, ST, WO and WT.



Results and Discussion

1. Sea Area as Threats and Potential

Indonesia sea are reached 6.32 million km2 with a coastline of 99.093 km2, making Indonesia as the center of gravity of in Asia Pacific that have high natural carrying capacity with the mega biodiversity. Sea has developed into a national assets, as the sovereign territory, ecosystems, resources are used as an energy source, a source of food and has a fungtion to be transportation line between islands, regional trade, exchange, socio-cultural and acts as a media

defense area and acts as the media to build influence on the other foreign [4]. With such a potential, there are consequences to be faced is increasingly the sea area then the threat to security at the sea are also more numerous and complex as the dynamics of the global environment, regional and national levels. Therefore, Indonesia should have ability to maintain security and stability in the sea so that this potential can be utilized as much as possible for the welfare of the Indonesian people.

1.1. Sea Area as a Threat

Maritime security, according to Prof. Purnomo Yusgiantoro is a condition in which the sea is free from the dangers posed by a group of people who harm and disrupt activities such as maritime piracy, robbery and terrorism. Then free from the threats as a result of bad geography and hydrographic conditions that cause impaired navigation and sea conditions that are free from violations of both national and international law such as illegal fishing, illegal logging, human trafficking, smuggling of illegal goods and others [5]. There are several elements that include parts of maritime security, namely:

- Peace and security of national and international
- Sovereignty, territorial integrity and political freedom
- Security of sea lines of communication
- Protection from crime or crimes sea
- Resource security, the access to the resources of the sea and seabed
- Environmental protection
- Security for sailors and fishermen[6].

One of the efforts to achieve security and stability in the sea is through the Maritime Security Operations (Opskamla) by the TNI AL. Maritime security operations is operating daily presence at sea that have strategic value for the existence of national sovereignty and maritime security in the territorial jurisdiction of Indonesia [7]. TNI AL task of implementing the rule of law and maintain security in areas under national jurisdiction in accordance with the provisions of national and international laws that have been ratified. In doing so, the TNI AL is supported by a variety of resources including a patrol vessel of the Republic of Indonesia (KRI), fuel logistics and budget allocations.

1.2. Sea Area as Seaweed Cultivation

As an archipelago with extensive sea areas, Indonesia has huge potential for the development of commodity seaweed, where development activities have been conducted in the waters of Indonesia, ranging from Nanggroe Aceh Darussalam to Papua. Indicative vast area that can be utilized for the cultivation of seaweed commodities Indonesia reached 769.452 ha. Of that amount, only about 50% or an area of 384.733 ha are effectively utilized.

Table 1. Total indicative effective potential areas for commodities seaweed[8].

No	Province	Area (Ha)	
		Indicative	Effective
1	Nanggroe Aceh Darussalam	24282	12141
2	North Sumatra	19 863	9932
3	West Sumatra	33 742	16871
4	Riau	0	0
5	Riau islands	0	0
6	Jambi	7646	3823
7	Bengkulu	6172	3086
8	South Sumatra	12 236	6118

No	Province	Area (Ha)	
		Indicative	Effective
9	Bangka Belitung	76 657	38 329
10	Lampung	15 819	7910
11	Banten	1814	907
12	DKI Jakarta	1641	821
13	West Java	0	0
14	Central Java	0	0
15	In Yogyakarta	0	0
16	East Java	12755	6378
17	Bali	4701	2351
18	West Nusa Tenggara	45330	22 665
19	East Nusa Tenggara	68 764	34 382
20	West Kalimantan	0	0
21	Central Kalimantan	0	0
22	South Kalimantan	10 208	5104
23	East Kalimantan	11 495	5748
24	North Sulawesi	3598	1799
25	gorontalo	20 621	10311
26	Central Sulawesi	65 426	32713
27	South Sulawesi	13201	6601
28	Southeast Sulawesi	54 770	27 385
29	Moluccas	99 185	49 593
30	North Maluku	82 179	41 090
31	Irian Barat	51 591	25 796
32	Middle Papua	22009	11005
33	East Papua	3747	1874
	Amount	**769 452**	**384 733**

2. Seaweed as Raw Material Biodiesel of Patrol Vessel

The increasing demand for diesel mainly in the transport sector have been demanding the government to diversify the alternative of renewable energy resources. One of them is biodiesel. Biodiesel has combustion properties very similar to petroleum diesel, so it can be used directly on the engine of diesel based without changing the engine. In Indonesia, biodiesel was made from oli palm as the main raw material. However, the land needed for oil palm plantations would be constraints in the utilization of this feedstock. It will make forest conversion to plantations that progressively increased, so the balance of nature and the ecosystem were jeopardized when the land was burn to clear forest area be plantations area. Therefore, for the production of biodiesel advised to use seaweed as its main raw material. The ultilizing of seaweed as biodiesel raw material was an answer to the contradiction in land utilizing between as plantations for biofuel raw materials and as a green open space. The existence of seaweed as an alternative energy resource will not interfere the use of land area.

Table 2. Seaweed production by province per year 2006-2008 (Ton) [9].

Province	2006	2007	2008	% Increase
South Sulawesi	433 180	630 741	690 385	27.5
NTT	478 114	504 699	566 495	8.9
Central Sulawesi	170 236	190 073	208 040	10.6

Province	2006	2007	2008	% Increase
Bali	164 687	152 226	170 860	2.3
Southeast Sulawesi	24 380	81 787	89 510	122.5
NTB	60 043	75 509	84 750	19.0
East Kalimantan	1,547	17 650	19 820	526.6
Moluccas	2,845	16 830	37 590	307.5
Gorontalo	6112	7117	7790	12.9
South Kalimantan	2,406	6058	6,850	82.4
North Sulawesi	6,369	4,241	4,640	12.0
Java Island	24 546	41 546	58 070	54.5
Total	**1374465**	**1728477**	**1.9448 million**	**19.1**

Table 2 shows that an increase of seaweed production per year by 19.1%. When the annual production of seaweed increased Â ± 19%, it can be assumed that the seaweed is the raw material that may be taken into account in an effort to find raw material for biodiesel. Seaweed growth is directly proportional to the needs of diesel can be one measure in an effort to fulfill energy needs.

Indonesian seaweed known has a good quality. This is happened because of the good and true way of cultivation, besides climatic and geographical Indonesia (sun, flow, pressure and water quality and salinity) is suitable with biological seaweed needs to growth. Seaweed is one of the marine plants that belong to the benthic macroalgae are a lot of living inherent in bottom waters. Seaweed is algae that live in the sea and is categorized in Thallophyta division. Seaweed classification based on pigment content consists of four classes, namely green seaweed (Chlorophyta), red seaweeds (Rhodophyta), brown seaweed (Phaeophyta) and seaweed blonde (Chrysophyta).

2.1. Estimated Biodiesel Production of Seaweed

According to research conducted by John[10], that seaweed contains potentially oil as biodiesel, oil is used to obtain the optimization of extraction techniques. Extractors used is hexane, the fatty acids obtained at most that palmitic acid. Palmitic acid is one of the main components of biodiesel. Based on research was conducted by Lemigas, vegetable oil content of the algae contained approximately 30-40%. While the CPO (crude palm oil/palm oil) is only 25%. A total of 5 kg of wet seaweed is expected to produce 2.5 liters of biodiesel. While the productivity of seaweed average of 25 tonnes per ha per crop (harvesting age 2 months)[11]. Then it can be assumed:

25 tonnes per ha per crop = 25,000 kg per ha per crop

5 kg of seaweed = 2.5 L biodiesel

Then in the first harvest;

25,000 kg per hectare per harvest x 2.5 L / 5 kg = 12 500 L / ha per crop

So in one year (6 times the harvests) = 75,000 L per ha per year

Assumptions amount of biodiesel produced is the largest when compared biodiesel from corn feedstock 172 liters per year, and 5,900 liters of palm oil per year. Table 2 If the effective area seaweed cultivation area is 384 733 ha, the total production of biodiesel that can be obtained is 28.854975 billion L / year, this amount is an optimistic assumption when seaweed preferred as raw material for making biodiesel a substitute for diesel fuel.

2.2. The Estimates of Biodiesel Supply for TNI AL Patrol Vessel

KRI require logistical support in the execution of his duties, one of which is the fuel that uses a type of diesel fuel. BBM allocation quota is provided in the form of rupiah, but the number always influence by oil prices of the world and the exchange rate currencies. The increasing of fuel price and the reduction of state budget funds which allocated to the operational activities of the military state resulted in the limited number of fuel. It means the operational of TNI AL patrol vessel will affected. The cost of diesel warships more expensive than normal ships. One unit of frigate warship class which length about 100 m needs 900 million diesel for the full day sail. The cost of diesel will increase if the area patrol vessels extensively [12]. The fuel requirements of each vessel is different. There are boats that require 15 tons of fuel every hour, so as to be able to patrol 24 hours a day, 300 tons of fuel required for a vessel [13].

Period of diesel 0.85 kg / liter

1 ton of diesel = 1.000 kg x 1 / 0.85 kg / liter = 1176.471 liters = 1,176 liters

300 tons of diesel = 352 800 liters

3. Sustainability Analysis (SWOT)

Strength	Weakness	Opportunity	Threats
1. Extensive sea areas 2. The availability of seaweed abundant	1. Lack of fuel logistics patrol vessel 2. Conversion technology seaweed into biodiesel not properly recognized	1. The realization of security in the sea 2. Availability new and renewable of seaweed as biodiesel	1. The threats to maritime security 2. Marine environment for the cultivation of seaweed fluctuating

External/Internal	Strenght	Weakness
Opportunity	S-O To convert seaweed into biodiesel as an alternative fuel patrol vessel	W-O Empowerment of coastal communities about biodiesel from seaweed
Threats	S-T 1. Conduct maritime security operations 2. Seaweed cultivation intensively	W-T 1. Dividing the area patrol 2. Biodiesel as an alternative to diesel fuel

Conclusions

Limitations of fuel as the primary fuel for patrol vessel an obstacle TNI AL in performing its duties. Assumed the use of diesel fuel in the patrol vessel as many as 352.800 L for one day patrol.

The availability of abundant seaweed can be converted into biodiesel, with total biodiesel production of seaweed about 28.854975 billion L/year, it was deemed potentially be an

alternative fuels for TNI AL patrol vessel to support of its efforts to maintain maritime security and stability in Indonesia.
This potential should be developed and supported with policies which related to the utilization of renewable energy in the field of defense.

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The Potency of Microalga Biomass as a Reliable and Environmental Friendly for Alternatives Bioenergy Source at Awur Bay

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Keywords: Microalga, oil fuel, bioenergy.

Abstract. Microalga is microorganism that has lipid content to produce phytofuel. the advantages of using microalgae are produce huge biomass in the short time, not compete with food comodity and reduce the carbon emission. Oil content from microalgae can be used for B20. In this paper presented the potency of microalgae as alternative energy using swot analysis from weakness, strenght, opportunity and threat aspects. according to the result, *Spirullina plantesis* and *Nitzchia palea* can be used as B20 so hopefully it can give the recommendation to Jepara's government to develop microalga as alternatives bioenergy source that it can be useful for society in there.

Introduction

The increasing of energy demand is equivalent with the increasing of human population, in 2007 energy demand increases is about 27% for transportation sector [1]. Microalga oilfuel is one of the option as phytofuel. The benefits of using microalga as biofuel source are produce huge biomass than jarak tree and palm oil [2], has 70% lipid from its body, renewable, environtmental friendly and it can develop along Indonesia's coastline [3]. One of the potential sea in the north java sea is Awur bay that has microalga diversity but it's still not usage optimally. The purpose of this paper is to know the potency of microalga biomass as a reliable and environmental friendly for alternatives bioenergy source at Awur Bay also can give recommendation to Jepara's government about potency of microalga as bioenergy source. Figure 1 shows the location of Awur Bay.

Figure 1. Map of Awur Bay.

Material and Method

This paper using literature study with journal, book and based on the previous research. Data analysis using SWOT method with observing strength, weakness, opportunity and threat to the potency of microalga biomass as a reliable and environmental friendly for alternatives bioenergy source.

Microalga Cultivation

Microalga cultivation method that appropriate with geographical conditions at Awur Bay is open pond which can do by society in there. The advantage use open pond are simply to make and just need sunlight for photosynthesis itself. The pond can be made by wall or fiber. Microalga seeds were taken from Teluk Awur sea by plankton net then identified in Laboratorium and the selected species are Spirulina plantesis and Nitzschia palea. Cultivation need steril sea water with salinity 30-32 ppt [4]. The growth of microalga is affected by many factors such as culture media, nutrition, temperature, pH, salinity and light intensity [5]. The full cultivation media and appropriate nutrition can produce huge biomass with good nutrient. To get the optimum growth of microalga by adding conwy fertilizer as nutrient source [4]. Most of the microalga spesies can live in the temperature between 16 – 35 0C [6]. According to [7] microalga need pH around 7,5-8,5 to grow well. Light is the important factor for microalga to do photosynthesis.According to [8], microalga cultivation need under 10.000 lux for the best result. Lipid is produced highly at exponential phase. Photosynthesis of microalga produce carbohydrate and the excess can storage as a lipid (Amy and Sachari, 2013).

Extraction Oil from Microalga

Microalgae are harvested filtered using a cotton cloth and then pasta as much as 50ml diluted to 100ml with water. Then added 10% H2SO4 30 ml are heated at a temperature of 80 ° C to break the cell walls. And then wait for 3 hours and separate circuitry using a funnel to separate oil and water with sediment. The oil is ready to be used for the manufacture of biodiesel [9]. Figure 2 shows the flowchart of oil extration and biodiesel production from microalgae.

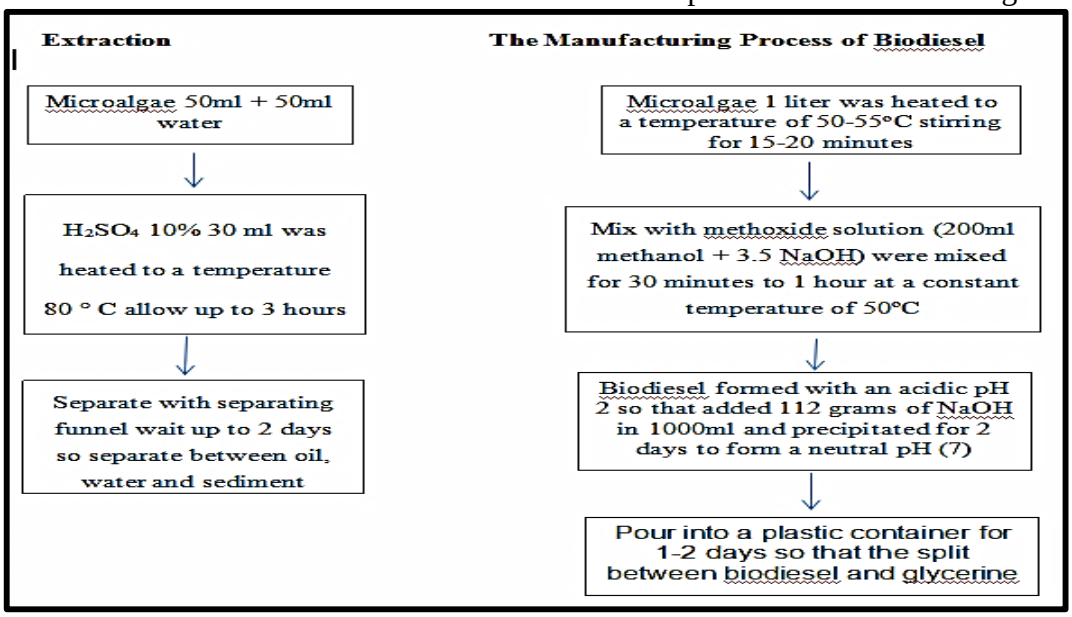

Figure 2. Flowchart of oil extraction and biodiesel production.

The Process of Making Microalga Oil Fuel

Making biodiesel is done by mixing a solution of pasta microalgae that has been heated at a temperature of 50-55^{o}C much as 1 L during 15-20 minutes, then blended for 30 minutes to 1

hour at a constant temperature of 50ºC. The result of such mixing is deposited in a plastic container for 1-2 days so it would separate the glycerin and biodiesel. Results of biodiesel still has a pH 2 (acid) that must be neutralized by adding 112 grams of NaOH in 1000ml precipitated for 2 days to form a neutral pH (7). Then split between biodiesel on the top layer and bottom layer of sediment and make sure only biodiesel are drawn.

Results and Discussion

Microalga Characteristics

The microalga selection based on their abundance at Awur bay, they are Spirulina plantesis and Nitzschia palea. Lipid content of microalga is one of the criteria to select the candidate. Figure 3 shows the abundance of microalgae at Awur Bay according to Hadiyanto et al, 2010.

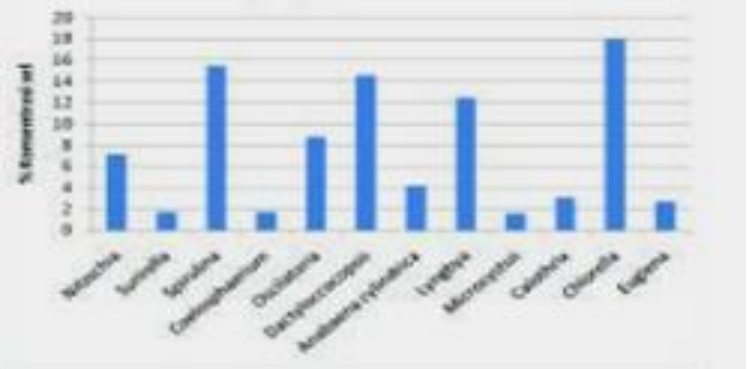

Figure 3. The abundance of microalga at Awur Bay.

Table 1. Lipid content of microalga.

Microalga	**Lipid Content (%)**	**Literature**
Spirulina plantesis	50-74	Simanjuntak, 2014
Nitzschia palea	45-47	Christi, 2007

The morphology of selected microalga

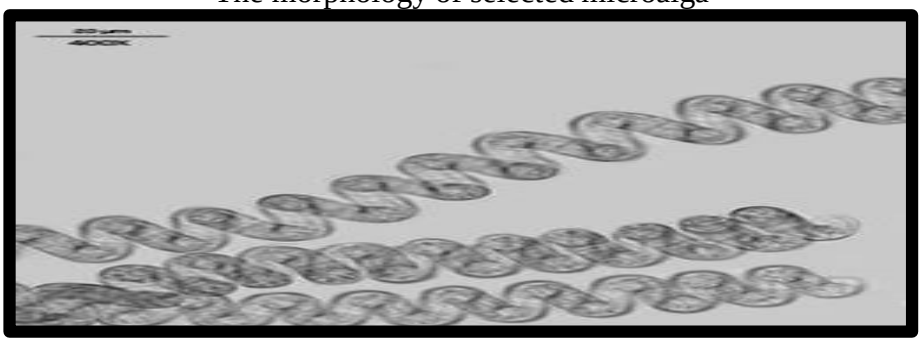

Figure 4. *Spirulina plantesis (studyblue,-).*

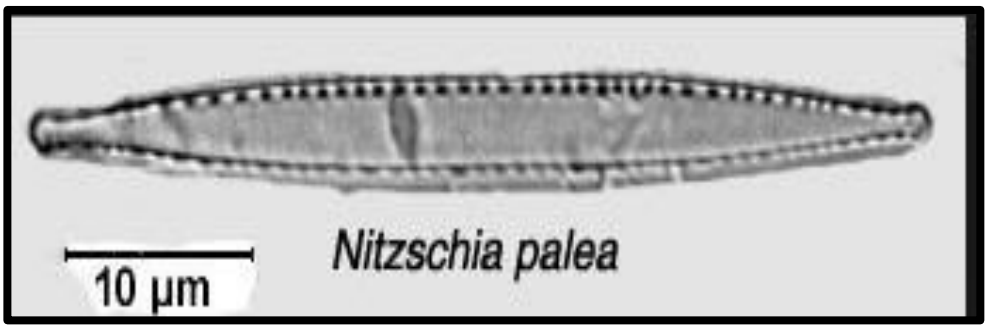

Figure 5. *Nitzschia palea (paleopolis,-).*

Figure 4 shows *Spirulina plantesis* that is blue green alga that live in north java sea. During this time the utilization is only used as animal feed and pharmaceutical industries. Figure 5 shows *Nitzschia* sp that is a single cell phytoplankton, blue green alga that live in sea water or fresh water. The abundance of microalga *Spirulina plantesis* and *Nitzschia palea* should be use maximally to keep their supply in the sea to make sure that they didn't caused blooming alga. The lipid content is produced optimally at exponential phase. The lipid content depends on many factors such as light intensity. Low light intensity is making the growth of microalga become not optimally so they use the energy to survive that caused minimum their lipid content. Otherwise the higher light intensity causing bad impact to photosynthesis process.

Process treatment

Cultivation

Until now, open ponds have been used for large-scale microalgae cultivation considering their simple construction and easy operation. There are various types of ponds, including unstirred, raceway and circular ponds. Unstirred ponds are the most economical due to their simple management and construction. Commercial unstirred ponds are built in natural water ponds of less than half a meter in depth. Unstirred ponds are commercially used for some microalgae species, such as Spirulina plantesis and Nitzschia palea. Although there are many advantages of the open systems, as described above, their limitations are as follows: (1) poor light consumption by cells, (2) evaporative losses, (3) diffusion limitation of CO2 from the atmosphere, (4) large land area requirement and (5) easy contamination by unwanted algae, mold, and bacteria [10]. These limitations can be overcome using translucent plastic covers or greenhouses over the open ponds.

Harvesting

Harvesting should be done at the right time is when the peaks of growth in order to obtain biomass with maximum weights. In general, microalgae can be harvested at days 10-12 with their dark green color [11]. Harvesting can be done in several ways, among others, are chemically by flocculation techniques, mechanically by filtration and centrifugation technology. Harvesting by using flocculation in principle to change the pH of the water so that each cell microalgae will experience van der Waals attraction so that it will form a pool of microalgae with greater mass. So with the force of gravity, the microalgae will go down so easily harvested with a screened using satin fabric to separate the microalgae in water. Harvesting cultivation can also be done using a micro filter that is adapted to the size of microalgae or by centrifugation adjusted between time and speed for each species of microalgae.

Dewatering

The dewatering process requires a number of mechanical thickening methods, such as centrifugation and filtration to reach a total solid matter concentration of about 15 percent [12]. Finally, thermal techniques dry the algae slurry to a higher solid matter concentration of at least

85 percent. Traditional thermal drying techniques, such as shelf spray or drum drying, are energy intensive, however, and may result in a negative energy balance [13]. Despite efforts on efficiency improvement and heat recovery, thermal drying consumes significantly more energy than mechanical solid- 193 liquid separation. An energy efficient and reasonably cheap drying method needs to be developed to make microalgae production attractive.

Extraction

Lipids are one of the main components of microalgae, depending on the species and growth conditions. Microalgae contain lipids at approximately 2–60% of the total cell dry weight. Lipid oils that are derived from microalgae are interesting because these oils contain fatty acids (mostly 16 carbons to 22 carbons in chain length) and triglyceride compounds that can be transesterified into biodiesel. Basically, a two-part process, the hexane solvent method (combined with pressing the algae) extracts up to 95 percent of oil from algae. First, the press squeezes out the oil. Then, leftover algae is mixed with hexane, filtered and cleaned so there's no chemical left in the oil.

The supercritical fluids method extracts up to 100 percent of the oil from algae. Carbon dioxide acts as the supercritical fluid-when a substance is pressurized and heated to change its composition into a liquid as well as a gas. At this point, carbon dioxide is mixed with the algae. When they're combined, the carbon dioxide turns the algae completely into oil. The additional equipment and work make this method a less popular option.

Once the oil's extracted, it's refined using fatty acid chains in a process called transesterification. Here, a catalyst such as sodium hydroxide is mixed in with an alcohol such as methanol. This creates a biodiesel fuel combined with a glycerol. The mixture is refined to remove the glycerol. The final product is algae biodiesel fuel.

The Characteristic of Microalga Oil Fuel

Nitzschia sp has flash point 56,50C, whereas Spirullina plantesis has 48,50C [9]. The result inform that microalga oil fuel is qualify as alternative biodiesel resources. One of the characteristics of biodiesel mixture that pour point which is the point of the fog at the highest temperature at which fuel began to be fog. The lower the pour point, the better is the quality of biodiesel. According to [9] pour point Nitzschia sp -120C lower than Spirullina plantesis. Biodiesel from microalga is qualify as biodiesel B20 with mix 20% biodiesel and 80% diesel fuel.

Table 2. Test result microalga as B20 biodiesel characteristic [9].

No	Checking type	*Spirulina plantesis*	*Nitzschia palea*	Method	Limit point
1	pH	7	7	refraktometer	6-8
2	Flash point ^{0}C	48,5	56,5	ASTM D 93-00	52 min
3	Pour point ^{0}C	18	-12	ASTM D 97-96 a	=
4	Viscosity kinematic at 40^{0}C mm^2/S	1,404	1,256	ASTM D 455-07	1,9-4,1 ASTM 445
5	Colour ASTM	0,5	0,8	ASTM D 1500	=
6	Cetane	49	49	ASTM D 976	40 min

The Reliability and Environmental Friendly of Microalga Oil Fuel as Bioenergy

There are three biofuel generations to subtitute fossil fuel, first generation is biofuel from sugar, powder, oil or animal fat. The second generation is made from non-food tree and the third generation is made from alga (Amy dan Sachari, 2013). The advantages of microalga as biodiesel is just need a few sampel from sea water so it's not disturb the supply in the ecosystem. Microalga as bioenergy source can minimize exhaust gas emission such as NO_3 and SO_4 so it can be reducing air pollution [9]. Furthermore, microalga did not compete with food comodity so the utilizing microalga as bioenergy source is better than use seaweed, corn, sugar cane and other food comodity.

SWOT	Strengths	Weakness
Internal	• The abundance of microalga as raw material. Microalgae have much faster growth-rates than terrestrial crops. the per unit area yield of oil from algae is estimated to be from 20,000 to 80,000 liters per acre, per year; this is 7–31 times greater than the next best crop, palm oil. • The yield of oil productivity of microalgae cultures exceeds than the best oil seed crops, e.g. biodiesel yield of 12,000 liter per hactor for microalgae (open pond production) compared with 1190 liter per hectors for rapeseed (Schenk et al., 2008). • Community development program to make mariculture • Saline water microalgae is potential to be develop due to unlimited medium (sea water) resource and natural nutrients • Microalgae biomass production can affect biofixation of waste CO2 (1 kg of dry algal biomass utilize about 1.83 kg of CO2) [14]. • Nutrients for microalgae cultivation (especially nitrogen and phosphorus) can be obtained from saline water, therefore, apart from providing growth medium, there is dual potential for treatment of organic effluent from the agricultural food industry. Algae cultivation does not require herbicides or pesticides application (Rodolfi et al., 2008) • The blue WF of microalgae biofuels varies between 23 and 85 m^3 GJ^{-1}	• The society did not know the important of phytofuel. • The price is not competed with petroleum • Lack of practical knowledge on microalgae cultivation and harvesting • Low energy profit ratio (EPR) • Variational Lipid Hydrocrbon Production/ Content • High investment

SWOT	Strengths	Weakness
	depending on process and geographic location (Batan et al, 2013) • Assuming the coastal length of 20,000 km by using a width of 1 km coastline (10% -11% of the size that can be achieved) alone, at least provided an area of 2,000,000 hectares. With regard to the productivity of algae in the field 10% of the conditions in the laboratory, obtained a total of deepwater oil production as much as 120 billion liters per year, or 2 million barrels per day	
External	Opportunity	Threat
	• The government rule about diversification energy. • It can be use as biodiesel for fisherman • It did not disturb supply of microalga in the sea • Additional benefit from biomass co-product for aquaculture feeds (high content of protein and carbohydrate) Even with algal species with up to 50% oil content, an additional 50% biomass remains. This biomass fraction contains valuable proteins for livestock, poultry and fish feed additives valued from $800 up to $2500 per ton [15]. • Integrated products of biofuel with aquaculture feed and food industry	• Blooming alga • Low price of fossil energy • It need the skill from the operator • Seasonal weather condition at Awur bay

Strategi S-O (Strenght-Opportunity)

Strategy formulation by considering the strengths of opportunities, among others:
1. The abundance of sea microalgae can be used as a source of biodiesel for fishermen
2. Institutions can support the implementation of policies related to energy diversification and conservation of energy launched by the government.
3. The Society at Awur bay can be utilized for the development of utilization of microalgae as a source of biodiesel.

Strategy S-T (Strenghts-Threats)

The formulation by considering the strengths of threats, among others:
1. The wisely usage of microalga to keep its supply in the sea and to prevent blooming alga.
2. Give training to the society to develop the microalga as biodiesel resource.

Strategy W-O (Weakness-Opportunity)

The formulation of strategies to reduce the effects of weakness to exploit opportunities.

1. Convene inter-agency coordination to unite the goals of achieving energy diversification programs and energy conservation.
2. Conducting community outreach with relevant government policy on energy diversification and energy conservation to instil the importance of the energy mix.
3. The use of microalgae as a source of biodiesel for fishermen who can be supported

Strategy W-T (Weaknesses-Threats)

Strategies to minimize losses due to weaknesses and avoid threats.

1. Establish a mechanism of subsidy to be competitive with the price of fuel.

In the application process of the usage of microalgae oil fuel as a source of bioenergy that are reliable and environmental friendly commitment of stake holders. The government have to support implementation of diversification energy policy according to PP No 79/2014 about national energy policy. In the Paragraph 2 about Priority Developed Energy Pasal 11 Ayat 2 C "The developed energy give priority to local energy resources". The scientist and institutions as a pioneer and developer to make society accept the technology. Businessman are expected to commit and support the implementation of microalgae as a source of bioenergy. The society is needed the awareness of the importance of new energy sources to replace fossil energy.

Conclusions

Oil content from microalga can use as environmental friendly bioenergy resource. So hopefully it can be use as mixed fuel for fisherman in there. According to PP No 70/2009 about conservation energy expected that the role of the central government, local government, businesses, and communities in implementing energy conservation that include the provision, exploitation, utilization, and conservation of resources. So expect this journal can be used as an input to the Jepara's government to be able provide to support in the development of microalgae as a source of bioenergy that can be used by local communities.

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MARINE SYSTEM AND LOGISTIC

Analysis of Integrated Filter Kalman and Acquisition Data System in Maritime Weather Station to Improve Prediction

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Keywords: Kalman Filter; Sensor; Data Acquisition; Maritim Weather; Accurate;

Abstract. Indonesia is a country that most of the residents in livelihoods at the sea. An information system was needed by the fisherman. A maritime weather station has been designed with a real information system. This station consists of hardware and software. The hardware device is the integration of sensors, data transmissions, and microprocessors for storage and data processing. The instrument of measure maritime weather in buoy weather is should be in high accuracy. The true of weather maritime can be obtained by designing a data acquisition system to reduce losses of data information. Acquisition data system manages a packet data of multi sensors by usage of an algorithm in time and measures data update. Kalman filter gives a high accuracy in the result of measurable. The sensors in maritime station respectively are temperature, humidity pressure air, wind speed and direction of speed. Filter Kalman is integrated with acquisition data can reduce an error of data measurable of the temperature sensor, humidity, pressure air, wind speed and the direction of the wind respectively: 0.005^o, 0.061%, 0.033 mBar, 0.155 m/s, 0.0015^o. The accuracy of the predictor in which usage a Kalman filter and an ANFIS predictor for 1 hour later in offline and real-time are 97% and 92% respectively.

Introduction

Indonesia is a country that most of the residents in livelihoods at the sea. As a tropical area which lies on the equator between two continents, two oceans and stretches from 6^o.08' of north latitude to 11^o 15' of south latitude and from 94^o 45' to 141^o 05' of east longitude. The pattern of climate was not well fitted in the certain month since 1991. The rise of sea levels in some parts of Indonesia waters have caused changing of rain pattern in areas of Borneo, Sumatra, Java and Celebes. The accurate forecasting for the present conditions is difficult to be obtained. The forecasting was needed by fisherman and other sea users [1].

A maritime weather station was a result of previous research is consists of 2 station, i.e: buoy weather in sea stations and in the ground station. The two systems are communicated in wireless. Buoy weather is consists of multiple sensors, data management, and data processing. The system sends data in wireless to the ground station The sensors are temperature, humidity, pressure, wind speed, and wind speed sensors. These variables will process in data acquisition, which is collected, processed, and transmitted to the ground station, and display them in monitor system. Data acquisition system is a system that functions to retrieve, process, and display of data as suitable with the real condition. The system converts the physical quantities in the form of a digital signal and processed it in a by a computer.

The instrument system is installed on the floating station consists of multiple sensors, signal conditioning systems, transmitters, a power supply, and the microprocessor. The systems were designed to be able to transmit to the multi-signal sensor to the ground stations in the highest

degree of accuracy. Data transmission of the result was received by a data acquisition system. The output of acquisition data will process in three sub-systems: (1) Predictor systems, (2) Information systems, and (3) Monitoring systems [2]. The instrument of maritime weather has a statics and dynamics property. The characteristic will determine the degree of accuracy of the measurement value.

A measurement system required a high accuracy of the measured values. The accuracy of the measured values is needed for the predictor system. A measurement system has several problems including the noise or interference in the measurement process, and also in transmission data. The technology to improve the sensor values of accuracy requires a significant financial cost. The strategic in the same aim for improving accurate in wich use of a Kalman Filter algorithm.

Kalman filter is a simple method for estimating data of measurement values. This filter estimates the variable state of the process and compares it with measurement value with and without noise in of measurement results. The Kalman filter is expressed in two equations, that are: (1) renewal a time equation (time update), and (2) the renewal measurement equations (measurement update). The renewal time equation determines the future value and future covariant errors based on the present value. This equation is frequently the name of predictor equation, and generate a model equation. The renewal measurement equation combines the estimation and feedback values of observing sensor measurement. This equation is also known a corrector equations. The goal of model equation is correct of actual sensors. This process will produce a better data. The other function of Kalman filter as a calculated algorithm which is used to reduce signal noise or linearization of a nonlinear system [3].

Design a maritime weather in the real system need a statics and dynamics characteristic i.e; high accuracy, high sensitivity, reliable, software supported to process data, sending data in a very short time, and also reject the noise [4]. This paper proposes the use of Kalman filters within the data acquisition system in weather stations. Kalman filter is to reduce the measurement error to be processed in the data-base and also to validate the sensor [5]. Data stored on data-base as input in the predictor system. The method in predictor system is Adaptive Neuro-Fuzzy Inference System (ANFIS) [6]. Performance of the data-base and predictor system will be analyzed which are use and without Kalman Filter.

Method

The design of maritime weather station consists of two stations, i.e: a buoy weather as floating stations and stations on the ground. Both stations are wirelessly connected. The design of stations consists of hardware and software. Hardware is composed of several integrated sensors ie: air temperature, air humidity, air pressure, direction and speed of the wind. These sensors will be connected to the microcontroller to be able to measure weather variables. Software design is performed on the Arduino IDE. This software is used to program the Arduino Mega. The program will process data from sensors and process them in the data-base, and then transmit to the ground station in wireless. Software used in ground stations (computer) is to predict the weather.

The two aims of acquisition data, that are: (1) Data transmission, and (2) data storage. Integration of both is needed in future processing on data based. Figure 1 shows the acquisition data system. The sensor is an analog system, and input of acquisition data is digital value. The Analog to Digital Converter (ADC) is needed to convert analog value to the digital value.

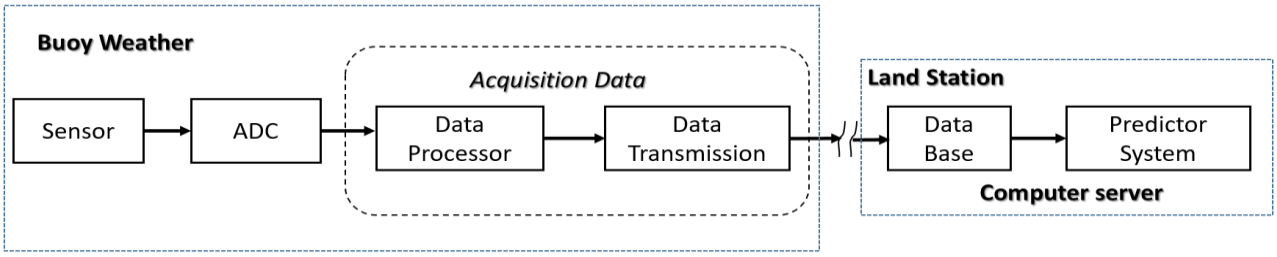

Figure 2. Acquisition data system in maritime weather station.

Integration between hardware and software in acquisition data system is shown in Figure 2. The hardware consist of sensors: (1) Air temperature, (2) Air Humidity, (3) Pressure air, (4) Wind direction, and (5) wind speed.

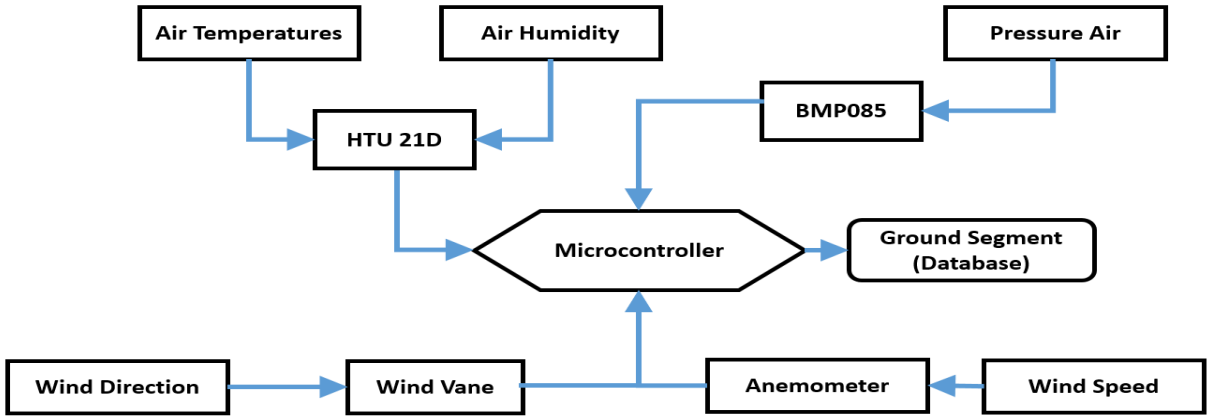

Figure 3. Integrated system of acquisition data on maritime weather station.

The Analysis of Sensor Characteristics

The five sensor have statics and dynamics property as suitable for a good electronic device [7]. The static properties achieved from measuring data in every 10 seconds. The dynamic properties achieve from measuring data in every 10 seconds. The static and dynamic characteristics of the sensor are required to determine sampling time on each sensor. These characteristics are better than the previous research.

The Integrated of Acquisition Data

The integration of data acquisition systems and Kalman filter in the programmed forms in Arduino microcontroller 2560. Figure 2 shows the integration of data acquisition systems in which the algorithm Filter Kalman embedded on it. Transmission wireless of maritime weather station towards to the ground stations (Data Base) use the YS-1020UA transmitters [4].

Design of Kalman Filter

Kalman filter is used to eliminate the effect of noise (error) on the sensor readings in order to get true value in which error is less. Kalman Filter is estimating state variables and comparing to the value of measurement feedback. There are two stages in the Kalman filter algorithm, which are the time updating and measurement updating [8]. The illustration of Kalman Filter in the process of the measurement system is showed in Figure 3.
Equations in time updates or predictions is expressed as follow:

$$\overline{x_k} = A\bar{x}_{k-1} + Bu_k \quad (1)$$

$$\bar{P}_k = AP_{k-1}A^T + Q \quad (2)$$

Equations in measurement updates is shown in equation (3 – 5) below:

$$K_k = \bar{P}_k(\bar{P}_k + R)^{-1} \quad (3)$$

$$\bar{x}_k = \overline{x_k} + K_k\,(z_k - H\overline{x_k}) \quad (4)$$

$$P_k = (I - K_k H)\bar{P}_k \quad (5)$$

In equation 1 – 5, the variables and parameters are:
X_k : The value of measurable variables of sensor
A = matrix system
F = 1 (the output of sensor is not undergoing rapid change)
B = 0 (there is not a action of control)
H = 1 (the output of sensor is only observed)
Q = the value of covariant measurement process
P_k = the value of corrected of covariant process at k time
The two equations in the Kalman filter are predictive and update of the measurement value is described in the block diagram of Figure 3 below.

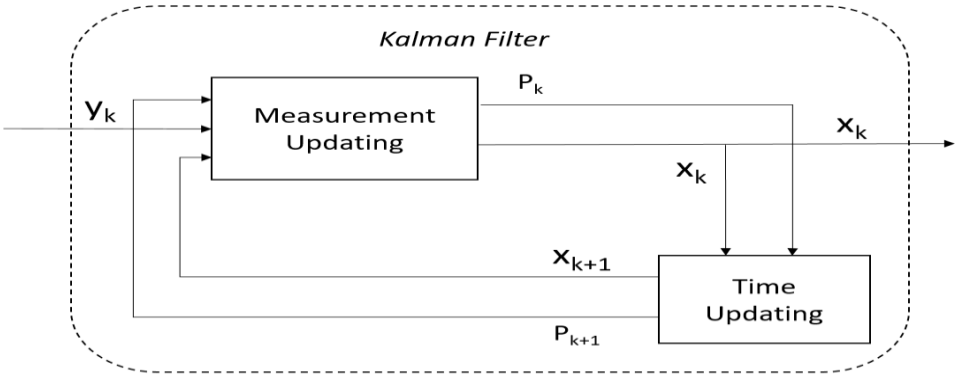

Figure 4. Algorithm of kalman filter in acquisition data of maritime weather system.

Predictor System

The method for weather prediction is ANFIS, with the input are five variables: (1) temperature, (2) humidity, (3) air pressure, (4) wind speed, and (5) wind direction. The five variables are changed in fuzzy variables. ANFIS is the incorporation of the mechanism used a fuzzy inference system in the neural network architecture. The fuzzy inference system used Tagaki-Sugeno-Kang (TSK) first order. ANFIS architecture is designed in 5 layers. The first and fourth layers are adaptive, in which the input parameters in this layer can change in their value. The second and fifth layers are non-adaptive. The second layer is multiplication process of inputs and the fifth layer generates the sum of input. The third layer serves as normalization of output as result of the second layer. The fourth layer is consist of fuzzy rules as a consequence of input values. There are 64 rules [6]. The number of membership functions used transform crisp values into fuzzy is 4, which is different from previuos research.

Figure 4 shows a system of maritime weather as integration between buoy, instrumentation, ground station, and information system. The weather information system is distributed to users using an Android application. There is three variables information: (1) wave height, (2) rainfall,

and (3) wind speed. The three variables are predictive results of the predictor system. The interconnection between predictor system and information system is shown in Figure 5. The 3 of 5 input variables of ANFIS, ie: temperature, humidity, and wind speed are used for predict of rain in the future. The wind speed in the present t and in the time of t – 3 are used for predict of wave height. The function of output predictor of wave height and wind speed shows in the equation 7 and 8. The time of future i in equation of 6-8, is consist of 4 ranges: (1) 07.00 am – 13.00 pm, (2) 13.00 pm – 19.00 pm, (3) 19.00 pm – 01.00 am, (4) 01.00 – 07.00 am.

Rain (i) = f(T_{noon}, RH_{noon}, V_{noon}, …., T_{night}, RH_{night}, V_{night})
(6)

$$H(t+i) = f\big(H(t), H(t-i), V(t)\big)$$
(7)

$$V(t+i) = f(V(t), V(t-i), V(t-2i), V(t-3i))$$
(8)

Equation 7 is predicting the wave height which is developed from the previous research. The wave height for the n time in the later was obtained based on the data of wind speed in the present, the wave height in the present and previous values. Initialization on H (t) and H (t-1) is used to be 0 meters [2]. The result of rainfall and wind speed predictions are not discussed in this paper.

The development of the data acquisition system by implementing the Kalman filter was tested using two stages. The first test for obtaining performance of Kalman Filter. This performance is based on the value of standard deviation all measurement results of the sensor. This phase is carried out in the Laboratory. The second test conducted in the Kenjeran waters in 3 times in August 2016. Each test carried out within 4 hours. The time sampling data is determined by the previous studies. The time sampling is different in each sensor.

The Sensors Characteristic

The experiment used of the system is shown in Figure 4. The input of acquisition data system is the signal of five sensors, and output of acquisition data is connected to the transmitter. Output will transmit to the computer in the ground station. The graph in Figure 3 shows the linearity temperature and wind speed sensors, whereas the humidity sensor is exhibited nonlinear properties. The temperature and humidity are required for rainfall prediction, and wind speed is required for wave prediction. The wind speed sensor has linearity with 93.1% correlation coefficient when velocity value above 2 m / sec.

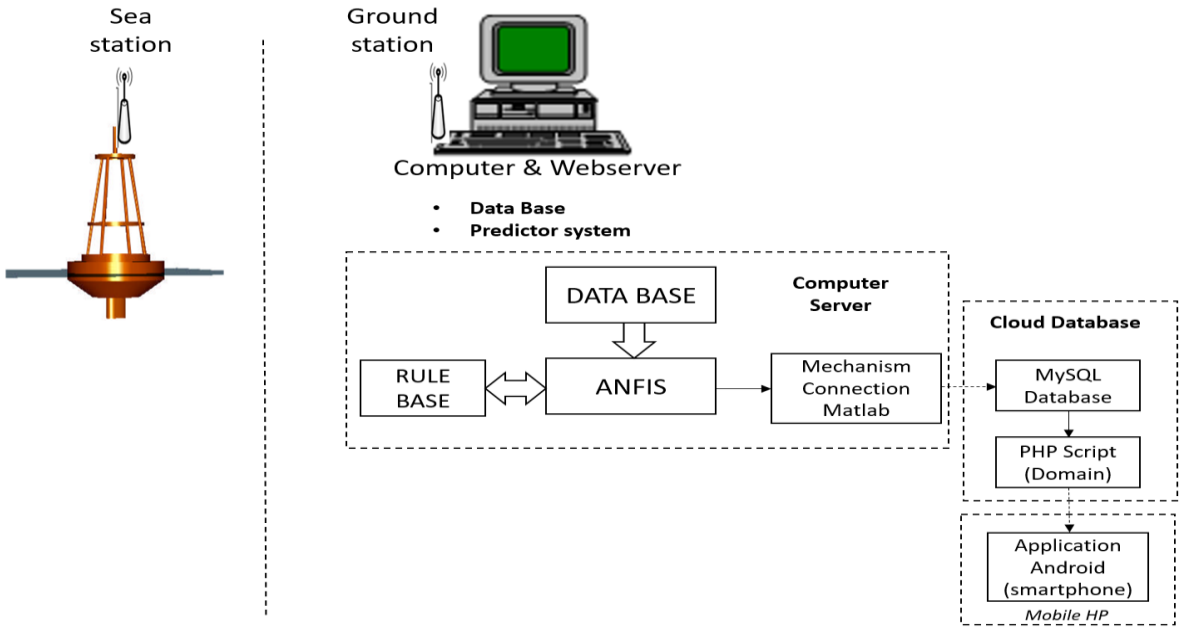

Figure 5. Integration system consists of buoy weather, data-base system, predictor system and information system.

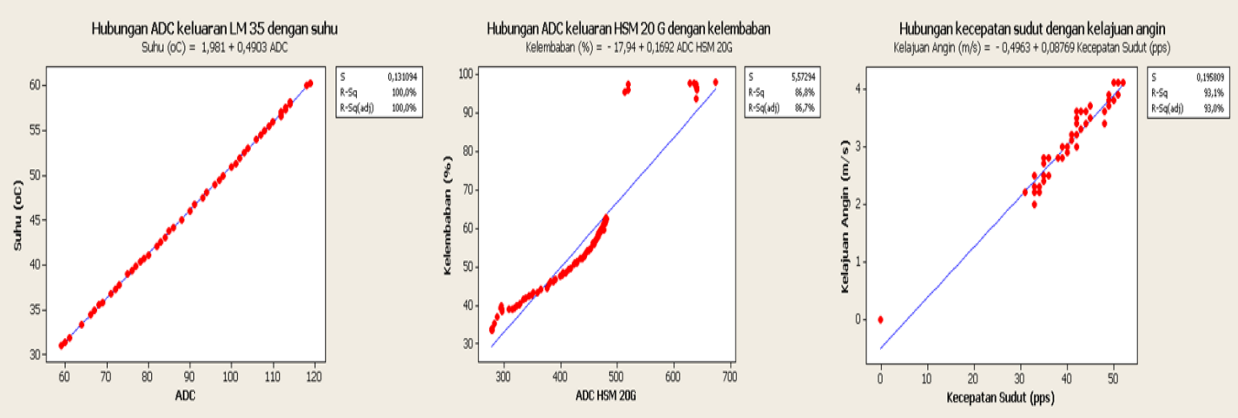

Figure 6. The output of ADC – Analog to Digital Converter sensor (a) Temperature, (b) Humidity, and (c) Wind speed in the maritime buoy weather.

Testing Acquisition Data System without Kalman Filter and Use of Kalman Filter

The testing in 30 data of measurement result of the sensor: temperature, humidity, pressure, wind speed and direction of speed are shown in Table 1. Acquisition data is design in without Kalman Filter. The sensor transmits the actual value directly.

Testing of Filter Kalman performances of five sensors shows in Table 1. The amount of data of each sensor is 12720. The experiment is conducted in Kenjeran waters, on 7.200346^{o}S and 112.8153^{o}E. Wind speed data is used to predict of wave height. The result of mean deviation standard of humidity sensors when using a Kalman Filter in acquisition data system is worst than without Kalman Filter, and better on four other sensors, i.e: Temperature, Pressure air, wind speed and wind direction.

Table 1. The result of testing on 5 sensors in condition without kalman filter.

Measurable Variable (unit)	Without Kalman Filter		Use Kalman Filter	
	Mean Absolute Error	Mean Deviation Standard	Mean Absolute Error	Mean Deviation Standard
Temperature (°C)	3.1340	1.35	0.0084	0.013
Humidity (%)	0.1586	0.07	0.0161	0.1057
Pressure Air (mBar)	0.4986	0.01	0.4863	0.043
Wind Speed (m/s)	0.0387	1.05	0.0140	0.4462
Direction of the Wind (°)	0.5500	23.57	0.01	0.0177

Result of Predictor System

Test of predictor system was conducted in two ways, that are offline and online testing. The offline testing used of data from Agency of Meteorological (BMKG), and the online test in real condition was conducted in Kenjeran waters - East Java. The result of the offline and online test for predict on 6 hours later of wave height is shown in Figure 6 and in numerical accuracy in Table 2 and 3.

Figure 7. (a) The offline test results (Validation of training) of ANFIS predictor for 6 hours later, (b) The online test results of ANFIS predictor for 6 hours later.

Table 2. The result of offline ANFIS prediction

No	Time of Predict (n hours later)	Number of Data	Accuracy (%)	RMSE
1	1	7994	97.273	0.161
2	3	7986	91.635	0.451
3	6	7974	79.634	0.979

No	Time of Predict (n hours later)	Number of Data	Accuracy (%)	RMSE
4	9	7962	68.337	1.526
5	12	7950	65.232	1.701

The accuracy of predicted results decreases with the increase of time either in offline test and real time condition. Predictions in 12 hours later show in a low value of 65.232% and 60.641% both in offline testing and real testing respectively. Offline test results differ slightly with previous research when used fuzzy predictors. The average of accuracy was 98% [6].This was seen when the training test for 1 hour later of prediction is 97.27% (Table 2). While the real test for predicted in 1 later of prediction is 92.05% (Table 3). This accuracy value decreased by 5%. Some of the causes of the decrease in accuracy are: (1) the amount of data in the real test is less than the simulation test, (2) The parameters in the ANN need to be optimized with other techniques [9]. Another possibility of worst in accuracy is static characteristics of the sensor.

Table 3. The result of online ANFIS prediction in real time in Kenjeran waters-East Java.

No	Time of Predict (n hours later)	Number of Data	Accuracy (%)	RMSE
1	1	780	92.051	0.333
2	3	780	88.846	0.562
3	6	780	75.897	1.188
4	9	780	67.949	1.559
5	12	780	60.641	1.673

Conclusions

From the above discussion, some conclusions are as follows:

- Designed maritime weather stations are well-functioned, it is able to measure weather variables and transmit to ground stations, and can predict of wave height for up to 12 hours later.
- ADC characteristics for all sensors have linear properties except wind speed sensors.
- The ADC characteristics for wind speed have linear properties above 2 m / sec.
- The use of Kalman Filter is able to minimize of measurement error of temperature, humidity, wind speed and wind direction sensors.
- High wave prediction results with the ANFIS method show reduced accuracy when the increase of time prediction.

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Semi-Empirical Energy Efficiency Operational as a Basis Performance upon Anchor Handling Tug Supply (AHTS)

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Keywords: Anchor handling tug supply, energy efficiency, ship energy, ship performance.

Abstract. The energy efficiency operational of anchor handling tug supply vessel is presented on this paper. The energy efficiency operational used as a basis performance for the vessel while the energy efficiency operational defines as fuel consumed divided by benefit, and in this case, benefit means mass of cargo carried times to distance moved. Fuel consumed and distance moved as recorded on vessel report, combine with GRT as mass carried, then recorded energy efficiency operational was obtained. The predicted energy efficiency operational was obtained by using Kwon's method that using voyage detail report and present the ship speed loss during voyage, the predicted time for each voyage was obtained as well as fuel consumed .By comparing between the recorded and predicted energy efficiency operational, the uncertainty related ship performance presented as percentage of the error. The error may assist ship owner or operator to determine the vessel performance for further works and suitable fuel saving method. The study shown that for newly built AHTS for one year operation, the error percentage increasing as a function of operation time, it's about 2.081% difference from the first voyage to a year operational. The percentage error represents the engine and hull degradation.

Introduction

Since Marpol take into force of Energy Efficiency Design Index (EEDI) and Ship Energy Efficiency Management Plan (SEEMP) at 1 January 2013, combined with the growth of offshore supporting vessel which is anchor handling tug supply (AHTS) vessel has the higher growth, the energy concern of AHTS become more real.

Assess ship performance depend on how detail that needed. Ship performance review using pyramid view, but commonly, ship performance consists of machinery performance and hull performance. Ship is driven by using engine, the engine power distributes to propeller to produce thrust. The final result of propeller thrust is ship's speed. Overall, the ship performance is the relationship between fuel consumed and ship's speed.

Determine ship performance involve the environment effect on ship during operation. Fuel consumption for each voyage or operation will be different, depend on environment condition. Environment effect approached by using speed loss due to added resistance, comparing the ship's speed for various environment condition with desired ship's speed.

Ship's speed loss is a function of weather direction relative to ship course, ship's block coefficient, loading condition and Froude number, and the function of ship shape. Speed loss coefficient due to weather condition is also based on Beaufort number (BN), where BN represent the wind speed that observe the sea condition.

Ship resistance will increase as a function of operational time until dry docking. Hull roughness is the main cause of the increased resistance. Ship resistance increase about 2% for 30μm increase of hull roughness. Ship performance assessment involve the time function related to increased resistance due to increased hull roughness [1].

Talking about ship performance will involves wide range of knowledge, based on technical, engineering, operational and commercial optimization. The ship energy optimization takes a big role to lead the environment protection as mentioned in Marpol. The operational optimization such as hull and propeller performance optimization, main engine performance optimization, cargo heating management, route optimization and trim optimization. Technical optimization mention about Propeller boss cap fin (PBCF), CPP programming, fuel slide valve upgrade, cylinder oil consumption optimization and sonic cleaning of economizer. Slow steaming and speed and fuel consumption matrix is part of commercial optimization. Hull coating and dry docking management is a part of energy optimization [2,3].

Energy efficiency operational index (EEOI) is a tool that utilize to represent the use of energy on board dependent from the benefit that given by the ship. The using of EEOI is widely for all type of ship and the EEOI as a basic ships performance. The calculated EEOI and actual EEOI can predict the uncertainty of ships during operational, this value shown the gap that can be improved by optimization process [4].

Marpol has published the statement related EEOI [5]

$$EEOI = \frac{Fuel\ Consumed(tonnes)\ x\ fuel\ to\ CO_2\ Conversion\ factor}{mass\ of\ cargo\ carried\ (tonnes)\ x\ distance\ moved\ (nautical\ miles)} \quad (1)$$

Sea State

The prediction of actual ship speed at actual sea condition has become more attractive and more method can be applied to approaches the effect of sea condition on ship. Added resistance approached by many methods involves sea state such as wave, wind and also ship direction. The added resistance due to sea condition caused the speed loss of the ship. The most common approach of speed loss due to added resistance is Kwon method that involves ship technical, ship operational and sea state [6]. The sea state measured as Beaufort Number (BN) that represents the wind speed and sea condition as shown at Table. 1.

Table. 1. Beaufort Number (BN).

BN	Description	Wind Speed	Wave height	Sea conditon	Pic
0	Calm	<1.1 km/h <0.7 mph <0.6 knot <0.3 m/s	0 m 0 ft	Flat	
1	Light Air	1.1 - 5.5 km/h 0.7-3.4 mph 0.6 - 3 knot 0.3 - 1.5 m/s	0 - 0.2 m 0 - 1 ft	Ripples without crest	
2	Light Breeze	5.5 - 11.9 km/h 3.4- 7.4 mph 3 - 6.4 knot 1.5 - 3.3 m/s	0.2 - 0.5 m 1 - 2 ft	Ripples without crest	
3	Gentle Breeze	11.9 - 19.7 km/h 7.4 - 12.2 mph 6.4 - 10.6 knot 3.3 - 5.5 m/s	0.5 - 1 m 2 - 3.5 ft	large wavelets. Crest begin to break.	
4	Moderate Breeze	19.7 - 28.7 km/h 12.2 - 17.9 mph 10.6 - 15.5 knot 5.5 - 8 m/s	1 - 2 m 3.5 - 6 ft	Small wave with breaking crest.	

Table. 1. Continued.

BN	Description	Wind Speed	Wave height	Sea conditon	Pic
5	Fresh Breeze	28.7 - 38.8 km/h 17.9 - 24.1 mph 15.5 - 21 knot 8 - 10.8 m/s	2 - 3 m 6 - 9 ft	Moderate waves of some length.	
6	Strong Breeze	38.8 - 49.9 km/h 24.1 - 31 mph 21 - 26.9 knot 10.8 - 13.9 m/s	3 - 4 m 9 - 13 ft	Long wave begin to form, white foam crest	
7	High Wind, Moderate gale, near gale	49.9 - 61.8 km/h 31 - 38.4 mph 26.9 - 33.4 knot 13.9 - 17.2 m/s	4 - 5.5 m 13 - 19 ft	Sea heaps up. Some foam from breaking waves is blown into streaks along wind direction.	
8	gale, Fresh gale	61.8 - 74.6 km/h 38.4 - 46.3 mph 33.4 - 40.3 knot 17.2 - 20.7 m/s	5.5 - 7.5 m 18 - 25 ft	Sea heaps up. Some foam from breaking waves is blown into streaks along wind direction.	
9	Strong / severe gale	74.6 - 88.1 km/h 46.3 - 54.8 mph 40.3 - 47.6 knot 20.7 - 24.5 m/s	7.5 - 10 m 23 - 32 ft	High waves whose crests sometimes roll over. Dense foam is blown along wind direction.	
10	Storm, whole gale	88.1 - 102.4 km/h 54.8 - 63.6 mph 47.6 - 55.3 knot 24.5 - 28.4 m/s	9 - 12.5 m 29 - 41 ft	Very high waves with overhanging crests. Large patches of foam from wave crests give the sea a white appearance.	
11	violent storm	102.4 - 117.4 km/h 63.6 - 72.9 mph 55.3 - 63.4 knot 28.4 - 32.6 m/s	11.5 - 16 m 37 - 52 ft	Exceptionally high waves. Very large patches of foam, driven before the wind, cover much of the sea surface.	
12	Huricane	>= 117.4 km/h >= 72.9 mph >= 63.4 knot >= 32.6 m/s	>= 14 m >= 46 ft	Huge waves. Sea is completely white with foam and spray. Air is filled with driving spray, greatly reducing visibility.	

Method

Operational data needed to assess the ship performance. The data include fuel consumption, environment data, and passage plan. As well as operational data, the ship technical data also needed.

Recorded fuel consumption and distance sailed, combined with ship technical data, the energy efficiency operational is obtained. The empirical energy efficiency operational is obtained by include environment data into the speed loss calculation and estimated fuel consumption for certain voyage.

The weather direction is relative to ship course / ship heading direction. The ship heading direction measured clockwise in degrees from 0^o to 359^o. Weather angle / encounter angle divided into four categories, head sea, bow sea, beam Sea, and following sea.

In this study, the Anchor Handling Tug Supply (AHTS) vessel will be presented with specific technical data. The energy efficiency operational can be calculated and compared to the predicted value with sea state consideration, while the variable defines as:

$$\frac{\Delta V}{V_1} 100\% = C_\beta C_U C_{Form} \quad (2)$$

$$C_u = 2.4 - 10.6F_n - 9.5F_n^2 \quad (3)$$

and C_β defines as on Table. 2.

Table. 2. C_β Coeficient.

Weather Direction	Encounter angle (deg)	Direction reduction coefficient C_β
Head sea and wind	0-30	$2C_\beta = 2$
Bow sea and wind	30-60	$2C_\beta = 1.7 - 0.03((BN - 4)^2)$
Beam sea and wind	60-150	$2C_\beta = 0.9 - 0.06((BN - 6)^2)$
Following sea and wind	150-180	$2C_\beta = 0.4 - 0.03((BN - 8)^2)$

and C_{form} defines as:

$$C_{form} = 0.5BN + BN^{6.5} / (2.7\Delta^{2/3}) \quad (4)$$

Ship Particular

Case study present newly built AHTS vessel for one-year operational data. Passage plan, fuel consumption, ship heading direction, weather condition, and other technical data of ship is used as a basic data to calculate the recorded EEO and predicted EEO.

Table. 3. Ship particular.

Ship's Name	Year Built	Dimension				GRT (Tonnes)	DWT (Tonnes)	Main Engine (BHP)	Speed (knot)
		L OA (m)	Bradth (m)	Depth (m)	Draft (m)				
BNI Castor	2012	59.25	14.95	6.1	4.95	1678	1340	2x2575	13

Figure. 1. BNI Castor.

Result and Discussion

The calculation step for recorded EEO and predicted EEO involves all the data, vessel data, weather data and operational data. Table. 4 show the calculation process of predicted EEO for one voyage.

Table. 4. Recorded EEO.

Dist	Course	Wind			Encounter Angle		BN	C_β	C_{form}	ΔV/V1 100%	V_2 (knot)	Time (h)
	(°)	Direction	(°)	Speed	(°)	direction						
1.4	175	SE	135	16	140	Beam Sea	5	0.42	63.0439504	37.07	8.18	0.17
2.7	141	SE	135	16	174	Following Sea	5	0.065	63.0439504	5.74	12.25	0.22
4.4	90	SE	135	16	45	Bow Sea	5	0.835	63.0439504	73.69	3.42	1.29
3.1	125	SE	135	16	170	Following Sea	5	0.065	63.0439504	5.74	12.25	0.25
5.7	144	SE	135	16	171	Following Sea	5	0.065	63.0439504	5.74	12.25	0.47
34.2	188	SE	135	18	127	Beam Sea	5	0.42	63.0439504	37.07	8.18	4.18
34	170	SE	135	18	145	Beam Sea	5	0.42	63.0439504	37.07	8.18	4.16
108.7	203	SE	135	14	112	Beam Sea	4	0.33	16.1956626	7.48	12.03	9.04
95.6	293	SE	135	14	22	Head Sea	4	1	16.1956626	22.67	10.05	9.51
284.5	276	SE	135	16	39	Bow Sea	5	0.835	63.0439504	73.69	3.42	83.19
64	328	SE	135	11	13	Head Sea	4	1	16.1956626	22.67	10.05	6.37
147.5	312	SE	135	12	3	Head Sea	4	1	16.1956626	22.67	10.05	14.67
195	304	SE	135	14	11	Head Sea	4	1	16.1956626	22.67	10.05	19.40
36.2	282	SE	135	16	33	Bow Sea	5	0.835	63.0439504	73.69	3.42	10.59
4.8	342	SE	135	11	27	Head Sea	4	1	16.1956626	22.67	10.05	0.48
15	331	SE	135	11	16	Head Sea	4	1	16.1956626	22.67	10.05	1.49
8.8	314	SE	135	11	1	Head Sea	4	1	16.1956626	22.67	10.05	0.88
4.4	360	SE	135	11	45	Bow Sea	4	0.85	16.1956626	19.27	10.49	0.42
4.2	329	SE	135	11	14	Head Sea	4	1	16.1956626	22.67	10.05	0.42
											Total	167.18

Fuel Rate	520	Liter/hour	
Total Fuel Consumed	86,932.95	liter	69.55 ton
Total Distance	1054.2	nm	
Energy Efficiency Operational (EEO)	0.065970742	ton/nm	

The predicted EEO compared with recorded EEO will produce an error that represents the ship performance uncertainty. Table 5 shows the comparison of recorded and predicted EEO for one year operational period.

Table. 5. Recorded and predicted EEO.

Voyage	Date	Fuel Consumption		Distance (NM)	estimated Time (hours)	Speed (knot)	Actual time	Ave. Speed	Energy Efficiency Operational (EEO)	Predicted EEO	Error (%)
		Ltrs	tonnes								
1	27 August - 3 Sept 2013	90,290	72.232	1,054.20	150.0	7.0	163.0	6.5	6.85E-02	6.60E-02	3.862%
2	7 -13 Sept 2013	70,190	56.152	1,009.50	136.0	7.5	159.0	6.3	5.56E-02	5.32E-02	4.555%
3	22 -28 Sept 2013	75,342	60.274	1,094.50	107.5	7.5	157.5	6.9	5.51E-02	5.23E-02	5.278%
4	8 -13 Dec 2013	99,490	79.592	1,126.20	110.0	10.5	128.0	8.8	7.07E-02	7.47E-02	5.438%
5	25 - 27 Feb 2014	27,690	22.152	503.30	67.0	7.5	66.0	7.6	4.40E-02	4.66E-02	5.47%
6	27-Jul-14	9,020	7.216	223.90	28.0	8.0	29.3	7.7	3.22E-02	3.74E-02	5.84%
7	6 - 9 August 2014	28,958	23.166	563.70	70.5	8.0	71.8	7.9	4.11E-02	3.88E-02	5.943%

As shown on Table. 5, the first voyage is on August 2013 and end at August 2014 for one year operational period. The comparison of recorded EEO and predicted EEO gives an error. Fig. 3 represent the error of EEO as a function of voyage or in other word in a function of time.

First voyage generate EEO value about 0.0685 ton/nm as recorded value, and about 0.066 ton/nm or predicted EEO value. This forst EEO valus has an error about 3.862%. one year later, the recorded EEO value is 0.0411 ton/nm, 0.0388 ton/nm for predicted value and 5.943% of error.

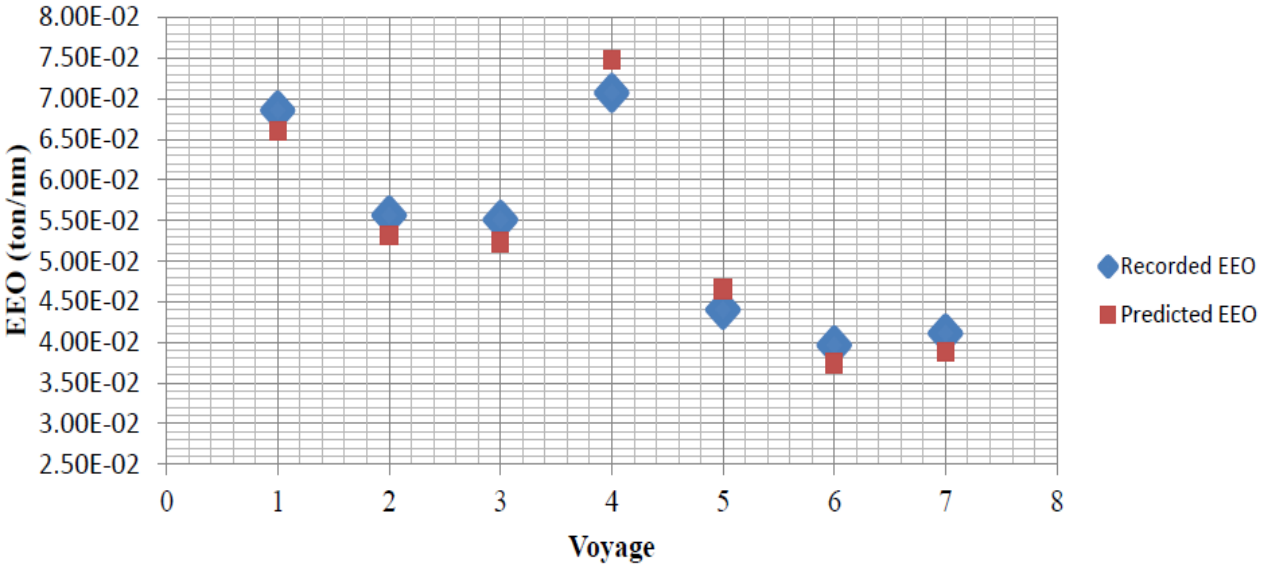

Figure. 2. Recorded and predicted EEO.

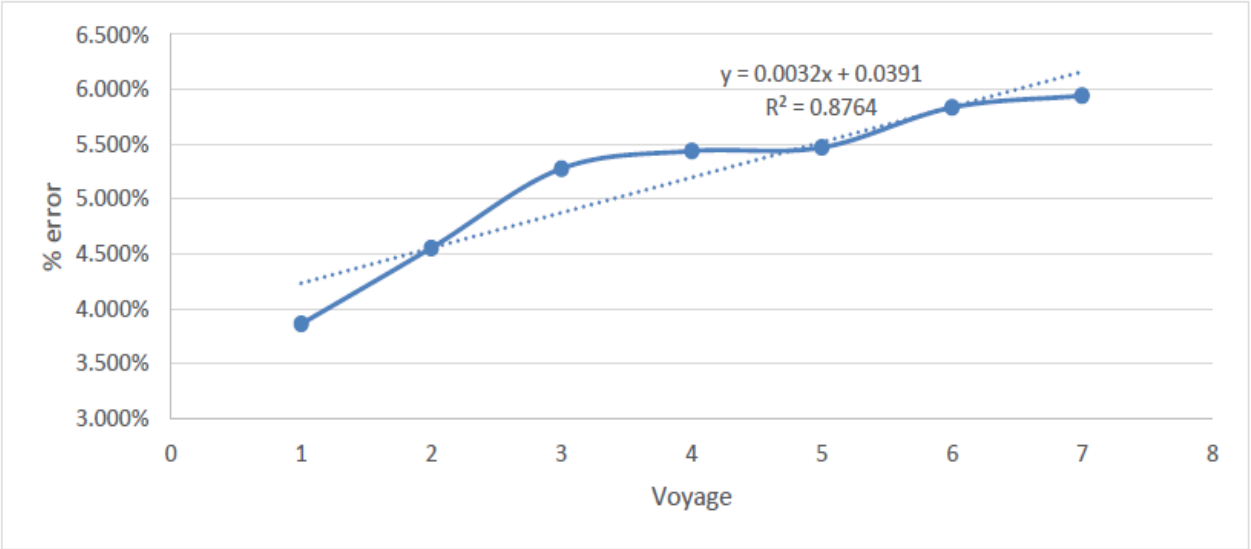

Figure. 3. EEO error.

Overall error for one year operation period indicates that the error increasing as function of operational time. In one year period, the error difference is about 2.081%, its mean that the uncertainty of ship performance in other word, the error represent the hull and engine degradatin about 2.081% a year.

Conclusion and Future Works

This study was conducted to find a basis performance of an anchor handling tug supply based on recorded and predicted energy efficiency operational. The comparison between recorded and predicted energy efficiency operational shown that the differences error for a 59.25 m LOA of AHTS vessel is about 2.081% for one-year operational period. Various ship ages, operational periods and operational mode, maintenance, dry docking schedule, and also another data related technical, engineering, operation and environment included management were needed to give more variable related ship performance. The differences error used as basis to optimize ship speed reduction by conduct simulation that produce minimum fuel consumed for given distance and environment condition. The improvement of ship performance is based on this particular method.

Acknowledgements

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Spare Part Inventory Policy with Reliability Approach (Case Study: PT. XYZ)

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Keywords: spare part, excavator, failure, replacement, reliability, availability, critical spare part, inventory.

Abstract. PT. XYZ is leading company specialize in mining and heavy equipment. It rents excavator, dump truck, and tractors. PT. XYZ has Doosan with three types, namely Doosan 500 (50 tons), Doosan 340 (30 tons), and Doosan 220 (20 tons). The excavator spare part lifetime is unpredictable and its long lead time vendor that causes PT. XYZ to keep ordering spare part in uncertain quantity, so sometimes PT. XYZ had experience shortage and excess spare part inventory and it can lead to profit loss. This problem lies in PT. XYZ, spare part needs is triggered by failure and replacing management. It means that the spare part condition is necessary and becomes the main consideration to manage spare part availability. This research is carried by employing critical spare part availability based on tools condition. Reliability approach and availability management are employed to contribute PT. XYZ improvement.

Introduction

A good maintenance system is influential towards company sustainability, mainly that it effects the flow production process. The flow of production process requires machines and production tools in good condition. In order to maintain a favorable condition that machines could function properly, maintenance is a necessary. If machines were not maintained well, a further defect would be discovered that results to higher cost for larger maintenance or even to replace defective spare parts. Replacing spare part requires spare parts availability in inventory and it is crucial asset for quantity and category seen from investment/ capital it consumes. In inventory management, if the control fails, it can cause loss profit to company.

In mining industry, heavy equipment such as excavator, dump truck, tractor, etc are important equipment. This heavy equipment has a unique characteristic that requires high maintenance [3], there are:

1) Need high investation so that Return of Assets (ROA) must be high
2) Made of complex technology and spare part.
3) Need high availability because it uses almost 24 hours non stop
4) Have a long lifetime

Heavy equipment availability depends on good maintenance from the owner. Heavy equipment unavailability can be caused by two cases, namely a corrective maintenance and a preventive maintenance action.

The problem existed in PT. XYZ is spare part inventory management. Spare part needs can be triggered with failure event and replacement activity. It means equipment condition should become main consideration to manage spare part inventory. This research will be conducted using critical spare part inventory based on equipment condition. Reliability approach and inventory management will be used at the same time to give solution how to manage optimal spare part inventory in PT. XYZ.

Iriani and Rahmadi [5] conduct research on bus's maintenance based on reliability critical inventory on Perum Damri Bandung. The research aims to determine the level of reliability bus spare part has before it's broken apart. Jaarsveld and Dekker [7] explain that there are components which are stored, shortage cost of each component or minimum fill rate is the key factor. In order to finish the problem estimating the shortage cost or minimum fill rate on component availability, they employ data collected from Reliability Centered Maintenance (RCM) which is collected by Gu et al [4] is study case of airplane industry. This research is focused on solving problem on maintenance cost by minimizing the component availability cost on airplane industry to achieve maximum productivity. Jaarsveld et al [6] conducts research using formula of integer programming (Column Generation) and policy (s,S) to improve component availability control of airplane's hangar. The research conducted at the moment is spare part inventory excavator Doosan S500 by considering preventive replacement upon PT. XYZ.

Methods

Optimum Preventive Replacement Interval with Reliability Approach

According to Jardine [8], an equipment has a spare part that is easy to broken and must be replace often. When it occurs too often, it will cause high cost of buying spare parts. This problem can make big profit loss because when spare part replaced, it needs additional cost to cover that replacement activity. Preventive replacement is important maintenance activity to avoid failure and it can reduce profit loss. One of replacement policy is preventive replacement age of equipment, it means doing preventive replacement when the equipment has reached some age (tp) and doing replacement when it fails [1]. This replacement policy can be seen in Figure 1 [8].

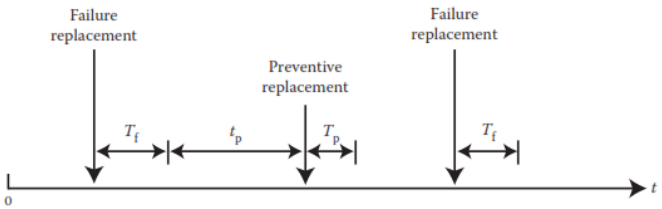

Figure. 1. Replacement Policy.

Replacement model from this policy aims to determine optimal spare part replacement lifetime and it can minimize replacement total cost expectation per unit time - C(tp). The equation is:

$$C(tp) = \frac{C_p \times R(t_p) + C_f \times \left[1 - R(t_p)\right]}{\left(t_p + T_p\right) \times R(t_p) + \left[\left(M(t_p) + T_f\right) \times \left(1 - R(t_p)\right)\right]}$$

dimana:

C_p = Preventive replacement cost per cycle
C_f = Corrective replacement cost per cycle
$R(t_p)$ = Reliability in periode t_p
$R(t)$ = Reliability in periode t
$M(t_p)$ = length of failure cycle expectation
t_p = preventive replacement interval
T_p = replacement time for doing preventive replacement (company policy)
T_f = replacement time for doing corrective replacement (company policy)

Preventive Replacement Spares

The aims from preventive replacement spares [8] is to forecast spare part that will need for replacement in some periode. This will be useful for the company because it can optimize order cost and holding cost that can be used for replacement. There are two models that will be used in preventive replacement spares, the constant interval model and the age - based preventive replacement model, but this research only use the last model.

$$EN\left(T,t_p\right)=\frac{T}{t_p\times R\left(t_p\right)+M\left(t_p\right)\times\left[1-R\left(t_p\right)\right]} \tag{2}$$

Where :

$R\ (t_p)$ = probability of preventive cycle

$M\ (t_p)$ = MTTF (Means Time To Failure)

$1 - R(t_p)$ = probability of a failure cycle

Average Spare part Requirements (N)

Average Spare part Requirements (N) used for determine amount of spare part that will be used in optimum replacement interval. The equation is:

$$N=\frac{t\times R(s)+t\times\left[1-R(s)\right]}{\int_0^s R(t)dt} \tag{3}$$

Where:

s = optimum replacement interval

EOQ (Economic Order Quantity)

For determine amount of optimal order spare part for inventory, it used EOQ equation like shown below in equation 4 [2]:

$$Q^*=\sqrt{\frac{2\times D\times OC}{H}} \tag{4}$$

Dimana :

D = Demand

OC = Order Cost

H = Holding Cost

Result and Discussions

Data processing is used to get research main aims, to optimize amount of spare part requirement in 1 year to avoid shortage or excess in inventory that can cause profit loss for PT. XYZ. Some spare part from excavator Doosan S500 will determine which spare part is critical. The criteria that is used to find critical spare part are frequent replacement of spare part. From data processing with pareto chart, it obtains critical spare part Doosan S500,that are bucket adapter, cylinder arm, motor starter and swing motor.

Table. 1. Doosan S500 critical spare part.

No.	Spare part	Distribution	Parameter		MTTF (hours)
			Beta (β)	Eta (η)	
1.	Bucket Adapter	Weibull 2	8,2121	742,2144	699,8557
2.	Cylinder Arm	Weibull 2	14,694	2203,9433	2126,87
3.	Motor Starter	Weibull 2	7,4553	1667,8435	1565,2025
4.	Swing Motor	Weibull 2	5,0833	3258,4785	2994,6831

In determining optimal spare part replacement interval or optimal spare part preventive replacement interval, mathematical models is used with minimize spare part replacement expectation cost nor spare part preventive replacement expectation cost criteria. Replacement expectation total cost consists of preventive replacement cost (*Cp*) and corrective replacement cost (*Cf*) per cycle. From that costs, it is divided into labor cost, lost production cost and spare part price. After it get results from the calculation *Cp* and *Cf* (shown in Table. 2), then optimal replacement interval calculation can be done.

Table. 2. Preventive replacement cost (*Cp*) and corrective replacement cost(*Cf*).

Spare part	***Cf* (Rp.)**	***Cp* (Rp.)**
Bucket Adapter	105.120.000	55.860.000
Cylinder Arm	151.330.000	52.510.000
Motor Starter	32.560.000	61.860.000
Swing Motor	83.690.000	79.860.000

Table. 3. Optimal spare part replacement interval.

Spare part	**MTTF (hours)**	**Calculation**		**Existing**	
		tp	***C(tp)***	***Tp***	***C(tp)***
Bucket Adapter	699,86	593	105.653.389	2000	145.200
Cylinder Arm	2126,87	1767	31.696,696	2000	37.020
Motor Starter	1565,20	3000	20.793,44	2000	21.190
Swing Motor	2994,68	5000	27.614,167	2000	40.350

After optimal spare part replacement interval value obtained as shown in Table. 3, then compared with MTTF value for each spare parts. InTable. 3 some critical spare parts have tp < MTTF. This is because in short interval preventive replacement cost will be greater then corrective replacement cost, while in the interval approached MTTF, the corrective replacement cost will be greater because the spare parts will be failure often. Preventive replacement cost and corrective replacement cost will reach a minimum when interval tp. Therefore replacement spare part do after spare part reach interval tp. For motor starter spare part have MTTF < **tp** < tp exsisting (PT. XYZ maintenance policy), then the replacement should be when spare part lifetime reach MTTF, while the swing motor spare part have tp exsisting (PT. XYZ maintenance policy) < **tp** < MTTF, then the replacement should be when spare part lifetime reach tp exsisting (PT. XYZ maintenance policy).

The value of tp is used for determine spare parts amount requirement (Eq. 2) and optimal spare part order amount (Eq. 4). The calculation result show in Table. 4.

Table. 4. The optimal spare part order amount and spare parts amount requirement.

Spare Part	Q* (EOQ) (in unit)	Q* (Reliability) (in unit)	Q Existing (in unit)	Requirement Amount (in unit)
Bucket Adapter	17	17	12	66
Cylinder Arm	5	7	3	6
Motor Starter	6	7	1	8
Swing Motor	5	5	1	5

We can see that Q for existing condition is more small from Q* for 2 methods (EOQ and Reliability) due to the order is not made based on failure data calculation that occurs, but it was from the warehouse employee experience. The cost is also less when it order in existing condition, but this cost has not been accumulated with lost production cost when replacement activity happened and have run out of spare parts. Meanwhile, inventory management with EOQ and Reliability methods have calculated lost production cost and optimum spare part replacement interval.

Conclusion

After comparison between inventory management based on EOQ, reliability and existing condition, then the recommendation for PT. XYZ is inventory management based on EOQ or reliability. Although the spare part requirement amount is more from existing condition, this research concluded that with use 2 methods, the spare part requirement more closer to real conditions. This is due to inventory spare part calculation based on time of optimal replacement interval and MTTF that obtained from data collection for critical spare part.

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Selection of Propulsion Systems for Naval Patrol Trimaran Vessels between the Hybrid Shaft Generator and Mechanical Propulsion System

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Keywords: Hybrid shaft generator propulsion system, mechanical propulsion system, trimaran patrol boat, engine propeller matching simulation.

Abstract. A hybrid shaft generator propulsion system has high operational flexibility, so its use is more appropriate to the ships that have varying operational speed, such as trimaran naval patrol. The patrol ship has five operation speed variation, namely trolling 5 knots, slow patrol 12 knots, economic patrol 18 knots, high speed patrol 24 knots and chase 30 knots. The selection of a trimaran patrol boat propulsion system, between hybrid shaft generator or mechanical propulsion system, is based on the result of technical and economis analysis for the five service speeds. According to the analysis result, the hybrid shaft generator propulsion system tends to have 2% higher investment cost but potential 60% lower operational cost compared to mechanical propulsion system. Therefore, the use of hybrid shaft generator propulsion system on trimaran naval patrol is more advantageous than the mechanical propulsion system.

Introduction

At this time, the selection of propulsion system for naval patrol vessels base on traditional criteria, namely ship speed requirements, shock capability, noise reduction, and infrared signature. As for the propulsion system choices for modern naval patrol vessels, there are some additional criteria, such as change in operation requirements, greater range of speed, added mission flexibility, longer periods away from base with smaller crews, and cleaner emissions.[1] Therefore, the service speed of naval patrol vessels becomes more varied. If the previous naval patrol vessels only have three service speeds, then the next generation has five service speeds with a wider distance. The five-speed service is trolling, slow patrol, economic patrol, high speed patrol and chase speed.[2, 3].

At present, most naval patrol vessels use mechanical propulsion systems and using two main engines. Because she has only two or three service speeds and the speed range is not too wider. In consequence of additional criteria in propulsion system choice, in this paper will analyze comparation between hybrid shaft generator (HSG) propulsion system and mechanical propulsion system to be used in naval patrol trimaran vessels.[4 - 7] The analyzing of propulsion system selection is based on technical and economical consideration in five service speeds, that is 5 knots, 12 knots, 18 knots, 24 knots and 30 knots.

Patrol Boat Trimaran

The trimaran is categorized as multi hull vessels. They have three separate hulls, where the biggest hull as mainhull is placed at the centre and the other two small hulls as demihull are located on the port and starboard sides. The dimension of the naval patrol trimaran trimaran is reviewed in this paper is as presented in Table 1.

The trimarans have many advantages over monohull vessel. At the same vessel length, the trimaran has a draft smaller, wider, deck and sleek hull shape.[8]–[10] These advantages make the trimaran ships able to sail in shallower water, a higher degree of stability, a more flexible placement of equipment and high power requirements at a lower speed. The disadvantage is the difficulty when making docking and using the harbor facilities, cannot enter the narrow shipping lanes and higher production costs.

Table 1. Main dimension of patrol boat trimaran.

	Trimaran	Main hull	Side hull
Length	67,0 m	59,4 m	39,4 m
Draft	2,1 m	2,1 m	1,8 m
Beam	17,8 m	5,7 m	2,0 m
Displacement	291,7 ton	224,7 ton	33,5 ton
Prismatic coefficient		0,585	0,8
Block coefficient		0,307	0,422
Midship coefficient		0,533	0,532

Mechanic and Hybrid Shaft Generator Propulsion Systems

Basically, the propulsion system used on ships can be grouped into three, ie mechanical propulsion systems, electric propulsion systems and hybrid propulsion systems.[6] The hybrid propulsion system is a combination of mechanical and electrical propulsion systems, so it can be operated as mechanical, electrical and combined both. If a hybrid propulsion system is equipped with a generator shaft, the system becomes a hybrid shaft generator propulsion system. The HSG propulsion system has four modes of operation, as shown in Figure 1.

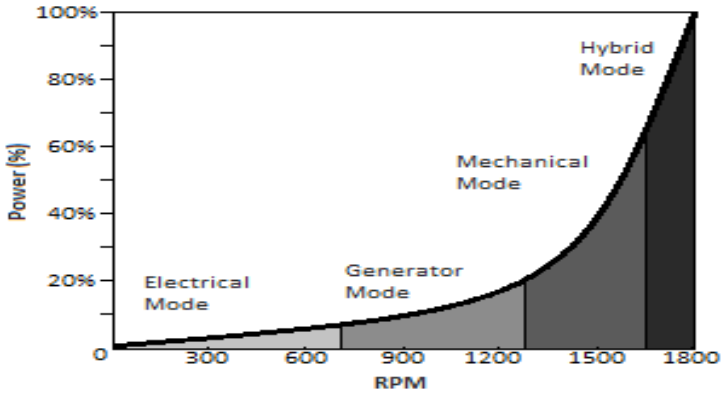
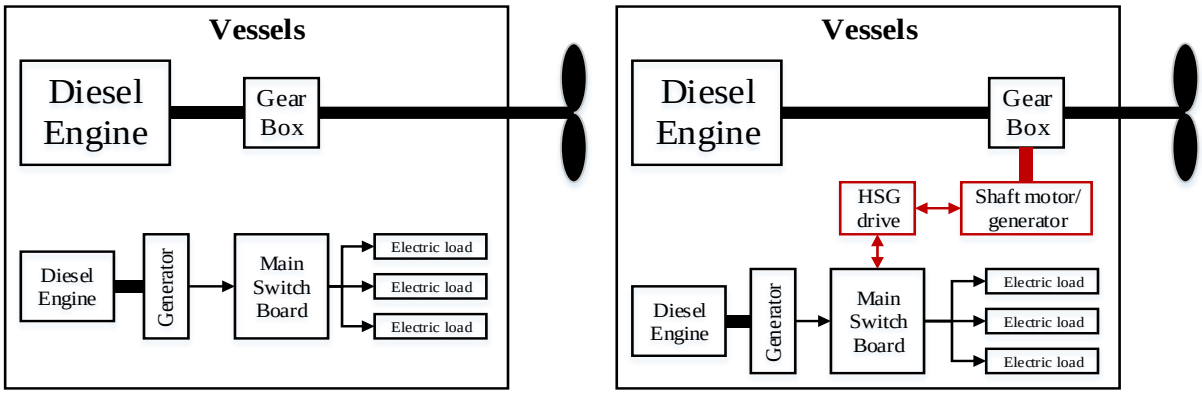


Figure 1. Some operation mode of HSG propulsion system.

Figure 2 shows the difference between the mechanical propulsion system and HSG propulsion system, where the difference lies in the shaft generator/motor (SGM) and HSG drive. SGM is an electric machine that is capable of operating as a motor and generator. When SGM is operating as an electric motor, HSG drive serves to control the rotation. When SGM is operating as a generator, then the HSG drive to maintain the frequency of the electricity generated is always fixed.



a. Mechanic propulsion system. b. HSG propulsion system.

Figure 2. Mechanic and hybrid shaft generator propulsion system.

Determination of Mechanical and Hybrid Shaft Generator Propulsion System Configurations

Configuration of a ship propulsion system component can be obtained after engine propeller matching (EPM) analysis, in which this analysis can be done manually or through simulation programme. The EPM analysis was developed based on the characteristics of obstacles ship, propeller and engine performance driving. The author has created a program of EPM analysis based on numerical calculation.[6], [11] This program can be used to analyze propulsion system of mechanical, electrical and hybrid, by making some modifications. The configuration of a mechanical propulsion system and a hybrid shaft generator propulsion system for a naval patrol trimaran ship as a result of the program is summarized in Table 2.

Table 2. Configuration of Mechanics and Hybrid Shaft Generator Propulsion System.

No	Component	Mechanic Propulsion Systems	HSG Propulsion System
1	Main Engine	**2** MTU 16V4000 M93 3120 kW/2100 rpm	**2** MTU 16V4000 M90, 2720 kW/2100 rpm
2	Auxiliary Engine	**2** GEP 550, 380-415 V, 50 Hz, 1500 rpm	**3** GEP 550, 380-415 V, 50 Hz, 1500 rpm
3	Propeller	**2** CPP B 4.40, ∅ 1,45 m, *P/D* 0,5-1,4	**2** CPP B 4.40 ∅ 1,45 m, *P/D* 0,5-1,4
4	Gear box	**2** Single input & output, ratio 3:1	**2** Double input & output, ratio 3:1
5	Shaft motor/ Generator		**2** 400 kW, 400 V, 50 Hz
6	HSG drive		**2** PWM converter with active front end 200 kW, 400 V

Economic analysis in the selection of the propulsion system

The method used in analyzing the economic choice of propulsion system is best suited for patrol boat trimaran is the payback period. There is some sense of payback period. The first is the period of return of an investment, based on the profits earned from these investments. The second is the period of time required to cover the return of investment spending by using net cash flows. The third is the length of time required to close the original cash outlay. Based on

the description of the third definition of an investment payback period is the length of time needed for the funds that are embedded in an investment can be recovered in full.

Analysis of the cost of certain investments based on the standard of price and with EPM based on the simulation results to calculate the fuel consumption based on variations in speed services planned.[6] Further analysis is a comparison between investment and operational costs in order to obtain a more suitable propulsion system. The results of the calculation of the cost of investment between the mechanics and hybrid shaft generator propulsion system are shown in Table 3.

The outcomes of the computation fuel consumption cost between the mechanics and hybrid shaft generator propulsion system are shown in Table 4.

Table 3. Investment compilation between mechanics and hybrid shaft generator propulsion system.

No	Component	Mechanic Propulsion Systems	HSG Propulsion System
1	Main Engine	2.121.600,00	1.997.600,00
2	Auxiliary Engine	320.000,00	480.000,00
3	Propeller	624.000,00	624.000,00
4	Gear box	187.200,00	215.280,00
Total investment		3.252.800,00	3.316.880,00

Table 4. Operation cost evaluation between mechanics and hybrid shaft generator propulsion system

Mission	Speed (kn)	Time Hours	Mechanic Propulsion Systems	HSG Propulsion System
Surveillance	5	250	225.616.835	164.452.239,00
Slow patrol	12	750	827.750.350	618.385.683,00
Med patrol	18	1125	2.679.286.883,00	2.207.242.885,00
Fast patrol	24	250	1.376.831.932,00	1.192.486.174,00
Pursuit	30	125	1.048.340.928,00	965.590.159,00
Total operation cost			6.157.826.928,00	5.148.157.140,00

Graph of the sum of the cost of investment and fuel consumption costs for the selection of the mechanical propulsion system and generator shafts hybrid propulsion system on a patrol boat trimaran is shown in Fig. 3. The graph shows that the intersection between the two propulsion systems occur in less than one year. If the calculation analysis in 10 years, then the cost savings of using a hybrid propulsion system shaft generator is Rp. 9,100,894,681.00.

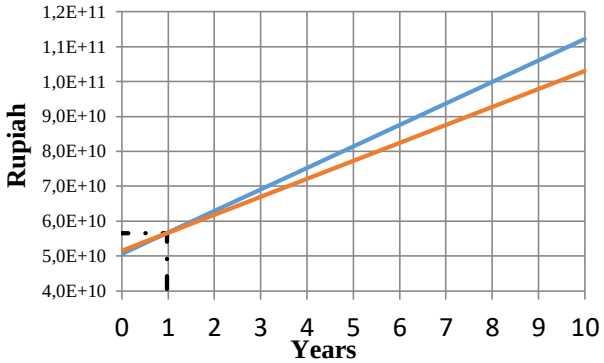


Figure 3. Cost evaluate between mechanic and hybrid shaft generator propulsion system.

Conclusion

Comparison of the results of technical and economic analysis of the propulsion system selection patrol boat trimaran, the mechanical propulsion system and generator shafts hybrid propulsion system, the hybrid propulsion system is more appropriate shaft generator was applied to the patrol boat trimaran.

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MARINE SYSTEM

Selection of Electrical Supply System of LNG Onshore Receiving Facilities in Bali Based on TOPSIS Method

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Keywords: Electrical supply system, LNG, onshore receiving facilities, TOPSIS.

Abstract. Liquefied Natural Gas (LNG) technology converts the volume of natural gas 600 times smaller than the original volume and turns to be more economical to be stored and transported. However, it is not widely used in Indonesia due to the lack of supporting facilities and infrastructures. This study is aimed to select the electrical supply system of a LNG onshore receiving facility (ORF) in Bali by using TOPSIS approach. There are three alternatives, namely diesel engine generator, gas engine generator, and electricity supply from PLN (state owned electricity company). The best alternative was then selected by using TOPSIS with two different weighing methods. This study found that best alternative is electricity supplied from PLN.

Introduction

The national electricity demand in Indonesia is increased gradually. In 2003, almost 80% of the demand comes from Jamali (Jawa-Madura-Bali) distribution [1]. While industrial sector still to be the largest demand since 2003 until 2020 (projected) as shown in Fig. 1. That increment must be followed by a sufficient electrical supply system to fulfil all of the demanded power. Bali is one of the province in Jamali that needs a lot of electricity as Bali is a tourism area. Bali itself has three gas turbine power plants (GTPP) spread in Gilimanuk, Pemaron and Pesanggaran with the total capacity of 432.2 that divided into 133 MW, 97.6 MW and 201.7 MW for each GTPP respectively.

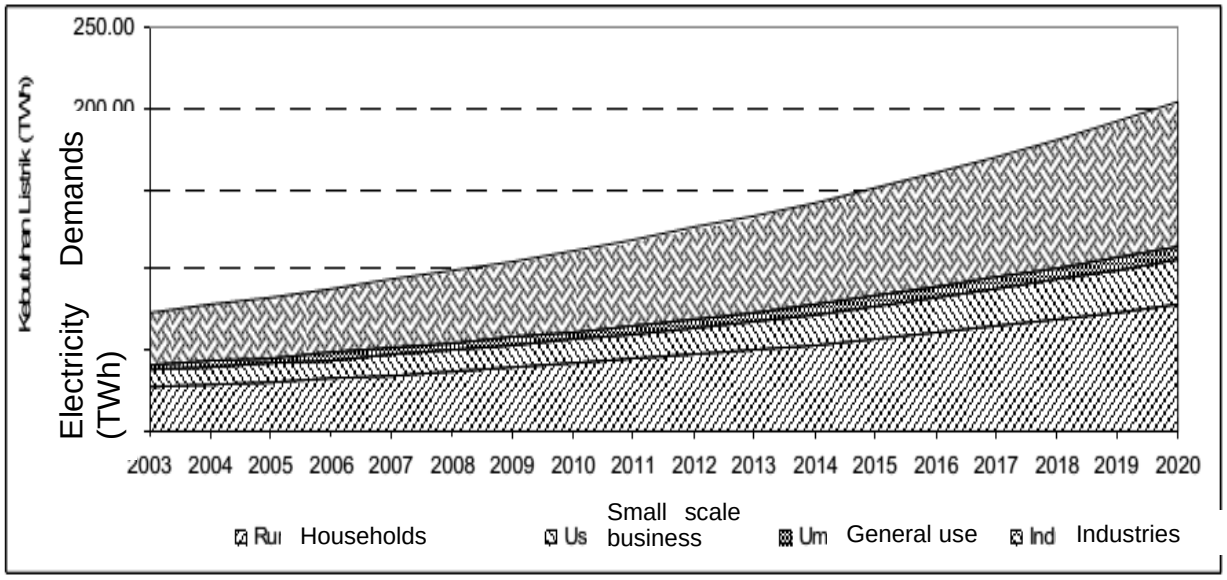

Figure 1. Electricity demands in Jamali for each sector [1].

These GTPPs that are supposed to be fuelled by gas, however, are fuelled by fossil fuel to keep the power generator operating due to the lack of gas supply. Diesel oil that is being used in the GTPPs is not environmental friendly as it produces more emission and also requires more operational. LNG can be considered as an appropriate fuel for the GTPPs because it is more economical and it can support the "Bali clean and green energy" program created by the Bali Government.

An LNG receiving terminal will be built in North Bali to receive the LNG carried by LNG tankers and then it will be distributed to the three GTPPs mentioned above. The receiving facilities itself consisted of two different structure, a floating storage unit that located near a jetty is used to temporary store the LNG before it is converted to gas phase and an onshore receiving facilities that consists of several equipment namely unloading unit, storage tank, pumps and loading arm. This ORF indeed needs electricity to powering all the equipment mentioned above as well as the lighting purposes.

Literature Review

Onshore Receiving Facilities (ORF). Liquefied Natural Gas (LNG) is natural gas that has been converted into liquid phase with temperature around -161°C in an atmospheric pressure. Liquefaction can reduce the volume of natural gas by 600 times smaller and makes it more economical as if there is no enough space to store the natural gas. It is also more convenience to distribute LNG if the distance is relatively far where pipeline can be too expensive. Liquefaction makes an intercontinental gas distribution possible especially by using LNG tanker. LNG supply chain consists of exploration and production from natural gas, liquefaction, LNG transportation and LNG storage, regasification and natural gas transfer to consumer [2]. Indonesia is the third biggest LNG exporter country after Qatar and Malaysia according to the International Gas Union (IGU) report on 2011[3]. However, the amount of gas that is used by Indonesia itself is quite small compared to the exported gas. This is due to the lack of infrastructure as well as the facility to support the distribution of LNG. Hence, the development of onshore receiving facility in Bali is extremely needed to help three GTPPs in Bali producing electricity.

Figure 2. Location of ORF and three GTPPs in Bali [4].

There will be three proposed alternatives that will be evaluated and then will be installed in the ORF to fulfill all the power demand. Those three alternatives are diesel engine, gas engine, and the grid. Each alternative has its own advantages and disadvantages. As for the diesel engine, it might release more emission compared to the other two options, but it is more economical and easy to maintain. The gas engine can be feed with the gas that is stored in the ORF, so no need to buy the fuel, but the maintenance can be slightly more complex and the price can be higher than those other two alternatives. Different from the previous options, electricity from the grid can be obtained easily and the capital investment might be really low and it does not emit any pollution. The electricity will be supplied by PLN (state-owned electricity company) from the nearest grid.

Power Demand. There are three types of power known in the field of AC power, apparent power, real power, and reactive power. These three power types are related to each other and can be calculated if the power factor is already identified. Figure 2 gives information about these three types of power and their relation.

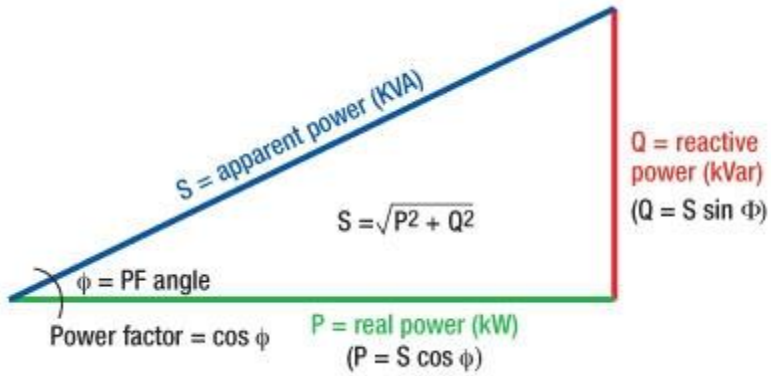

Figure 3. AC power [5].

The figure above can be explained by this following paragraph [6]:

- *Real* power, measured with watt (W), is the energy that will be used to convert mechanical energy to the other types of energy.
- *Reactive* power, measured with volt-amperes reactive (VAR), is the power needed by the equipment that works with electromagnetic system for creating the magnetic field. In addition, it can be assumed that reactive power is just being swapped between source and sink at two times of the electrical frequency.

- *Apparent* power, measured with volt-amperes (VA), is the power that absorbed by the device from the grid. It can simply be said that the value of the apparent power is the sum of the magnitude of real power plus reactive power as an imaginary number.
- Power factor (cos φ) – ratio of the apparent power and the real power. The equation can be expressed as:

$$\cos\varphi = \frac{real\ power\ (kW)}{apparent\ power\ (kVA)} \quad (1)$$

TOPSIS. A lot of ranking methods can be used to answer the multi criteria decision making problems. Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) will be utilised to solve this research. TOPSIS has been used in many sectors in order to select the best alternative based on the chosen criteria, for example [7] used TOPSIS for selecting the mobile network interface, while [8] utilised this approach for ranking the life cycle sustainability performance of alternative vehicle technologies. In term of decision making, the weight of each criteria affects the process of choosing the alternative. According to [9], TOPSIS algorithm can be explained by these following procedures:

1. Determine the criteria that is going to be used to evaluate alternatives
2. Determine the weight of each criterion by using pairwise comparison
3. Create a decision matrix D according to m alternatives that will be evaluated based on n criteria, which can be defined as:

$$\widetilde{D} = \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \cdots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \cdots & \tilde{x}_{2n} \\ \vdots & \vdots & \ldots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \ldots & \tilde{x}_{mn} \end{bmatrix} \quad (2)$$

while the weights of each criterion can be calculated with this following equation:

$$W = (w_1, w_2, w_3, \ldots, w_n), \sum w = 1 \quad (3)$$

4. Create a normalised decision matrix that can be formed from the equation below:

$$\tilde{R} = [\tilde{r}_{ij}]_{m\times n} \quad (4)$$

$$\tilde{r}_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \quad (5)$$

With i=1,…,m and j=1,…,n.

5. Calculate the normalised weighted decision matrix by using the formula below:

$$\tilde{V} = [\tilde{v}_{ij}]_{m\times n}, i = 1,2,3,\ldots,m; j = 1,2,3,\ldots,n \quad (6)$$

With, $\tilde{v}_{ij} = \tilde{w}_i(.)\tilde{r}_{ij}$.

6. Calculate positive ideal solution matrix A^+ and negative ideal solution A^-.

$$A^+ = max(\tilde{v}_1^+, \tilde{v}_2^+, \tilde{v}_3^+, \ldots, \tilde{v}_n^+) \quad (7)$$

$$A^- = min(\tilde{v}_1^-, \tilde{v}_2^-, \tilde{v}_3^-, \ldots, \tilde{v}_n^-). \quad (8)$$

7. Distance between ideal solutions and each alternative can be calculated by these following equations:

$$D_i^+ = \sqrt{\sum_{j=1}^{m}(\tilde{v}_{ij} - \tilde{v}_j^+)^2}; i = 1,2,3,\dots,m. \quad (9)$$

$$D_i^+ = \sqrt{\sum_{j=1}^{m}(\tilde{v}_{ij} - \tilde{v}_j^+)^2}; i = 1,2,3,\dots,m. \quad (10)$$

8. The relative closeness to the ideal solutions is calculated by using equation as follow:

$$CC_i = \frac{D_i^-}{D_i^+ + D_i^-}; i = 1,2,3,\dots,m \; with \; 0 < CC_i < 1 \quad (11)$$

Methodology

This research will discuss about the electrical supply system selection by using TOPSIS method and the main purpose is to select the most suitable electrical source for the ORF in Bali. The research starts with calculating the total power needed by all the equipment operated in the ORF. After knowing the electricity demand, the next step is determining the criteria that will be used to evaluate the alternatives. The criteria can be chosen by doing literature study or by brainstorming with another engineering expert. Furthermore, the alternatives will then be assessed by using TOPSIS approach to calculate the ideal solution and distance from each alternative to the ideal solution. The chosen alternative is the one with the biggest relative closeness.

Results and Discussion

Total Electricity Demand. The ORF in Bali has the total electricity demand 214.6 kW consists of the main components such as pumps, compressors, loading arms, etc., as well as the lighting demand. This total capacity is then going to be supplied by the chosen alternative.

Electrical Supply System Selection. It is important to determine suitable criteria for a selection process. Therefore, this step must be conducted carefully in order to get the best selection result. In this case, there are four criteria considered for the selection study. Each criterion has three sub-criteria to make the analysis more detail. The first criterion is environmental aspect, with installation area, emission, and noise as the sub-criteria [10]. Second criterion is technical aspect, that has three sub-criteria namely installation easiness, installation time and lifetime of the equipment. The third criterion is cost aspect and capex, operational cost as well as maintenance cost as the sub-criteria [11]. The last criterion is operational aspect that consists of operational easiness, maintenance easiness and operational safety.

Weight of each criterion and sub-criterion were collected by making a questionnaire and filled by the electrical engineering expert. The data collected is then processed by using pairwise comparison. Table 4 shows the weight of each sub-criterion in environmental aspect.

Table 4. Weight of each sub-criterion in environmental aspect.

	INS	EMS	NOI
INS	1	0.98	1.13
EMS	1.02	1	2.67
NOI	0.88	0.38	1

From the table above, we can conclude that the installation area is 0.98 time less important than the emission, the installation area is 1.13 times more important than the noise, and the emission is 2.67 times more important than the noise. By using the same way as what was used for the environmental aspect then the relative weight for every criteria and sub-criteria can be calculated and the result is as shown in Table 5.

Table 5. Relative weight for all criteria and sub-criteria.

Environmental	**0.42**	**Technical**	**0.19**	**Cost**	**0.21**	**Operational**	**0.17**
Installation area	0.33	Installation easiness	0.34	Investment	0.41	Operational easiness	0.24
Emission	0.44	Installation time	0.2	Operational cost	0.33	Maintenance Easiness	0.21
Noise	0.22	Lifetime	0.46	Maintenance cost	0.26	Operational safety	0.55

The next step is to calculate the preference of each criteria and sub-criteria for every alternative. Three alternatives are chosen to be evaluated, those alternatives are diesel engine, gas engine, and the grid. Following the TOPSIS procedure, the distance between each alternative to the positive and negative ideal solutions as well as the relative closeness was obtained and can be found in Table 6 and Table 7.

Table 6. Distance between alternative to positive and negative ideal solutions.

Alternative	**A+**	**A-**
Diesel	0.422	0
Gas	0.204	0.222
PLN	0.000	0.422

Table 7. Relative closeness.

Diesel	**Gas**	**PLN**
0	0.521	1

According to the two tables above, PLN or the grid has the highest relative closeness value equals to 1. Hence, it can be concluded that the best alternative for electrical supply system in the ORF is PLN.

Conclusions

Based on results of the analysis above, we can conclude that:

- Total power demand of the ORF in Bali is 214.6 kW includes the power that will be used at the starting condition (starting power is three times higher than the operational power).
- The grid or PLN (state owned electricity company) is chosen as the best alternative based on the calculation that is using TOPSIS approach.

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The Effect of Biodiesel from Waste Cooking Oil Against Exhaust Gas Emissions of 4 Stroke Diesel Engine Customized with IMO Tier III

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Keywords: Methyl ester waste cooking oil, exhaust gas emissions, diesel engine, imo tier III.

Abstract. Biodiesel processing can be done with the process of esterification and transesterification. Biodiesel is processed from used cooking oil can be done only by the transesterification process. Ester transesterification is the process of converting into esters in another form by reacting carboxylic esters and alcohols with alkaline catalyst (NaOH), in processing biodiesel transesterification process is the process of converting triglycerides of cooking oil into methyl or ethyl ester as biodiesel. From the observation and chemical properties when compared with the standard, then the biodiesel synthesis result can be used as a diesel fuel.

Introduction

The use of fuel bland between Methyl Ester of Waste Cooking Oil (MEWCO) and Diesel fuel in the ratio 10:90 (B10) increasing the power of diesel engine when compared with pure diesel fuel at a certain speed and load. The also occurred in a fuel bland of 20:80 (B20) and 30:70 (B30). Even with the fuel composition MEWCO 100% at 2000 rpm rotation an increase in the effective power of 30.34% when compared to using diesel fuel [9]. MEWCO will be promoted as a substitute for diesel fuel and then be widely used as a fuel in the future [1].

Diesel engine options as the research object based on the belief that this type of motors still have a good competitiveness with other types of prime movers commercial basis even in the future, the diesel engine is a type of driver that needs to be taken into account. With the increasing scarcity of conventional fuel, niaka to think about the fuel substitute is right on target [1].

MEWCO has a viscosity and density are still within the allowable limit as diesel engine fuel, at room temperature viscosity kinematisnya 7.5 cst (higher 27.11% of diesel fuel) and a density of 800 kg/m (less 3.75% of diesel oil) and has a higher cetane number than diesel that affect the burning process [1]. MEWCO mixing diesel oil with a resulting effect on power and specific fuel consumption of the diesel engine when compared to using diesel fuel [1]. The power generated fatherly B10, B20, B30 of MEWCO tend increased in 2000 and 2400 rpm [9].

Economic problems is the central issue become an obstacle in the development of biodiesel from palm oil and jatropha. It is therefore necessary raw materials for cheaper and not fully utilized until now [2]. Used waste cooking oil (recycled frying oil) is one of the raw materials that can be used for biodiesel because it has the properties similar to diesel [2]. Currently MEWCO from oil have been produced in Europe, America, and Japan. Biodiesel from MEWCO in Austria known as AME (Altfett Methyl Ester), in Germany in addition to known AME is also known by the name fritten diesel or ecodiesel, where as in Japan is known as e-oil

[2]. The development of biodiesel from cooking oil more rapidly by banning the use of Waste cooking oil for mixed fodder, because it is carcinogenic [3].

Utilization cooking oil in Indonesia is still not optimal. Until now, most cooking of the company was sold to vendors who then used for frying food merchandise and others disappear down the drain[2]. When viewed from the chemical composition, MEWCO contains compounds that are carcinogenic which occur during the frying process. Then the use of used waste cooking oil that is sustainable can damage human health and the consequences can further reduce the next generation of intelligence. The increase in production quantities this was offset by an increase in consumption, which in 2005 reached 6.4 million tons (83.13%) consists of cooking oil feedstock CPO[2].

Table 1. Development of oil production edible oil palm and coconut (million tons) [4].

Type / Year	1999	2000	2001	2002	2003	2004	2005
Cooking oil palm	2.49	2,81	3,14	3,51	3,96	4,53	5,06
Coconut cooking oil	0,73	0,77	0,81	0,85	0,88	0,93	0,93

From the above data we can know that the production and consumption of oil continues to increase, which means also more and more waste cooking oil (MEWCO) wasted if not utilized optimally. If we are able to collect used cooking oil (recyeled frying oil), there are some advantages to be gained: Preventing the pollution of the environment (water and soil) in the absence of disposal of used waste cooking oil to any place. Will be obtained FAME (Fatty Acid Methyl Ester) or more appropriately called RFOME (Recyeled Frying Oil Methyl Ester) are cheap so as to obtain biofuels inexpensive and environmentally friendly[2]. Reducing carcinogenic substances circulating in the community. As it is known that the use of cooking oil repeatedly (marked with dark brown, black and contain about 400 chemical compounds) will oxidize unsaturated fatty acids form a cluster peroxide and monomersiklik. This compound has the potential to cause cancer, enlargement of the liver, kidney and heart problems [2].

Technical Standard, the European Standard EN14214 biodiesel is a number, which can be translated into the national standards of each country Area formed by the CEN (European Committee for Standardization) [5]. For example, for the United Kingdom, BS EN 14214 and to the German DIN EN14214. There is another standard specification that ASTMD6751 as a reference standard that is commonly used in the United States and Canada. In addition there are also naming DIN standards for three types of biodiesel, which is made in accordance with the type of raw material sources: RME (Rapessed Methyl Ester) in accordance with DIN E 51 606, PME (Vegetable Methyl Ester), pure oil in accordance with DIN E 51 606, FME (Fat Methyl Ester), vegetable oil and fat products, in accordance with DIN V 51606. With reference to normative on some standard above, Indonesia has also set quality requirements, test methods, requirements and test pass through a standard way of packaging that is the Indonesian National Standard (SNI 04-7182-2006) [5]. This standard is used for the substitution of diesel motor fuel that is a mixture of (blending) with diesel fuel in motor vehicles or other diesel engine. The blended diesel fuel include, among others diesel fuel, diesel fuel and fuel oil that meets the specification requirements that published by the competent authority [5].

Metyhl Ester Waste cooking oil: frying cooking left overs that can not be used should be discarded. This will impact the rest of the frying pan to the environment if not treated properly. Useless left over frying can be used as bio-diesel. Biodiesel can be either used as complement diesel fuel (gas oil) as a diesel engine [1]. The results showed that various mixtures of methyl esther of cooking oil with diesel fuel does not degrade engine performance significantly [1,6].

Already some researchers use as a cooking oil in gredient make of methyl esther. Reed TB using soy bean waste cooking oil, biodiesel is used as a blending with diesel fuel as fuel diesel engine on a city bus in Denver and power changes do not occur significantly. Mittelback has been collecting used waste cooking oil from restaurants and a few other places to make biodiesel and other researchers have studied the effect of physical and chemical properties of biodiesel on engine performance direct injection type diesel [1,7,8].

Use of Mixed MEWCO and diesel fuel in the ratio 10:90 raise the effective day a diesel engine when compared with pure diesel fuel at a certain rpm and load. The increase also occurred in a mixture of 20:80 and 30:70. Even with the fuel composition MEWCO 100% at 2000 rpm rotation an increase in the effective power of 30.34% when compared to using diesel fuel. MEWCO will be promoted as a substitute for diesel fuel and then be widely used as a fuel in the future [1,9].

MEWCO has a viscosity and density are still within the allowable limit as diesel fuel, at room temperature kinematic viscosity 9.48 cst is higher than diesel fuel and its density 895.3 kg/m3 is greater than petroleum diesel and has a cetane number higher than diesel fuel thus affecting the combustion process. MEWCO mixing diesel fuel with a resulting effect on power and specific fuel consumption of the diesel engine when compared to using diesel fuel. The power generated fatherly B10, B20, B30 tends to increase in 2000 and 2400 rpm [1,9]. Diesel fuel Production of Pertamina gas stations acquired from used waste cooking oil derived from plant Crackers. The material specifications are as follows:

Table 2. Specifications of diesel fuel [2].

No	Characteristics	Check Up Result	Method
1	Specific gravity at 60 / 60 °F	0,83	ASTM D 1298
2	Flash point P.M.c.c, °C	72	ASTM D 93
3	Viscosity kinematics at 40°C, cSt.	3,78	ASTM D 445
4	Water content, % vol	Trace	ASTM D 95
5	Pour poit, °C	3	ASTM D 97
6	Ash content, % vol	Nil	ASTM D 482
7	Conrad son Carbon Residue,%wt	0	ASTM D 189

Table 3. Spesifikasi MEWCO [2].

No	Characteristics	Check Up Result	Method
1	Specific gravity at 60/60°F	0,879	ASTM D 1298
2	Flash point P.M.c.c, °C	150,286	ASTM D 93
3	Viscosity kinematics at 40°C, cSt.	5,121	ASTM D 445
4	Water content, % vol	0,083	ASTM D 95
5	Pour poit, °C	9,829	ASTM D 97
6	Ash content, %vol	0,008	ASTM D 482
7	Conrad son Carbon Residue, %wt	0, 121	ASTM D 189

Table 4. Characteristics of the blend (blending) [2].

No	Characteristics	The Calculation Results			
		B5	B10	B15	B20
1	Specific gravity at 60/60°F	0,8325	0,8349	0,8374	0,8399
2	Flash point P.M.c.c, °C	75,9143	79,8286	83,7429	87,6571
3	Viscosity kinematics at 40°C, cSt.	3,8471	3,9141	3,9812	4,0482
4	Water content, % vol	0,0041	0,0083	0,0124	0,0166

No	Characteristics	The Calculation Results			
		B5	B10	B15	B20
5	Pour poit, °C	3,3414	3,6829	4,0243	4,3657
6	Ash content, %vol	0,0004	0,0008	0,0012	0,0016
7	Conrad son Carbon Residue, %wt	0,006	0,0121	0,0181	0,0241

Table 5. Relationships CO emissions in diesel and biodiesel blends [2].

Rotation RPM	Emission CO (%)				
	Solar	B5	B10	B 15	B 20
1650	5,475	0,017	0,006	0,017	0,010
1950	5,051	0,048	0,010	0,022	0,013
2300	5,04	0,055	0,020	0,036	0,028
2650	2,490	0,059	0,026	0,038	0,036
3000	3,500	0,063	0,027	0,041	0,045

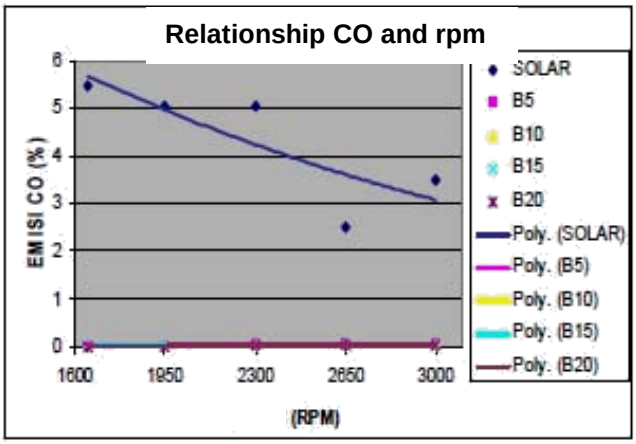

Figure 1. Graph relationship emissions of CO and round [2].

Carbon monoxide (CO) is formed due to lack of oxygen in the reaction with the fuel during the combustion process. It shows that a high percentage of CO resulting fuel cannot burn completely due to a lack of oxygen. In Figure 1 above can be in the know that the diesel fuel CO emissions are far above the CO emissions of biodiesel blends, reaching 5.475%. CO emissions in diesel fuel tends to decrease with increasing spin machine. Much difference between CO emissions in diesel and biodiesel blends due to the diesel fuel occurred while in the rich mix of biodiesel fuel mixture lean mixture occurs. A rich blend of diesel fuel that can be seen in table 4.5, that excess water (λ) is less than 1, while the biodiesel mixture excess water (λ) is greater than 1. To reduce emissions of CO, the mixture should be made lean or lambda greater than 1 [2].

In Figure 2 below shows that the mixture of all types of biodiesel increased by increasing the engine rotation. B5 fuel is at the top compared to other biodiesel blend ranging from 1650 to 3000 rpm rotation. Fuel B15 and B10 have the same trend when viewed from a line (line) on the chart. However, B10 is at the lowest position, which means that the content of CO emissions of these fuels is at least compared to other fuels. While on B20 tends to rise with a higher percentage increase than B15 and B10. This is evident by the formation of a straight line which rises with increasing rotation [2].

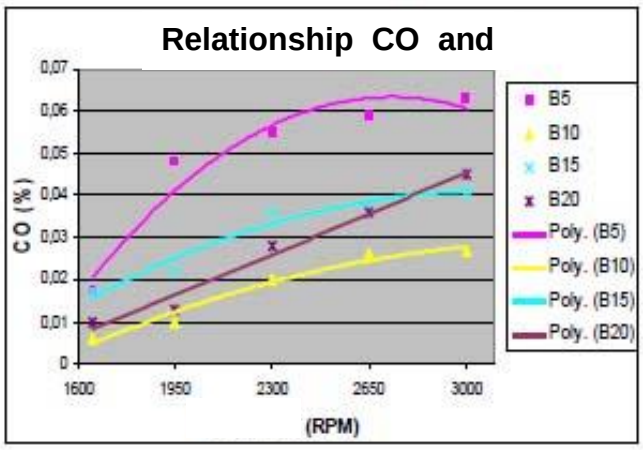

Figure 2. Graph relationship CO emission biodiesel blends and rpm [2].

The increase in CO can be caused due to the high temperature reaction between carbon dioxide (CO2) and carbon (C) which produces CO gas. CO2 at high temperatures can decompose back into CO and oxygen. Reaction formation CO faster than the formation of CO2, so that the end result is still burning CO gas may be present. The higher the temperature of combustion, the amount of CO2 gas is dissociated into CO and O each. Therefore, the increase in CO with increasing rounds for biodiesel fuel mixture can be caused by the high temperatures. Due to the high temperature is the formation of the CO[2].

Relations CO2 emissions: (carbon dioxide) and Round Reaction perfect fuel combustion will produce high CO2 and H2O. Due to the rising cost of CO2, the more energy that is formed in this combustion. Conversely, if the price the lower the CO2, the less energy is formed in the combustion reaction. The low value of CO2 can be caused due to some elements of the fuel turns into carbon monoxide (CO) and hydrocarbons (HC)[2]

Table 6. Relations CO_2 emissions in diesel and biodiesel blends [2].

RPM	EMISSION CO_2 (%)				
	Solar	B5	B10	B15	B20
1650	20	11,54	11,32	11,45	11,34
1950	20	13,31	11,97	12,13	11,95
2300	20	13,55	12,37	12,41	12,47
2650	18,86	13,55	12,33	12,53	12,4
3000	15	12,3	11,18	11,41	11,36

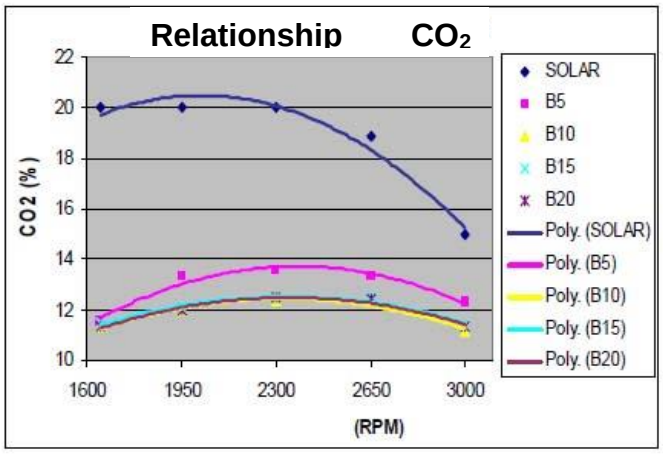

Figure 3. A graph of CO_2 emissions and rpm [2].

From Table 6 or Fig. 3 above shows that diesel fuel is at the top, meaning the energy that is formed larger than the biodiesel blend. Diesel fuel tends to decrease with increasing rounds. This is because the combustion quality decreases. While the mixture of biodiesel fuel has a tendency to rise at 2300 rpm rotation, but then fell in the round of 3000 rpm. This decrease was caused by air entering the combustion chamber cannot react completely with fuel or can also be caused by CO2 dissociates into CO and oxygen due to high temperatures. The percentage of CO2 in the fuel B5 biodiesel blend is higher than the other. While fuel B10, B15 and B20 have similar characteristics. This is shown in the graph that the lines of each type of fuel coincide. From that analysis, it can be said that the CO2 in the fuel mix of biodiesel does not occur a significant difference, but there are significant differences when compared to diesel [2].

Table 7. Relations HC emissions in diesel and biodiesel blends [2]

Rotation RPM	EMISION HC (PPM)				
	Solar	B5	B10	B15	B20
1650	4166	19	23	3	8
1950	4086	55	22	8	8
2300	3896	52	21	7	0
2650	3516	56	17	5	0
3000	3653	56	21	7	1

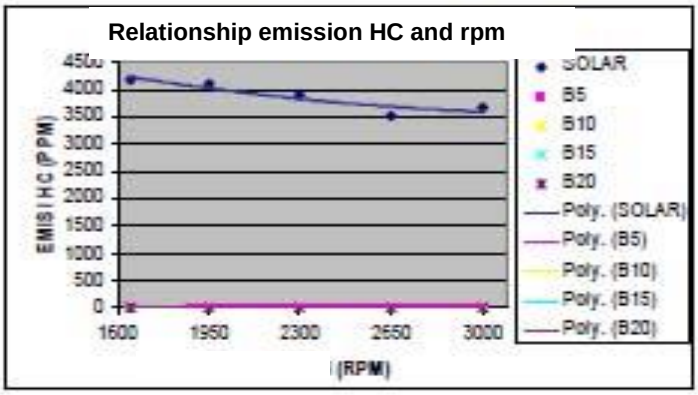

Figure 4. Graph relationship HC emissions and rpm [2].

Emissions relationship HC (Hydrocarbons) and rpm: Hydrocarbons (HC) can be formed due to hydrogen molecules and carbon in fuel does not burn completely (unburned) during combustion takes place. In conditions of excess air ($\lambda > 1$), HC emissions are very few reproduced, but it became very significant in conditions of lack of air ($\lambda < 1$). HC emissions with a small molecular weight also be produced around the fire for their thermal decomposition process (thermo-pyrolysis). However, because the radical H contained in the hydrocarbons turn into H2O, C atoms contained in the hydrocarbon turns into CO and further oxidized to CO2, HC and soot, the production is very little. Contrary to this, on the condition of lack of air, not much changed HC to CO and H2O, so that the HC issued in its initial form or in the form of carbon powder. In Figure 4 above we can know that there is a huge difference between HC emissions on diesel fuel and biodiesel blends. HC emission diesel fuel is above emission biodiesel blends of up to 99.9%. This happens because the diesel fuel combustion, occurs richer or lack of oxygen. In accordance with the test results, that λ is a factor of excess air in diesel fuel is less than 1. Thus causing the fuel is not burned completely [2]. Unlike the case with a mixture of biodiesel fuel, and Figure 4 looks to be far below the emission diesel. This is because the mixture of biodiesel fuel is the case of excess water (λ) is more than 1, so that the hydrocarbons formed less than diesel [2].

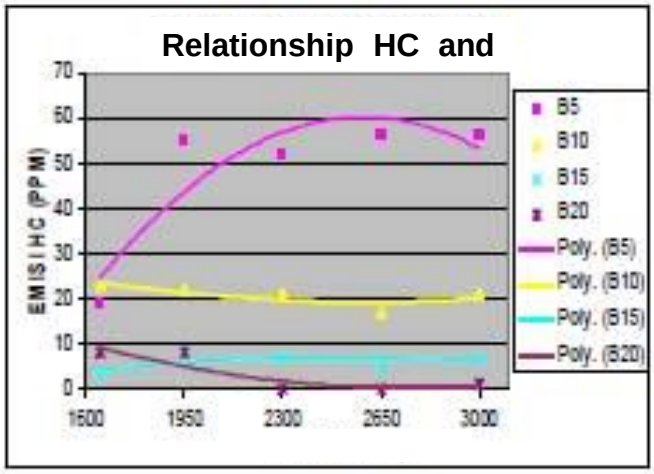

Figure 5. Graph relationship HC emissions of biodiesel blends and rpm [2].

In Figure 5 above shows that there is a difference is a trend towards HC emissions for each percentage mix. B5 fuels ranging from 1650 to 3000 rpm rotation is above the other mixture HC emissions, and has a tendency to increase with increasing rounds. In subsequent position is B10 which has a downward trend with increasing engine rotation. While on B15 fuel is not seen there was significant difference with increasing engine rotation. The largest decline occurred among the B20 biodiesel blend, which is getting down with increasing engine rotation. In addition to those mentioned above, the HC emission can also be formed due to the low temperatures in the area of the cylinder wall, so that the temperature is not capable of performing the combustion process [2].

Table 8. Relationship Capacity and Turn on diesel and biodiesel blends [2].

RPM	EMISSION HC (PPM)				
	Solar	B5	B10	B15	B20
1650	26,590	23,460	20,240	21,290	13,890
1950	31,820	26,590	26,590	23,430	18,120
2300	27,620	28,670	23,430	22,370	16,010
2650	24,480	22,370	20,240	20,240	13,890
3000	22,370	23,430	17,050	17,050	13,890

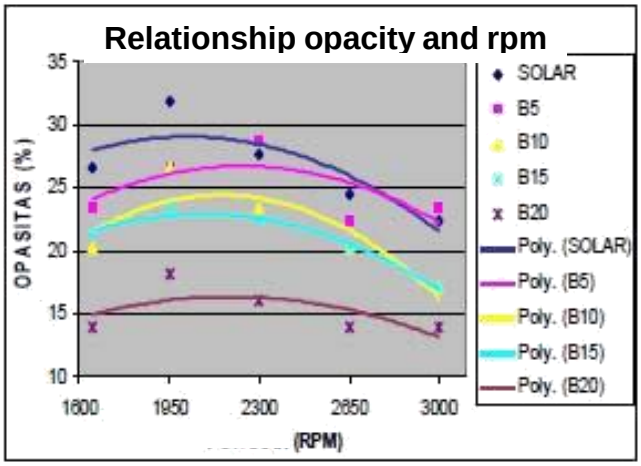

Figure 6. Graph relations capacity and rpm [2].

Relations rpm and opacity: Opacity indicates the degree of darkness and invisibility failure of an exhaust emissions. The higher the opacity, meaning that the higher the percentage does not seem an object as a result of this exhaust emissions. These particulates mainly composed of soot, which is the process of briefly is the condition in which less oxygen HC under high temperature conditions will undergo thermal decomposition and then going dehydrogenisation and followed the polymerization so that it will form an intermediate compound intermediates which contains carbon and further growth is core particle, Figure 6 shows that the opacity of all types of fuel tends to decrease with increasing spin machine. In round 1650 rpm, diesel fuel is at the top, while at 3000 rpm declines, under B5. In the fuel B10 and B15 have the same tendency as there was no significant difference in the round of 1650 rpm to 3000 rpm. While B20 fuel is at the lowest position, means to have properties more environmentally friendly. The low opacity can be caused because in theory fatty acids contained in biodiesel is easier to oxidize or burn completely [2].

The international Maritime Organization (IMO) Tier III NOx: Emissions standards, reducing the combustion temperature is an important in cylinder measure to decrease NOx emissions of marine diesel engine [11].

Table 9. Coefficient U gas and fuel specific parameters for raw exhaust gas [28].

Gas		**No_x**	**CO**	**HC**	**CO_2**	**O_2**
ρ gas kg/m^3		**2.053**	**1.250**	*****	**1.9636**	**1.4277**
	ρ e ŧ	**Coefficient U gas ŧ**				
Liquid fuel	1.2943	0.001586	0.000966	0.000479	0.001517	0.001103
Rapeseed Methyl Ester	1.2950	0.001585	0.000962	0.000536	0.001516	0.001102
Methanol	1.2610	0.001628	0.000991	0.001133	0.001557	0.001132
Ethanol	1.2757	0.001609	0.000980	0.000805	0.001539	0.001119
Natural gas	1.2661	0.001621	0.000987	0.000558	0.001551	0.001128
Propane	1.2805	0.001603	0.000976	0.000512	0.001533	0.001115
Butane	1.2832	.001600	0.000974	0.000505	0.001530	0.001113

* Depending on fuel

** Petroleum derived

ŧ ρ e is the nominal density of the exhaust gas

At $\lambda = 2$, wet air, 273 K, 101.3 kPa.

Values for given in table 5 are based on ideal gas properties. In multiple fuel type operation, the U gas value used shall be determined from the values applicable to those fuels in the table set out above proportioned in accordance with the fuel ration used for other fuel oils, default value as approved by the administration [28].

Table 10. Default fuel oil parameters [28].

	Carbon	Hydrogen	Nitrogen	Oxygen
	WEET	WALF	WDEL	WEPS
Distillate fuel oil (ISO 8217 : 2005, DM, grade)	86.2 %	13.6 %	0.0 %	0.0 %
Residual fuel oil (ISO 8217 : 2005, RM grade)	86.1 %	10.9 %	0.4 %	0.0 %
Natural gas	75.0 %	25.0 %	0.0 %	0.0 %

The third stage harmful emission control regulations of the International Maritime Organization (IMO) (IMO Tier 3) have been in place since 1 January 2016. In order to comply

with the IMO Tier III NOx standards, newly built marine diesel engines operating in the Emission Control Areas (ECA) must apply in-cylinder control measures or after treatment devices to satisfy the NOx control requirements. Selective Catalyst Reduction (SCR) is a major after treatment device considered as a good option to decrease NOx to meet the limit of Tier III, but the uncertainties of future fuel and urea market prices make it difficult to make a decision to install it. Therefore in-cylinder NOx control measures are important options to meet IMO Tier III standards. Since the NOx limit of IMO Tier III corresponds to 76% reduction from that of IMO Tier II level, using a single in-cylinder measure alone cannot reach IMO Tier III standard. There must be a combination of multiple in-cylinder control measures to decrease NOx emissions to IMO Tier III level. The basic rule for decreasing NOx emissions is to reduce the maximum combustion temperature and reduce the oxygen concentration of the cylinder charge [12]. The effective method to reduce NOx emissions of diesel engines. By changing the valve timing, the effective Compression Ratio (CR) is reduced, and accordingly a lower combustion temperature leads to decreased NOx.

Determination of physical properties: density and viscosity of biodiesel samples, to determine the density (density) and viscosity of biodiesel, respectively workmanship performed 3 repetitions. Observations can be seen in [28].

Table 11. Density biodiesel and viscosity biodiesel.

Density biodiesel		**Viscosity biodiesel**	
The results (average)	**German standards**	**The results (average)**	**German standards**
0,8976 ± 0.0003 g/mL	0.85 – 0.90 g/mL	(4.53 ± 0.09) mm^2 /s	3.5 – 5.0 mm^2 /s
The calculation of the density results obtained biodiesel at temperatures 15°C is in the range of biodiesel standard DIN V 51 606 is 0.85 to 0.90 g/mL. from the calculation, the viscosity of biodiesel at temperatures 40° c still meet the standard range biodiesel standard DIN V 51 606 ie 3.5 - 5.0 mm / s		The nature biodiesel samples Chemical properties analyzed were acid value, saponification value, iodine value. The experiment was conducted with three replications. The analysis results are shown in Table 9.	

Table 12. Data Results of Acid, saponification and iodine number of samples.

Acid		**Saponification**		**Iodine number**	
The results obtained (average)	**German standards**	**The results obtained (average)**	**German standards**	**The results obtained (average)**	**German standards**
(0.4238, 00397) mg KOH / 1g biodiesel	0.5 mg KOH / g biodiesel	0.2093, 0,0006) mg KOG / kg biodiesel	< 5 mg KOH / kg	9.3354, 0,0167 Iod / 100g	<115g Iod / 100 g

From the observation and chemical properties when compared with the standard, then the biodiesel synthesis result can be used as a diesel fuel.

Conclusions

The use of diesel engines are increasing at the moment, the other hand supplies of petroleum base diesel oil in the market decreasing. There for we need alternative fuels to use as supplement fuel for diesel engines. Biodiesel processing can be done with the process of esterification and trans esterification. Biodiesel is processed from MEWCO can be done only by the trans esterification process. Ester trans esterification is the process of converting into esters in another form by reacting carboxylic esters and alcohols with alkaline catalyst (NaOH), in processing biodiesel trans esterification process is the process of converting triglycerides of cooking oil into methyl or ethyl ester as biodiesel. The fuel composition MEWCO 100% at 2000 rpm rotation an increase in the effective power of 30.34% when compared to using diesel fuel. MEWCO will be promoted as a substitute for diesel fuel and then be widely used as a fuel in the future. The calculation of the density results obtained biodiesel at temperatures 15° c is in the range of biodiesel standard DIN V 51 606 is 0.85 to 0.90 g/mL. from the calculation, the viscosity of biodiesel at temperatures 40° c still meet the standard range biodiesel standard DIN V 51 606 i.e. 3.5 - 5.0 mm/s. From the observation and chemical properties when compared with the standard, then the biodiesel synthesis result can be used as a diesel fuel.

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MARITIME MANUFACTURING INDUSTRY

Consequence Analysis of Ship Collision based on Multi Criteria Decision Making and Fuzzy Logic

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Keywords: Analytic hierarchy process, consequence analysis, fuzzy logic, qualitative assessment.

Abstract. Ship collision is one of the most potential risk in marine traffic activities. The analysis of the risk has been approached by several methods. This paper applied qualitative method to assess the consequence of potential hazard as one important parameter in ship collision risk. A multi-criteria decision-making (Analytic Hierarchy Process) would be integrated with fuzzy logic to obtain consequence index for each potential ship collision. Analytic Hierarchy Process is used to rank the criteria and sub criteria which affect to the consequences by their weight. Then fuzzy logic determined the consequence index of potential risk of the ship. Consequence index obtained by this paper can be used to evaluate ship collision risk apart in terms of its frequency.

Introduction

Shipping accident is one of the most serious threat for marine traffic safety. One of the common shipping accident is ship collision. When the accident occurs, the risk of life, property and marine environment immediately becomes higher [1].

Risk is a way to evaluate the safety of an activity. Risk has two important components, probability or frequency and consequence. It means, when a hazard with a high probability of occurrence and a high consequence would have a result of a high risk, and vice versa [2]. This paper will be focused to examine the consequence of ship collision as an important component of risk.

Qualitative, semi-quantitative or quantitative approach have been used by many researchers to analyze the risk based on their availability of required data. Each of those approach has its own characteristics, advantages and disadvantages [3]. This paper will be applying a qualitative method because the consequence is estimated not only by the "expert" judgement as but also from ship data obtained from Automatic Identification System (AIS). This paper aims to estimate consequence of a ship collision which described by 'Consequences Index', CI [4].

Consequences Index (CI) is examined by using a combined method between multi-criteria decision-making, Analytic Hierarchy Process (AHP) and fuzzy logic. AHP is used to rank all parameters of each criterion for every factor that will be affecting the consequence by its weight. The consequence that may occur when the accident happens and considered in this paper are human safety, structure damage of the ship and effect to environment. Those three consequences from the AHP result are then will be input in fuzzy logic. The output from fuzzy is CI which described as a level of consequence; 'very high', 'high', 'moderate', 'low' and 'remote'.

Method

Analytic Hierarchy Process (AHP)

"The Analytic Hierarchy Process (AHP) is a theory of measurement through pairwise comparisons and relies on the judgements of experts to derive priority scales."[5]. AHP is structured by multi criteria and the criteria have some sub criteria.

It will be used to get the weight for all criteria and sub criteria in each consequence parameters (human safety, structure damage and environmental consequence).

Criteria and sub criteria in this study are determined based on the source data which has been used to obtain probabilities and probability density function in collision scenario, studied by Brown (2002) [6]. Derived from some report, damages due to ship collision include some variables of collision event such as ship type, ship speed, and displacement [6].

Hierarchy of criteria and sub criteria for ship collision frequency is constructed based on the previous source data about collision events. Figure 8 shows hierarchy of criteria and sub criteria for human safety.

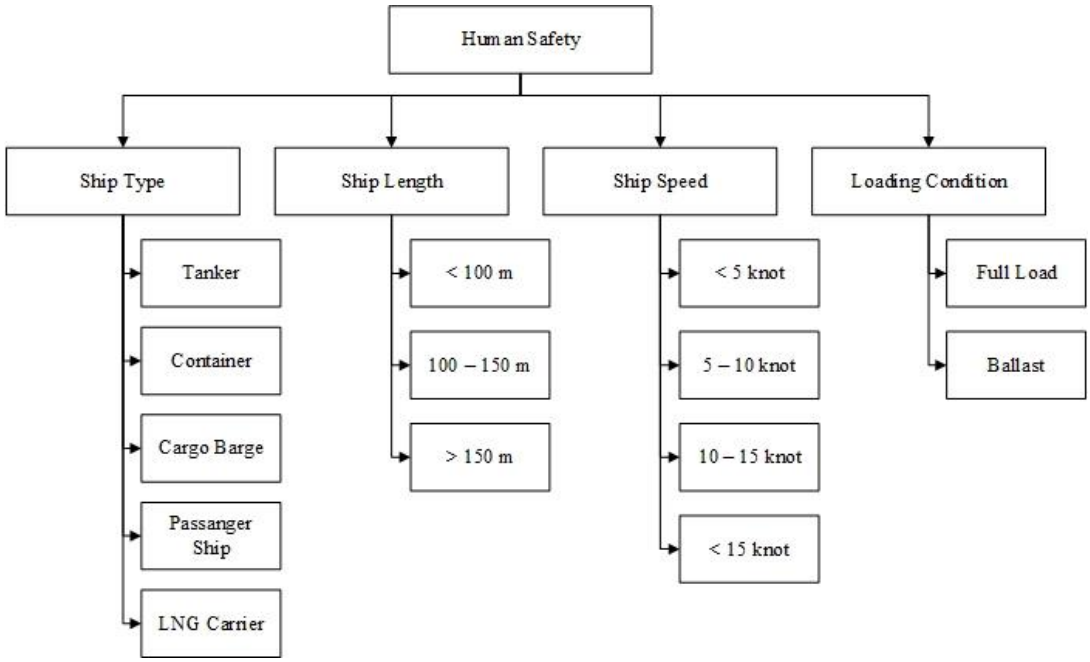

Figure 8. Consequence parameters hierarchy.

Hierarchy of AHP in Figure 8 is not only for human safety consequence, but also applied for others consequence, namely structure damage and environment. Figure 8 presents that consequence for human safety has four criteria: ship type, ship length, ship speed and loading condition. Criteria consist of at least two sub criteria. Among criteria and sub criteria will then be compared related to its importance using pairwise comparison matrix to obtain their weight. When the results obtained from questionnaires show that the highest weight of criteria or sub criteria among others, it means that that criteria is more important than others due to its consequence.

Consequence index can be calculated when all the weight of all criteria and sub criteria has been derived from AHP. the consequence index for each parameter can be calculated by using the equation below [4, 7].

$$CI_i = \sum_j W_j \times f_{ij} \quad (1)$$

Equation 1 shows that CI is consequence index which obtained by summing the multiply of all the weight of each criteria and the value of function of each index.

Fuzzy Sets Theory

Fuzzy sets theory was firstly introduced by L. Zadeh in 1965 to deal with uncertainty, ambiguous, and vagueness that may occur in many various problems [4, 8]. The process involves membership functions, fuzzy logic operators, and if-then rules. In this study, fuzzy system is used to determining the level of consequence index. Input parameters for fuzzy inference system are human safety, structure damage and environment. Consequences index (CI) as an output of fuzzy is determined based on those three parameters.

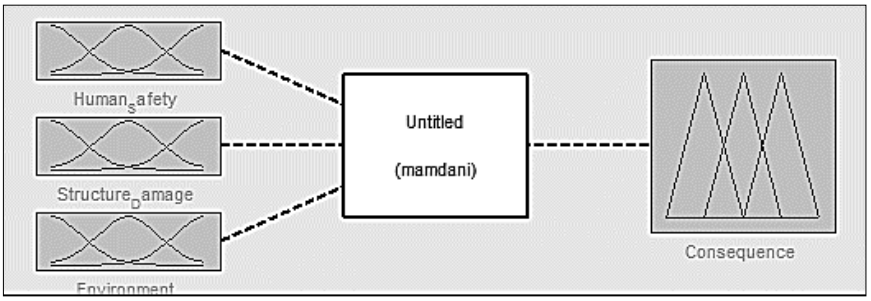

Figure 9. Fuzzy inference system for consequence.

Figure 9 presents the fuzzy inference system with the output is consequence of risk collision ship. While the membership function for human safety is shown in Figure 10. The same membership function is also applied for others parameter.

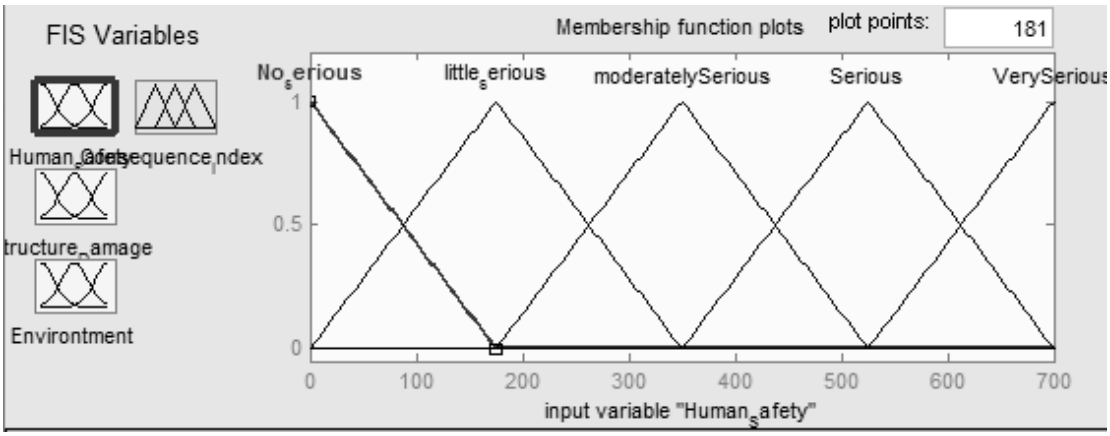

Figure 10. Membership function of human safety.

Fuzzy logic consists of fuzzy sets and fuzzy sets operations as subjects and verbs. To formulate the conditional statements that comprise fuzzy logic, if-then rules statements are used. A single fuzzy If-Then rule assumes the form [9].

If x is A_1 Then y is B_2 (2)

Where A_1 and B_2 are linguistic variables defined by fuzzy sets on the range x and y respectively. The If-part of the rule 'x is A_1' is called the premise and the Then-part of the rule 'y is B_2' is called the consequent [9].

Hence, the conditional statement can be expressed in mathematical form as shown below [9].

If A_1 Then B_2 or $A_1 \rightarrow B_2$ (3)

Result

This paper gives two main result, weighting result from AHP and CI from Fuzzy Logic. The first result obtained from AHP can be seen in Table 8-3 about the weighting of all criteria for human safety indicators, structure damage and environment. Consequence index of each criterion and sub criterion are calculated using Eq. 1 above.

Table 8. Weighting of human safety indicators.

Category Sub Category	Weight to Human Safety	Function Score	Consequence Index
Ship Type	0.564	1000	
Tanker	0.126	564	**71**
Container Ship	0.042	564	**24**
Cargo/Barge	0.066	564	**37**
Passenger Ship	0.64	564	**361**
LNG Carrier	0.126	564	**71**
Ship length	0.059	1000	
< 100 m	0.731	59	**43**
100 - 150 m	0.188	59	**11**
> 150 m	0.081	59	**5**
Ship Speed	0.319	1000	
< 5 knot	0.051	319	**16**
5 - 15 knot	0.227	319	**72**
> 15 knot	0.722	319	**230**
Loading Condition	0.059	1000	
Full Load	0.5	59	**30**
Ballast Condition	0.5	59	**30**

Table 8 shows that passenger with ship length not less than 100 m with speed more than 15 knot, it gives high consequences for human safety. Meanwhile, the highest severity of structure damage will occur if a ship (<100m length) with speed more than 15 knots and in a full load condition experienced a collision.

Table 9. Weighting of structure damage indicators.

Category Sub Category	Weight to Structure Damage	Function Score	Consequence Index
Ship Type	0.064	1000	
Tanker	0.2	64	**13**
Container Ship	0.2	64	**13**
Cargo/Barge	0.2	64	**13**
Passenger Ship	0.2	64	**13**
LNG Carrier	0.2	64	**13**
Ship length	0.113	1000	
< 100 m	0.731	113	**83**
100 - 150 m	0.188	113	**21**
> 150 m	0.081	113	**9**
Ship Speed	0.74	1000	
< 5 knot	0.051	740	**38**

Category Sub Category	Weight to Structure Damage	Function Score	Consequence Index
5 - 15 knot	0.227	740	**168**
> 15 knot	0.722	740	**534**
Loading Condition	0.082	1000	
Full Load	0.75	82	**62**
Ballast Condition	0.25	82	**21**

Different result compared to another consequence is shown in Table 10. This is the weight of criteria and sub criteria for environment consequence. Tanker with length less than 100 m, in a full load condition and it operates with high speed (more than 15 knots) will give high consequence for environment.

Table 10. Weighting of environment indicators.

Category Sub Category	Weight to Environment	Function Score	Consequence Index
Ship Type	0.595	1000	
Tanker	0.595	595	**354**
Container Ship	0.08	595	**48**
Cargo/Barge	0.243	595	**145**
Passenger Ship	0.05	595	**30**
LNG Carrier	0.032	595	**19**
Ship length	0.052	1000	
< 100 m	0.731	52	**38**
100 - 150 m	0.188	52	**10**
> 150 m	0.081	52	**4**
Ship Speed	0.052	1000	
< 5 knot	0.051	52	**3**
5 - 15 knot	0.227	52	**12**
> 15 knot	0.722	52	**38**
Loading Condition	0.3	1000	
Full Load	0.9	300	**270**
Ballast Condition	0.1	300	**30**

Membership function for consequence adopted from *Risk Priority Number* (RPN) and modified the interpretation of linguistic priority term for severity [7]. If-Then rules are also developed from this interpretation as shown in Table 11. For example, if ship collision has no serious on people, structure damage and environment, it means, that consequence level is in remote ranking.

Table 11. Interpretation of linguistic priority term for severity.

Effect	Severity of Effect (Interpretation)
Very high	Ship collision has a very serious effect on people, and environment
High	Ship collision has a serious effect on people, and environment
Moderate	Ship collision has a moderately serious effect on people and environment
Low	Ship collision has little serious effect on people and environment
Remote	Ship collision has no serious effect on people and environment

In this research, fuzzy inference system to obtain the consequence index of ship collision is carried on by using the fuzzy toolbox in MATLAB R2010a.

Based on ships data operated in Madura Strait which obtained from AIS in 2015, it shows the highest traffic density in shipping lane happened in April 2015. This study only analyzes the ship consequence in 8th April 2016 at 3 AM and 1 PM because it has the highest traffic density. Ship data obtained from AIS in that time is then be analyzed and it can be concluded that there are two type of ships, passenger ship and general cargo, with a similar specification. Hence, this methodology is applied for passenger ship and general cargo that operated in highest traffic density time.

Consequence index of three type of consequences are inputted to fuzzy inference system, then the final CI as an output of FIS will show the level of ship collision consequence. It can be seen in Table 12.

Table 12. Summary of consequence index for some ship collision.

Consequences Impact Factor	Ship Data (1)	Consequence Index	Ship Data (2)	Consequence Index
Human Safety				
Ship Type	Container Ship	24	General Cargo	37
Ship length	138.87 m	11	87 m	43
Ship Speed	7.2 knot	72	9.8 knot	72
Loading Condition	Full Load	30	Full Load	30
Total		**137**		**182**
Structure Damage				
Ship Type	Container Ship	13	General Cargo	13
Ship length	138.87 m	21	87 m	83
Ship Speed	7.2 knot	168	9.8 knot	168
Loading Condition	Full Load	62	Full Load	62
Total		**264**		**325**
Environment				
Ship Type	Container Ship	48	General Cargo	145
Ship length	138.87 m	10	87 m	10
Ship Speed	7.2 knot	12	9.8 knot	12
Loading Condition	Full Load	270	Full Load	270
Total		**339**		**436**
Consequences Index		**Low (2.5)**		**Moderate (5)**

Conclusions

A qualitative approach that combining AHP and Fuzzy Inference System for estimating the consequence of ship due to collision is presented in this paper. Methodology in this paper was applied in ships that operating in Madura Strait. Ship's data was obtained by AIS. From fuzzy inference system, a container ship has a lower consequence based on human safety, structure damage, and environment than the General Cargo. The method in this study may not as validate as simulation method for predicting the ship collision consequence, but this paper presents simplified method of consequence calculation by using AIS data. Consequence index produced by this paper is expected to be used for evaluating collision risk of every ship in larger shipping lane.

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Determining Health Boat Route to Improve Health Care for Small Islands in Derawan Archipelago using Distance and Population Density Consideration

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Keywords: Health boat, health, vehicle routing problem, shipping route.

Abstract. One of the methods to improve insufficient health services in Derawan Archipelago is by building a floating health infrastructure (Health Boat). It requires a method to decide optimal and effective route. Health Boat optimization uses a mathematical method, by considering distance and time shipping, number and condition of the patient based on total population, and optimization of the two variables. That's why from the three routes that are modeled in this study, a route which optimizes both constraint is chosen. To facilitate the discussion, researcher used alphabet in naming the islands. First alternative route is determined based on the distance of the island from Tanjung Batu and the result is: O-A-F-B-D-C-E-G-H-O with total distance is 256.07 nm. Second alternative is determined based on total population and the result is: O-E-F-C-G-A-H-B-D-O with distance is 442.16 nm. The last alternative is determined by a combination and the result is: O-F-E-C-D-B-A-G-H-O with distance is 328.29 nautical miles. Researcher chooses Route III as the optimal route considering distance and total population.

Introduction

The number of islands in Indonesia, according to data from Ministry of Home Affairs of the Republic of Indonesia in 2004, was as much as 17,504 islands. 7,870 of them have names, while 9.634 do not yet have a name. As a maritime country, Indonesia has a coastline of 95.181 km; making it the second country with the longest coastline in the world.

East Kalimantan itself has 363 small islands scattered in some areas and from the data of Directory Small Islands of Indonesia, the data collection of those islands are not finished yet, so the data obtained shows some islands are still uninhabited. From observations, Derawan Archipelago has 31 small islands, only 8 are populated by people, they are Derawan, Maratua, Kakaban, Sangalaki, Semama, Panjang, Balikukup and Kaniungan Besar Island.

The total population in Derawan District that consists of Derawan, Sangalaki and Panjang Island is 1,694 people, in Batu Putih District is 8.171 people, in Biduk-Biduk District is 5,836 people while in Maratua District that consists of Kakaban and Maratua Island is 3,555 people.

Distribution of medical facilities in Indonesia is uneven. Doctors, medical personnel and major hospitals only found in large cities so that citizens in remote island have difficulties to reach these facilities.

Data from the Central Bureau of Statistics District of Berau shows that Berau only have one hospital located in Tanjung Redeb named Abdul Rival hospital which is a Government Hospital in Berau District, type C with 6 types of basic health services and has 170 bed units. From the data of Department of Health of East Kalimantan, the number of people died in Abdul Rival hospital is 309 people in 2014. While the numbers of patients in the Derawan Islands are 777 people in 2013 with the numbers of health facilities are 10 units.

Therefore, it is necessary to build a health care floating facilities (health boat), which provides hospital standards care. This ship has a specific route determined by a mathematical method, Vehicle Routing Problem.

They are several studies on the method of vehicle routing problem, especially in the field of shipping route determination. Zhang, et al. (2015) [1] discuss VRP with the consideration of fuel cost, carbon emission cost, and vehicle usage cost into the traditional VRP problem and establish a low-carbon routing problem model. This research show that the route and vehicle arrangements based on fuel consumption and carbon emission are both economic and environmentally friendly.

Since our goal is to find optimal fixed routes for health boat operation on a regular schedule, our problem falls into the liner shipping category. We consider the strategic problem of creating long term routes that fulfill the demand with as few ships as possible. This problem is strongly reminiscent of the vehicle routing problem (VRP), and indeed most papers dealing with liner ship routing have formulated the problem as a variant of VRP (e.g., Fagerholt, 1999; Fagerholt & Lindstad, 2000; Sambracos, Paravantis, Tarantilis, & Kiranoudis, 2004; Karlaftis, Kepaptsoglou, & Sambracos, 2009).

Jiaotong (2015) has objective that is to determine a Danish tramp shipping company in the tanker business which orders to serve and to find the optimal route for each ship and the optimal sailing speed on each leg of the route so that the total profit is maximized.

Method

I. Research Location

The location used as a case study in this research is Derawan Archipelago. Berau District consists of thirteen (13) districts, including the District of Maratua and Derawan Districts.

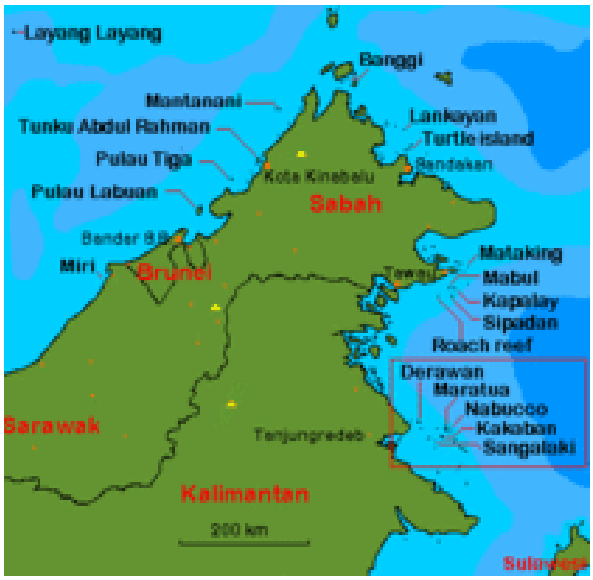


Figure 1. Location of Derawan archipelago.

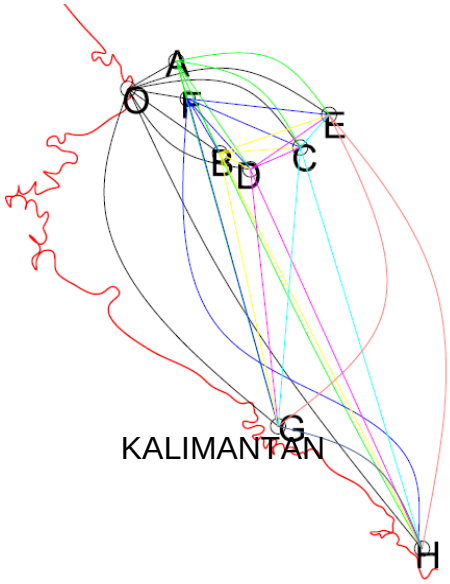


Figure 2. Research object.

The Derawan Archipelago consist of 31 islands and a few sand island (*gosong*) and atolls. From the 31 islands, taken 8 inhabited islands, they are Derawan, Maratua, Kakaban, Sangalaki, Semama, Panjang, Balikukup and Kaniungan Besar. Location of the islands can be seen in Fig. 1 and distances between islands are presented in Table 2. To facilitate the discussion, alphabet is used in naming the islands (Table 2) and provide redrawn map (Fig. 2) so that the operation area of Health Boat is clearly revealed.

II. Preparation of Data

The data needed are the number of population in each small island in East Kalimantan, as stated in Table 1.

Table 1. Total population in Derawan archipelago.

No	Island Name	Total Population (People)
1	Derawan,	1500
2	Maratua,	2818
3	Kakaban,	737
4	Sangalaki,	20
5	Semama	20
6	Panjang	174
7	Balikukup	600
8	Kaniungan Besar	60

However, it was difficult to gather data about number of ill and dead patients in Derawan Archipelago because of lack of information from East Kalimantan Health Ministry.

III. Distance Estimation

The distance between each small island to home base in Tanjung Batu is measured by using the google earth.

Table 2. Derawan archipelago distance matrix.

No	Alp.	Unit (Nm)	Distance Matrix								
		From - To	O	A	B	C	D	E	F	G	H
0	O	Tanjung Batu	0.0	8.5	16.4	31.0	22.9	40.5	8.9	55.7	83.5
1	A	Panjang	8.5	0.0	17.6	22.7	20.7	24.5	4.2	59.0	89.6
2	B	Semama	16.4	17.6	0.0	12.2	6.2	17.0	12.1	45.4	77.0
3	C	Kakaban	31.0	22.7	12.2	0.0	8.3	9.7	20.3	46.8	64.9
4	D	Sangalaki	22.9	20.7	6.2	8.3	0.0	13.8	15.8	45.7	67.0
5	E	Maratua	40.5	24.5	17.0	9.7	13.8	0.0	22.3	51.7	65.9
6	F	Derawan	8.9	4.2	12.1	20.3	15.8	22.3	0.0	53.2	80.8
7	G	Balikukup	55.7	59.0	45.4	46.8	45.7	51.7	53.2	0.0	38.3
8	H	Kaniungan Besar	83.5	89.6	77.0	64.9	67.0	65.9	80.8	38.3	0.0

IV. Mathematical Modeling

We make three routes for the health boat by taking into account the distance and shipping time, the number and condition of the patient, and the optimization of the two variables. The Health boat will return to its home base in Tanjung Batu to resupply equipments and medicines and to change medical personnel on board. We use mathematical models called TSP.

The purpose of the Traveling Salesman Problem (TSP) is to establish a minimum distance in one cycle in which each vertex is visited just once. If the distance is symmetric, the travel distance between locations is not dependent on the direction of travel; this problem is called symmetric TSP problem. Otherwise, the problem is called asymmetric TSP problem.

Mathematically the problem TSP can be described as a salesman who must travel out of town 1,2, ..., n. Distance from town i to town j is dij, for i ≠ j = 1 to n. The salesman wants to embark on a journey to several towns, visit each town exactly once and return to the origin town. The problem is to determine the optimal sequence of the journey, so the total distances will be small.

Suppose that the salesman begins from town 1. If he travels from town to town in order i to i + 1, i = 1 to n - 1, and then from town n to town 1, this route can be represented by the sequence 1, 2, ..., n; 1. That order is called a tour; it has to visit each town exactly once. So the beginning of the tour can be from any town because each town is connected to one vertex. For example, from town 1, salesman can go to town n - 1 or other. So there is n-1 different ways in which salesman can choose which town he wants to visit after town 1. From this town, salesman can go to n-2 remaining town.

So the number of possible tour in n TSP town is (n-1) (n-2) ... 1 = (n - 1) !. The mathematical model of the TSP can be formulated as follows:

$$x_{ij} \begin{cases} 1, \text{if j town is visited from i town} \\ 0, \text{if not} \end{cases} \quad (1)$$

If d_{ij} is distance from i town to j town, the TSP mathematic model is:

$$Minimize\ z = \sum_{i=1}^{n}\sum_{j=1}^{n} d_{ij}\, x_{ij}\ , d_{ij} = \infty\ for\ all\ i = j \quad (2)$$

Subject to:

$$\sum_{j=1}^{n} x_{ij} = 1, i = 1,2,3, \dots n \quad (3)$$

$$\sum_{i=1}^{n} x_{ij} = 1, j = 1,2,3, \dots n \quad (4)$$

$$x_{ij} = (1,0) \qquad i,j = 1,2, \dots, n \quad (5)$$

In determining the optimal route of Health Boat, we need to pay attention to the distance and shipping time, the number and condition of the patient, and the optimization of these two variables.

Result and Discussion

I. Route I

Route I is determined based on the distance of the island from the town of Tanjung Batu which is the home base of the Health Boat. The mathematical model based on data in Table 2 is used to decide Route I. The Health Boat departs from home base in vertex O, and chooses the shortest route from O (the first island), resume to other island using the shortest route and so on.

$$Minimize\ \{X_{OA}, X_{OB}, X_{OC}, X_{OD}, X_{OE}, X_{OF}, X_{OG}, X_{OH}\}, \quad (6)$$
$$x_{ij} = 1, i\ and\ j = 1,2,3, \dots n$$

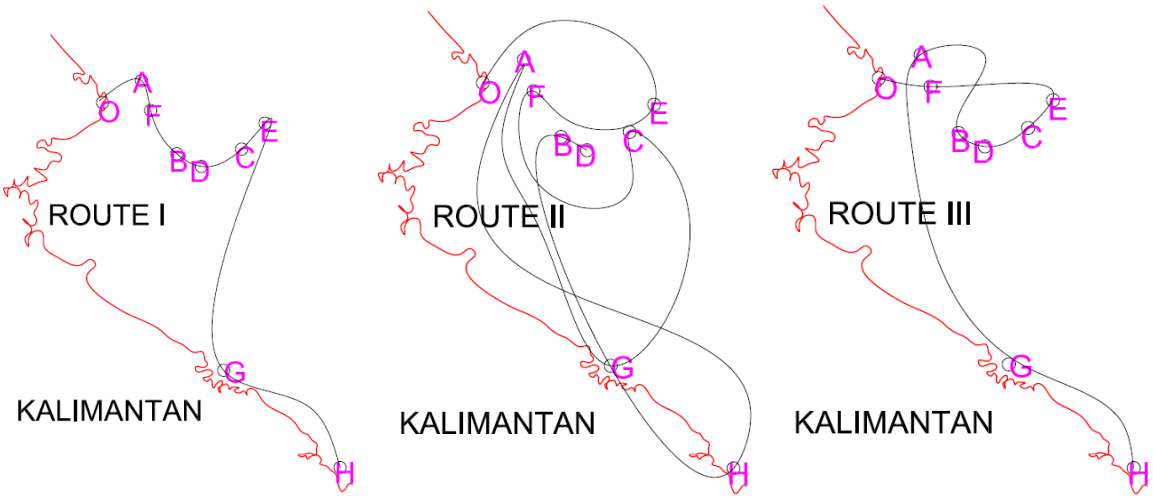
X_{OA} = distance from vertex O to vertex A

From this model, A island is chosen as the first destination, and A is eliminated from next mathematical model because A is the starting island (i),

$$Minimize\ \{X_{AB}, X_{AC}, X_{AD}, X_{AE}, X_{AF}, X_{AG}, X_{AH}\},, x_{ij} = 1, i\ and\ j = 1,2,3, \dots n \quad (7)$$

X_{AB} = distance from vertex A to vertex B

From this model, F island is chosen as the second destination, and F is eliminated from next mathematical model because F serves as the starting island (i), and so on until all the islands is visited exactly once and return to O. The Route I as a result from the calculation is: O-A-F-B-D-C-E-G-H-O and the route can be seen in Fig. 3(1). Total distance of this route is 256.07 nautical miles, the service speed of health boat is 10 knots, so the travelling time is 25.607 hours.



(1) (2) (3)

Figure 3. Result of the route.

II. Route II

Route II is determined based on the number and condition of patients. However, because of the data limitation from the Department of Health of East Kalimantan, we decide to use total population data of each island to decide the route. The Health Boat departs from and returns to O (see Table 2). The Route II as a result from the calculation is: O-E-F-C-G-A-H-B-D-O (see Fig. 3 (2)). Total distance is 442.16 nautical miles, the service speed of health boat is 10 knots, so the travelling time is 44.216 hours.

III. Route III

Route III is determined by a combination of distance and total population of each island. The decision of this route is based on premier data, site visit and interview result of people in Kaniungan Besar island. We got additional information that the time to travel from Kaniungan Besar to Biduk-Biduk District, is the same as the time needed to travel from Balikukup to Batu Putih District, which is only about 30 minutes. Therefore, although Balikukup took the 4th place in term of total population, we decide to visit this island last because of its distance. The Route III as a result from the calculation is: O-F-E-C-D-B-A-G-H-O (see Fig. 3 (3)). Total distance is 328.29 nautical miles, the service speed of health boat is 10 knots, so the travelling time is 32.829 hours.

Conclusions

Of the three routes that are modeled in this study, we have measured the distance for each route. We choose route III because it is the most optimum route in term of time and total population. The Route III has a total distance is 328.29 nautical miles, covering all of 5929 population in 8 islands. The service speed of health boat is 10 knots, so the travelling time is 32.829 hours.

Acknowledgement

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A Study of Ship Ballast Water Management Regulation in Indonesia

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Keywords: Ballast water, ballast water management, IMO, maritime, regulation

Abstract. Regulations that control and manage ballast water are issued by IMO (International Maritime Organization) adopted from ballast water management convention. As of November 2015, the government of the Republic of Indonesia, having examined and considered the aforesaid convention, has decided to accede the same through Presidential Decree No. 132 Year 2015 concerning accession of the international convention for the control and management of ships' ballast water and sediments, 2004. This study aims to analyze the intercourse of Indonesia's law to this convention and the impact caused by implementing ballast water management convention. By using descriptive qualitative analysis method in this study, shows that it will give good impact and there is no need to harmonize Indonesia's law to this convention because the Indonesia's law has already been accordance with it. However, implementing it as national law needs to be supported by the availability of human resources, administrative things, and necessary support facilities.

Introduction

Seas and other water bodies have for long connected human populations, serving as a route for transportation of people as well as merchandise, and today more than 90% of all worldwide trade goods are transported on the ocean [1]. Ballast water contains organisms that are harmful to the environment, human health, property or resources of biodiversity, or interfere with the use of an area if it is released in the sea. The inadvertent transfer of harmful aquatic organisms and pathogens in a ship's ballast water has been determined to have caused a significant adverse impact to many of the world's coastal regions.

There are 110 Indonesian-flagged ships that sail out of the country, a smaller number of ships from abroad who do the cruise and stop by at ports in Indonesia [2]. In 2014 data from the central bureau of statistics show that the number of ship visits in Indonesian ports, cultivated and not cultivated are 863.036 units. This information suggests that the potential for abusing of ballast water discharged from foreign-flagged ships are bigger than Indonesian-flagged ships, so that the implementation of the international convention for the control and management of ships' ballast water and sediment, 2004 is very important.

Indonesia had a problem in ballast water occurred in the bay of Lampung in 2012. There found many species of fish suddenly died. After investigation, it indicated that the incident was caused by the presence of foreign organisms from outside Indonesian waters, coming into the bay of Lampung carried by ballast water on ship. So, good treatment is a must due to threatening maritime ecosystems from organisms in ballast water.

Due to reasons above, the government of the Republic of Indonesia has ratified the ballast water management convention in 2015. This study aims to analyze the harmonization of

Indonesia's law to this convention and the impact caused by implementing ballast water management convention.

Methods

Reviewing the Ballast Water Management Convention. Under the convention, all ships in international traffic are required to manage their ballast water and sediments to a certain standard, according to a ship-specific ballast water management plan.

This convention will require all ships to implement a ballast water and sediments management plan. The convention will enter into force 12 months after ratification by 30 states, representing 35 percent of the world's merchant shipping tonnage. Forty-seven countries have now ratified the convention, but whether the requirement for parties to hold 35% of the world's tonnage has been met is still being calculated [3]. All ships will also have to carry a ballast water record book and an international ballast water management certificate. The ballast water management standards will be phased in over a period of time. As an intermediate solution, ships should exchange ballast water mid-ocean. However, eventually most ships will need to install an on-board ballast water treatment system [4].

The Ballast Water Management (BWM) convention will apply to all ships including submersibles, floating craft, floating platforms, FSUs and FPSOs. It will not apply to:

- ships not designed to carry ballast water
- warships, naval auxiliary ships or other ships owned or operated by a state
- ships only on non-commercial service, or
- ships with permanent ballast water in sealed tanks.

All ships will be required to manage their ballast water on every voyage by either exchanging or treating it using an approved ballast water treatment system. Ballast water treatment systems must have a type approval certificate in compliance with the IMO guidelines for the approval of ballast water management systems.

Table 13. Timetable for installation of ballast water treatment systems.

Ballast Capacity	Years of Ship Construction			
	Before 2009	2009+	2009-2011	2012+
< 1.500 m^3	Ballast water exchange or treatment until 2016. Ballast water treatment only from 2016.	Ballast water treatment only.		
1.500 - 5.000 m^3	Ballast water exchange or treatment until 2014. Ballast water treatment only form 2014.	Ballast water treatment only.		
> 5.000 m^3	Ballast water exchange or treatment until 2016. Ballast water treatment only from 2016.		Ballast water exchange or treatment until 2016. Ballast water treatment only from 2016.	Ballast water treatment only.

Ships participating in a programme approved by the administration may use a prototype technology for up to five years before being required to install an approved treatment system in

accordance with the timetable in Table 1. A prototype system is a system under test and evaluation for meeting or exceeding the requirements of regulation D-2. Below is Table 2 showing the standard for ballast water treatment.

Table 14. IMO D2 standards for ballast water treatment.

Catetgory	IMO Standard
> 50 µm (Zooplankton)	< 10 viable organisms per m^3
10 - 50 µm (Phytoplankton)	< 10 viable organisms per ml
Bacteria	
Toxicogenic Vibrio Cholorae	< 1 cfu/100 ml or
	< 1 cfu/gram wet weight
	Zooplankton samples
E-Coli	< 250 cfu/ 100 ml
Intestinal Entercocci	< 100 cfu/100 ml

Table 2 presents the current IMO D2 standards for ballast water treatment. There is no limitation to the method used to achieve compliance with the D2 standard. The only exception is treatment using an active substance. All active substances have to be approved by IMO, to ensure that the discharge of ballast water treated with an active substance have no harmful effectson the environmentor human health. Whether or not a system uses an active substance is decided by the flag state, in some cases in collaboration with a classification society.

An exemption may be granted to a ship or ships on a voyage or voyages between specified ports or locations, or to a ship which operates exclusively between specified ports or locations. An example of a ship that would qualify for this exemption would be a ferry trading solely between one or more ports.Any exemption granted is valid for a maximum of five years subject to an intermediate review and provided the ship does not mix ballast water or sediments other than between the ports or locations specified in the exemption.

Reviewing Indonesia's law for ballast water management. The substance of the convention further strengthen its effort in protecting of marine environment in the country and in relation to international shipping.

The 1945 Constitution Section 28H of the Republic of Indonesia mandates that a good environment is human and constitutional rights of every citizen of Indonesia. Therefore, the state, the government and all stakeholders are obliged to conduct environmental protection and management in the implementation of sustainable development, so that the environment in Indonesia can remain a source of life and support for the people of Indonesia. Law No. 32 Year 2009 on protection and environmental management explaines that protection and management of the environment means to commit systematically to preserve the environmental function, to prevent pollution and environmental damages that include plan, utilization, control, maintenance, supervision, and law enforcement.

In terms of environmental protection at sea, the Law No. 17 Year 2008 on the voyage and Governmental Decree No. 21 Year 2010 on the protection of marine environment explain specifically that marine environmental protection is any effort to prevent and control pollution of marine environment from shipping activities. Sea transport as a mode of transportation, it also supports, encourages, and provides the growth of areas that have the potential of natural resources, but also has a potential to make pollution and destruction on marine environment as a result of the operation of ships and port activities

To prevent and mitigate pollution and destruction on marine environment as a result of the operation of ships and port activities, it is necessary to establish regulations which is an

integrated system including transport in the waters, port, as well as the safety and security of its waters. In the global order, international maritime community, represented by the International Maritime Organization (IMO) has long been discussing and formulating the aspect of marine environment protection that is consistent with the intent and purpose of the protection on marine environment nationwide, it is the international convention for the control and management of ships' ballast water and sediments, 2004.

The United Nations convention on biological diversity which has been ratified by Law No. 5 Year 1994 states in Article 3 that in accordance with the charter of the United Nations and the principles of international law, each country has the sovereign right to exploit its resources accordance with its own development policies, and the responsibility to ensure that activities within its jurisdiction do not cause damage to the environment of other states or the environment beyond the limits of national jurisdiction.

Ocean resouces should be functionalized to the people prosperity. Article 14 of Law No. 32 Year 2014 on the marine, governing the use and exploitation of marine resources. Utilizationing includes fisheries, energy and mineral resources, coastal resources and small islands, and non-conventional resources. And it can also be either the marine industry, marine tourism, marine transportation and marine construction. Provisions indicate that the use and exploitation of ocean covering many aspects. Social, economic, and cultural using of the sea as a sustainer of life has been carried out by coastal communities and small islands long ago until now. Due to this reason, it is proper to manage ballast water which it could potentially cause damage to ecosystems. In line with the above, the international convention for the control and management of ships' ballast water and sediments 2004, regulates the obligation of the parties to implement the provisions to prevent, reduce, and ultimately abolish the displacement of HAOP (Harmful Aquatic Organism and Pathogens) through controlling ballast water

Ballast water issues in Indonesia. Indonesia is the largest archipelago in the world with 13,466 islands, land area of 1,922,570 km^2 and water area 3,257,483 km^2 [5]. As the world's largest archipelago, Indonesia has great potential to be a global maritime axis. The President of Indonesia giving speech at the 9th East Asia Summit (EAS) on November 13 2014 in Nay Pyi Taw, Myanmar, asserted the concept of Indonesia as global maritime axis so that the development agenda will focus on five main pillars, those are:

- Rebuilding the Indonesian maritime culture.
- Maintaining marine resources and create food sovereignity to fisherman at sea.
- Giving opportunity to insfrastructure development and maritime connectivity by building sea toll road, deep seaport, logistics, shipping industry, and maritime tourism.
- Applying maritime diplomacy, through the enhancement cooperation proposal in the field of maritime and wiping out the sources of conflict, such as illegal fishing, a violation of sovereignity, territorial disputes, piracy, and marine pollution with emphasis that the sea should be uniting the nation not separating.
- Building a maritime power as a form of responsibility to maintain the safety on shipping and maritime security.

Indonesia is also known as a sea coral triangle region, involving the east Indonesia region, Malaysia, the Philippines, Papua New Guinea, Timor Leste, and Solomon Island [2]. Studies show that this region is the richest marine life in the world with more than 600 species of corals and over 3,000 species of fish that sustains life and food for 120 million people living in this region. Healthy marine resources support the marine tourism industry and also protect coastlines from erosion and damage. To maintain the natural resources and to support the efforts of the maritime policies, one of its important factors in the environmental sector is ballast water.

The ballast water issue is the most recent addition to this challange. It requires immediate as well as long-term solutions through regional and international collaborative efforts.

Analysis the impact by ratifying ballast water management convention. As of November 2015, the government of the Republic of Indonesia, having examined and considered the aforesaid convention, has decided to accede this convention through Presidential Decree No. 132 Year 2015 concerning accession of the international convention for the control and management of ships' ballast water and sediments, 2004. The impacts by ratifying this regulation are analyzed by regarding some aspects such as reviewing its ballast water management regulation, Indonesia's law in marine aspects, and ballast water issues in Indonesia.

Result and Discussions

The aims by ratifying IMO ballast water management convention in Indonesia. By ratifying IMO ballast water management convention, there are some aims to be gotten, those are:

- Created a legal constitution for the Indonesian government to protect the environmental sustainability of maritime and river pollution due to discharge of ballast water of ships both Indonesian and foreign-flagged.
- As a basis for monitoring by the port state control officer in examining of foreign ships that enter the territorial waters of Indonesia's jurisdiction.
- As a basis rule of Indonesian rights for a coastal state water management related ballasts, of ships conducting seabed and sub-soil exploration and exploitation activities in Indonesia.
- The presence of international recognition of certificates of ballast water management issued by the government of Indonesia.
- As a party signatory to the convention, Indonesia has the right to participate in the submission of proposed amendments to the provisions of this convention in accordance with the mechanism that has been done.

The impacts caused by implementing IMO ballast water management regulation. As a party to this convention, Indonesian-flagged ships that sail out of the country would be treated in accordance with the provisions of the convention like the coming foreign-flagged ships in Indonesian ports. Ships from countries that are not parties of this convention will have difficulty in getting services at the ports of the parties. In addition, states parties may submit proposals for technical assistance in the development of competencies and human resource capacity related BWM. As a party to this convention, Indonesia reserves the right to inspect the foreign ships by the port state control and issues certificates related to BWM. Participating as a party to this convention will improve competitiveness in the shipping industry. In summary, Indonesia as a party to the BWM convention will receive the following benefits:

- Improve the protection of the marine environment and biodiversity.
- Fully standardized law enforcement related to ballast water management against foreign ships entering the port, or offshore terminal under the jurisdiction of Indonesia.
- Participate in the process of proposing amendments to the BWM convention and its requirements through mechanisms that have been determined.
- Exchange information on the research and development of new, best practices, and

practical experience in the management of ballast water and invasive aquatic species.

- Improve economic competitiveness in shipping industry/ transportation in Indonesia on regional and international levels in order to support government's programs to change in the terms of trade of the FOB export cargo into CIF.
- Reduce the risk of Indonesian-flagged ships sailing detention to foreign countries that have ratified the BWM Convention.
- Prevent Indonesia's waters from being a disposal ballast water area by the others countries who do not ratify the BWM Convention.

The consequences of Indonesia as a party to the international convention must implement the provisions of these conventions and agreements. What should be prepared are:

- Competent human resources, have capability and sufficient quantities to be able to apply the implementation of the convention both in terms of regulators, operators, shipyards, and other stakeholders.
- The national shipping company must fulfill the existing provisions for its ships to ensure good operations, to prepare the equipment, infrastructure, and ideal human resources to develop a system and things related to ship ballast water management.
- Preparing policies for technical regulations through national legislation and the necessary budget for the implementation of this convention.
- Setting up an administrative things such as an inspection certificate and the necessary forms, and technical devices required by the Port State Control Officer (PCSO), or organizations designated (Recognized Organization) including the sailors who operate the device or other necessary support facilities.

Ballast water management regulation in Indonesia. Indonesia has become the latest country or being the 47th to ratify the Ballast Water Management (BWM) Convention, according to the International Maritime Organization (IMO) on 24 November 2015 at the 29th session of the IMO Assembly. As the new one to ratify this convention, Indonesia has no specific authorities and specific national requirements to handle ballast water management for protection and maintenance of native ecosystems, as part of its commitments to global convention. By regarding the aspects stated above, it is given the proposal in the Table 3 as follows:

Table 15. National requirements proposal of Indonesia.

National requirements proposal of Indonesia	
Authority:	The Ministry of Transportation.
Ports affected:	All.
Ships affected:	All ships.
Implementation:	Mandatory.
Start date:	2015.
Acceptable methods:	a) Ballast Water Exchange (BWE): To be conducted in open-sea following the IMO approved methods, i.e., flow-through, over-flow or sequential exchange. b) Treatment system/ ballast discharge standard: Treatment standard in the same as that contained in the IMO Convention-Regulation D-2.
Unwanted organisms and pathogens:	IMO Regulation D-2 and Ministerial Decree No. 29 Year 2014 Section II paragraph 3 Article 49

National requirements proposal of Indonesia	
Sampling:	Sampling of vessels ballast water will be carried out in accordance with Article 9 of the convention.
Ballast water management plan:	All ships are required to be prepared to submit for inspection a ballast water management plan as described by Regulation B-1 of the Convention and Ballast Water Record Book as described by Regulation B-2.
Records and reporting:	Required.
Alternatives to en route management procedures:	1. Normal discharge based on risk assessment taking into account the type of vessel, origin, and risk factors at port of entry, e.g. fish farms; 2. Withholding discharge until analysis of samples found to be free of harmful organims; 3. Ship to proceed to designated area or open sea to exchange balast.
Procedure for unacceptable ballast water:	Ship to proceed to designated area or open sea to exchange.

Conclusions

This research is intended to analyse the intercourse of Indonesia's law to the international convention for the control and management of ships' ballast water and sediment, 2004 and the impact caused by it. By using descriptive and qualitive analysis it could be concluded as follows:

1. This convention will provide corroboration for maritime protection in Indonesia, through the cooperation and support of the international community.
2. By implementing this convention will give positive impacts for Indonesia in environment, human health, property or resources of biodiversity.
3. There is no need to harmonize Indonesia's law to this convention because the Indonesia's law has already been accordance with it.
4. However, implementing this convention as national law needs to be supported by the availability of human resources who are competent, have the capability and sufficient quantities and also the availability of technical policy and administrative things such as certificates of inspection and the necessary forms, and technical devices required by the PCSO as well as devices or other necessary support facilities. In addition, the necessary steps to carry out dissemination to stakeholders in the shipping industry.

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The Navy Harbors Placement Using Binner Matrix Decision Variable and Fuzzy MCDM Methods

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Keywords: Navy harbor, binner matrix decision variable, fuzzy mcdm.

Abstract. Navy Harbor which is located in the region of a country has a very important role as the development of sea power to the operating area. Efforts to control maritime security operations is carried out through activities held by Ships and Navy Harbor as a base of support. This study aims to select the location of Navy Harbor that already exists, with various characteristics of different regions to be developed or increased classification status becomes a main Navy Harbor. Model compiling an application of the theory and method of Binner Matrix Decision Variables (BMDV) is integrated with Fuzzy Multi Criteria Decision Making (Fuzzy MCDM). BMDV is used to select the Navy Harbor by minimizing the number of selected Navy Harbor can cover and replace other Harbor. Fuzzy MCDM methods used to select the Harbor by assessing the weight value of the Harbor by the political, technical and economic aspects. Variables in the Political Aspects include: region vulnerability, sea crime, borders violation and society conflict. Technical aspects include: war ship compatibility, geography, geology, hydro oceanography and port facilities. Economic aspects include: advanced development cost and operations cost.

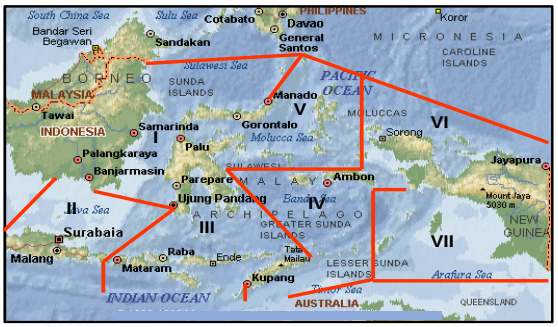
Introduction

Navy Harbor located in the region of a country has a very important role as national defense and security aspect, developing of sea power to a military operations area (Deployment Forces Position), and as "Home Base" which has the function of 5 (five) R, namely: Rest, Refresh, Refuel, Repair and Replenishment. Navy Harbor development requires huge resources. Therefore, we need strategic calculations and considerations to decide the development of a navy Harbor location. According to the author, an important factor in the development of Navy Harbor was influenced by considerations in terms of Political, Technical & Economic aspects as in the figure:

Figure 1. The important aspects in the placement of navy harbor.

Indonesian Navy Harbors

Indonesian Navy divides the working area of its command into two Main Command regions that are Western Fleet Command and Eastern Fleet Command. In this research, the discussion is limited to the Navy Harbor in the Eastern Fleet Command. The Navy Harbor number in the region of Eastern Fleet Command is 26 Navy Harbors, which spread from the Java Sea to the Arafura Sea appropriate in Fig. 2.



Operation sectors	Available Navy Harbors in Sector
I	Makassar, Sangatta, Balikpapan, Tarakan, Palu, Toli
II	Cilacap, Semarang, Banyuwangi, Benoa
III	Mataram, Kupang, Rote, Maumere
IV	Kendari, Ambon, Tual
V	Tahuna, Ternate, Manado, Sorong
VI	Biak, Jayapura, Manokwari
VII	Timika, Aru

Figure 2. Navy operation sectors map and navy harbors.

The Concept of Navy Harbors Placement

The concept of placement is optimizing navy harbor method having the goal to minimize quantity of hub port / navy harbor is needed to serve / cover another navy harbor. The Selected navy harbor will cover another navy harbor thus it will minimize quantity of navy harbor in case of cost saving because the selected navy harbor will be developed as the main navy harbor. According Heragu (1997), set covering appears in a system that has every customer requirement can be reached by at least one facility. Meanwhile, according to Daskin (1995), set covering technique is how to determine the lowest cost of placement facilities, where each demand node can be reached by at least one facility. The second understanding of the above, generally covering technique can be defined as the selection of the alternatives location that exists for the purpose of minimizing the entire factors that influence the restriction that any demand can be reached by the selected location.

The Methods

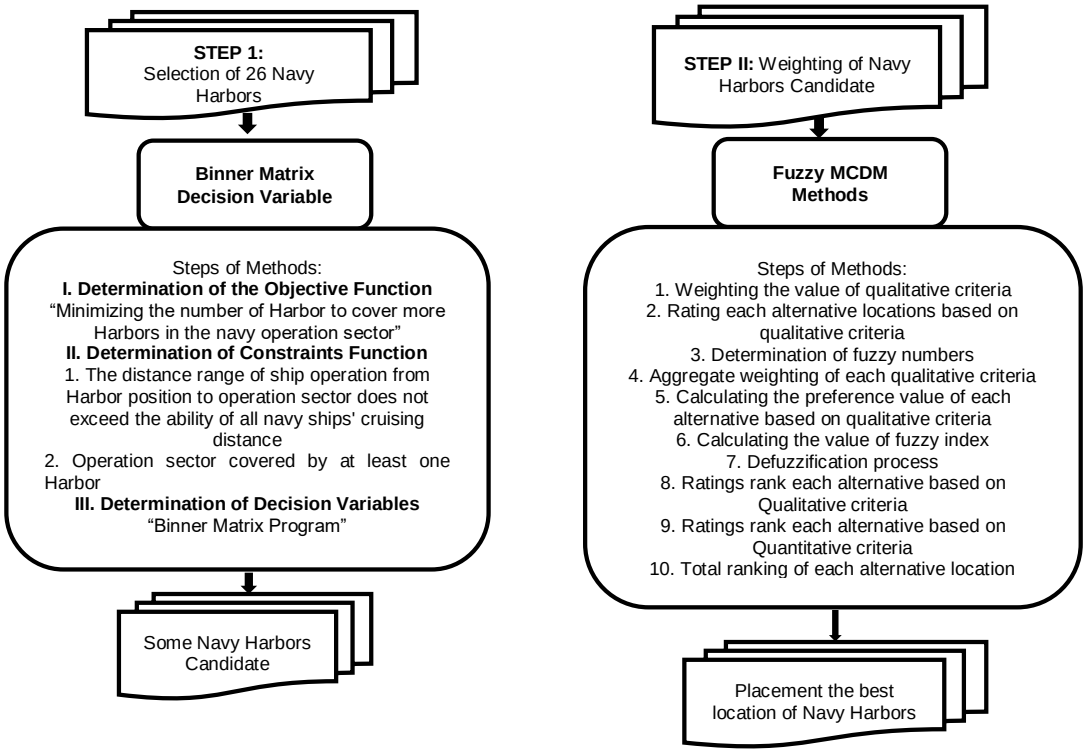


Figure 3. The proposed methodology.

Binner Matrix Decision Variable (BMDV)

The first step of this research is selection of Naval Harbor in navy operations sector with the Binner Matrix Decision Variable (BMDV), the model can be formulated on the following sequences:

- Determining the Objective Function
  1. Minimizing the number of naval harbor-k to cover more naval harbors in the operation sector-j
  2. Maximizing the range operation of the patrol ship in naval harbor -k to operation sector-j

$$Z\ min = \quad Xkj \quad ; \qquad \sum_{k\in K}^{n}\sum_{j\in J}^{n} \quad Zmax = \qquad Dkj \quad \sum_{k\in K}^{n}\sum_{j\in J}^{n} . Xkj$$

- Determining the Constraints Function
  1. The distance range of patrol ship operation from naval harbor position -k to operation sector-j and return to naval harbor-k does not exceed the ability of ships cruising distance endurance (RE navy ship).

$$Dkj \; . \; Xkj \; \leq \; RE \; Navy \; Ship$$

  2. Operation sector -j covered by at least one naval harbor –k.

$$Xkj \; \geq 1$$

Xkj = Naval harbor -k to cover navy operation sector -j
Dkj = Range operation of navy ship in the naval harbor-k to navy operation sector-j then subsequently return to naval harbor -k
RE = Cruising distance of patrol ship in once endurance

In this paper, the creativity and development of the concepts of placement navy harbor methods is an additional program in the form of Binner Matrix Decision Variable. Binner matrix is the decision-making variables that have price value of 0 (zero) or 1 (one). 0 (zero) means that the Navy Harbor (Xkj) is not selected, and 1 (one) means that the Navy Harbor (Xkj) is selected.

Table 1. Binner matrix decision variable.

VARIABLE –k Navy Harbors	VARIABLE –j ; Navy Operation Sectors				
	j-1	.	.	.	j-n
k-1	X 1,1	X 1,2	X 1,3	X 1,4	X 1,j
.	X 2,1	X 2,2	X 2,3	X 2,4	X 2,j
k-n	X k,1	X k,2	X k,3	X k,4	X k,j

The Concept of Fuzzy MCDM

The concept of fuzzy theory was initiated by Lotfi A. Zadeh (1974) with his paper "Fuzzy sets and their applications to cognitive and decision processes". With fuzzy theory it can be shown that all theories can be used as the basic concept of fuzzy or continues membership function. Multi-Criteria Decision Making (MCDM) is a decision-making method which consists of theories, processes, and analytical methods for decision making that involves uncertainty, dynamics, and aspects of the multi-criteria decision. Multi Criteria Decision Making (MCDM) is the terminology used in solving problems whose existence MCDM approach is expected to get the best alternative.

Results and Discussions

The results of the investigation and data process :

- Calculation of Max Cruising Distance (RE) of patrol ship, based on the data: speed, radar range, endurance (E) and cruising distance of patrol ship (S).

Table 2. Calculate max cruising distance (RE) of ships.

No	Ships Code	Speed (knot)	Radar (mil)	E (day)	S (mil)	RE=E*S (mil)
1	AA	14	48	4	336	1.344
2	BB	15	48	4	360	1.440
3	CC	13	48	4	312	1.248
4	DD	16	46	5	384	1.920
5	EE	17	46	5	408	2.040
6	FF	15	46	5	360	1.800
7	GG	23	42	3	552	1.656
8	HH	24	42	3	576	1.728
9	JJ	25	42	3	600	1.800

Calculation of operation sector area, including: the number of harbors in each sector of operation, and sector area of operation which has to be secured.

Table 3. Operation sector area.

Operation sector	Number of Harbors	Sector Area (mil^2)
I	6	248.720
II	5	264.975
III	3	240.900
IV	3	200.070
V	4	232.215
VI	3	245.725
VII	3	256.160

Calculation of navy harbor data, including: the distance between harbors and range of the harbors to the operation sector as starting point for the movement of ships (D).

Table 4. The distance of harbor to the operation sector (D; mil).

Harbors	Sector I	Sector II	Sector III	Sector IV	Sector V	Sector VI	Sector VII
Cilacap	2310	1826	1835	2130	2275	2320	2380
Semarang	2235	1790	2325	2845	2310	2655	2745
Banyuwangi	2357	1820	2490	2575	2375	2690	2875
Benoa	2300	1810	2415	2510	2305	2615	2805
Makassar	1575	2515	2355	2480	2225	2580	2775
Sangatta	1662	2450	2655	2795	2873	2986	2943
Balikpapan	1675	2285	2433	2543	2690	2755	2735
Tarakan	1590	2200	2235	2305	2415	2545	2525
Palu	1660	2250	2386	2255	2425	2505	2495
Toli	1673	2412	2155	2102	2390	2410	2350
Tahuna	1802	2765	3225	2450	2375	2510	2702
Mataram	1835	3750	3115	2640	1401	2245	3675
Kupang	2850	2245	1840	2275	2750	2910	2725
Rote	3225	3310	1865	2560	2975	3275	2775
Maumere	3045	3075	1812	2255	2450	2775	2455
Kendari	2950	2875	1775	2202	2575	2810	2240
Ambon	2775	3211	2655	1535	2277	2550	2470
Tual	3150	3345	2455	1410	1365	2330	1925
Ternate	2975	3424	2375	1455	1390	2290	1990
Manado	2865	3155	2305	2110	1312	2235	2650
Sorong	2245	3576	2648	2020	1377	2285	2780
Biak	2650	3875	2723	2093	1370	1283	2365
Jayapura	2855	3890	2833	2235	2074	1295	2476
Manokwari	3035	3955	2955	2496	2255	1275	2519
Timika	2968	3825	2801	2428	2190	1225	2375
Aru	3105	3765	2791	2393	2154	2775	1390

The data process is done by using **excel solver optimization** program, in accordance with the methodology of this study, which includes the steps:

1. Set the Objective → (Determination of Objective Function)
2. Changing Variable Cell → (Determination of Decision Variable)
3. Subject to the Constrain → (Determination of Constrain)

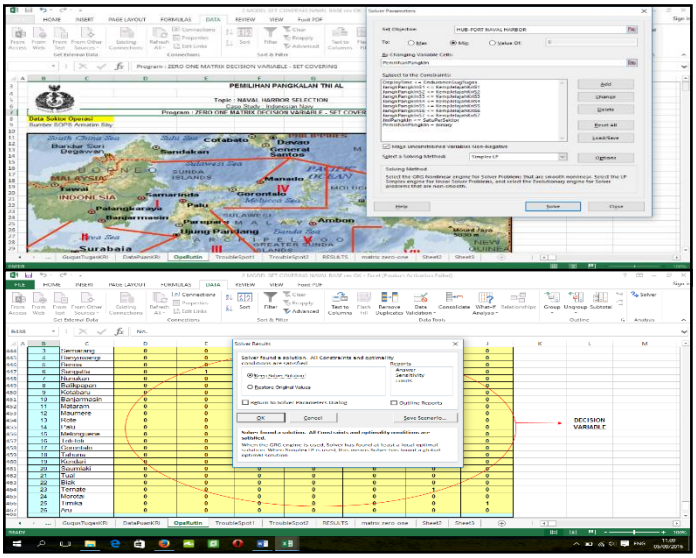


Figure 4. Excel solver optimization program.

The results obtained binner matrix selection navy of Harbor in operation sectors, such as table below:

Table 4. The result of binner matrix decision variable.

Navy Harbors	Decision Variable Of Navy Harbor Selection						
	Navy Operation Sectors						
	I	II	III	IV	V	VI	VII
Cilacap	0	0	0	0	0	0	0
Semarang	0	0	0	0	0	0	0
Banyuwangi	0	0	0	0	0	0	0
Benoa	0	0	0	0	0	0	0
Makassar	0	0	0	0	0	0	0
Sangatta	**1**	**1**	0	0	0	0	0
Balikpapan	0	0	0	0	0	0	0
Tarakan	0	0	0	0	0	0	0
Palu	0	0	0	0	0	0	0
Toli-toli	0	0	0	0	0	0	0
Tahuna	0	0	0	0	0	0	0
Mataram	0	0	0	0	0	0	0
Kupang	0	0	0	0	0	0	0
Rote	0	0	0	0	0	0	0
Maumere	0	0	0	0	0	0	0
Kendari	0	0	**1**	**1**	0	0	0
Ambon	0	0	0	0	0	0	0
Tual	0	0	0	0	0	0	0
Ternate	0	0	0	0	**1**	**1**	0
Manado	0	0	0	0	0	0	0
Sorong	0	0	0	0	0	0	0
Biak	0	0	0	0	0	0	0
Jayapura	0	0	0	0	0	0	0
Manokwari	0	0	0	0	0	0	0
Timika	0	0	0	0	0	0	**1**
Aru	0	0	0	0	0	0	0

Sangatta Navy Harbor (NB1) →to cover operation sectors I & II
Kendari Navy Harbor (NB2) →to cover operation sectors III & IV
Ternate Navy Harbor (NB3) →to cover operation sectors V & VI
Timika Navy Harbor (NB4) →to covers operation sectors VII

The next step in this research is applying Fuzzy MCDM method to get the rank or weighting for placement of Navy Harbor. Data processing is used by fuzzy MCDM algorithm. The weighted Navy Harbors are required as a form of giving priority to the Navy Harbor which will be developed. The Navy Harbors are: Sangatta (NB1), Kendari (NB2), Ternate (NB3), and Timika (NB4). Previously, filling the questionnaire has been done by **6 expert assesors or decision makers (E1 - E6)** who are competent in the field of Navy Harbor. Scale questionnaire is divided into two linguistic scale and a numerical scale. The examples of linguistic scale is "very low", "low", "medium", "high" and "very high", while numerical scale interval of values take 1-10, as the table below :

Table 5 Scale questionnaire.

Aspect / Criteria	Very Low		Low		Medium		High		Very High	
	1	2	3	4	5	6	7	8	9	10

The data process is done by using **Fuzzy MCDM** algorithm, in accordance with the methodology of this study

1. Weighting the results to diagram level assessment qualitative criteria to get the value of the weight aggregates.

No	Criteria of Navy Harbors	E1	E2	E3	E4	E5	E6
A	**Political Aspects**						
1	Region Vulnerability	7	8	9	7	8	9
2	Society Conflict	7	6	7	7	5	8
3	Sea Crime	8	7	7	8	7	8
4	Borders Violation	8	7	6	7	8	7
5	Foreign Countries Threats	6	7	8	6	8	8
B	**Technical Aspects**						
6	Rock Soil Conditions	5	6	7	6	5	7
7	Climate Weather Conditions	6	7	6	7	6	8
8	Environmental Conditions	7	6	8	5	5	7
9	Hinterland Conditions	7	8	7	8	7	8
10	Maintenance Facilities	7	8	8	7	8	7
11	Logistics Facilities	7	5	5	7	6	5
12	Recreational Facilities	7	5	6	7	8	5
13	Hospital Facilities	8	8	8	8	5	8
14	Broad Waters	7	8	8	7	8	8
15	Broad Land	7	7	8	7	8	7
16	Height Location	8	8	8	8	7	8
17	Bathymetry	8	5	7	8	7	7
18	Sea Wave Heights	7	8	7	7	8	7
19	Wind Velocity	6	7	7	6	6	7
20	Tide Water	7	8	8	7	7	8
21	Sedimentation Rate	7	7	7	7	8	7
C	**Economic Aspects**						
22	Development Cost	8	6	7	7	8	8
23	Advanced Operations Cost	7	8	7	8	7	7

2. Diagraming the results of the assessment or preference rating for each alternative based on qualitative criteria.

No	Qualitative Criteria	Navy Harbors	E1	E2	E3	E4	E5	E6
1	Region Vulnerability	NB1	8	7	9	8	8	7
		NB2	8	8	8	8	9	7
		NB3	7	5	7	7	7	6
		NB4	9	9	8	9	9	8
2	Society Conflict	NB1	8	5	7	8	5	8
		NB2	7	7	6	7	6	7
		NB3	8	7	9	8	8	8
		NB4	7	6	7	7	6	6
3	Sea Crime	NB1	7	6	6	6	7	6
		NB2	6	7	7	6	6	7
		NB3	9	9	10	9	9	9
		NB4	5	5	5	5	5	5
4	Borders Violation	NB1	8	6	6	7	8	7
		NB2	7	7	8	9	7	9
		NB3	7	7	7	8	7	7
		NB4	8	8	8	7	8	8
5	Foreign Countries Threats	NB1	7	6	7	6	8	7
		NB2	9	6	8	6	8	9
		NB3	7	9	7	9	8	7
		NB4	9	7	6	7	6	9
6	Rock Soil Conditions	NB1	7	6	8	6	5	7
		NB2	7	8	6	8	7	9
		NB3	8	8	8	8	8	9
		NB4	7	6	7	6	7	6
7	Climate Weather Conditions	NB1	6	6	5	7	6	8
		NB2	7	7	6	8	9	7
		NB3	8	9	8	9	8	8
		NB4	7	6	7	5	8	8
8	Environmental Conditions	NB1	6	7	8	9	5	7
		NB2	7	7	7	7	6	6
		NB3	8	7	8	7	8	8
		NB4	6	7	6	8	5	9

No	Qualitative Criteria	Navy Harbors	E1	E2	E3	E4	E5	E6
9	Hinterland Conditions	NB1	7	8	7	7	8	9
		NB2	5	7	5	8	6	7
		NB3	7	8	7	8	9	9
		NB4	7	7	8	7	5	8
10	Maintenance Facilities	NB1	6	8	8	7	8	8
		NB2	8	9	7	8	8	9
		NB3	9	9	10	10	9	9
		NB4	8	8	7	8	9	8
11	Logistics Facilities	NB1	8	6	5	7	6	7
		NB2	8	7	8	6	8	7
		NB3	8	7	8	8	7	6
		NB4	7	8	7	7	9	8
12	Recreational Facilities	NB1	6	5	6	7	8	5
		NB2	8	6	8	8	7	6
		NB3	6	5	6	7	8	5
		NB4	8	6	8	8	7	6
13	Healthy Facilities	NB1	5	8	8	8	5	8
		NB2	7	6	7	6	7	6
		NB3	8	8	8	8	8	9
		NB4	9	9	8	9	9	8

Figure 5 below shows the data processing result by Fuzzy MCDM methods. Based on the Figure 5 we can analyze that the weighting political, technical and economic aspects criteria are 0.410, 0.320, 0.270, and the weighting final result of Navy Harbors are Timika 0.268, Kendari 0.247, Sangatta 0.245 and Ternate 0.240. This shows that the Timika Navy Harbor is priority developed to be a main Navy Harbor.

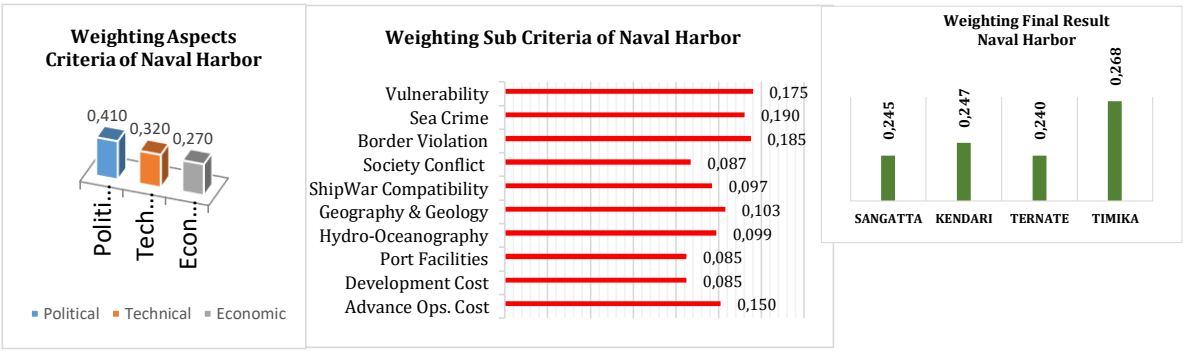


Figure 5. Navy harbor weighting final results.

In general, studies about site priority placement research has a lot to do. Methods for site placement have also been widely applied and developed. Some researchers who have done: Borah et al (2013) conducted a wind turbine site selection optimization with fuzzy logic and GIS system uses three parameters that are qualitative environmental conditions, location and the physical condition of the human factor. Norat et al (2013) conducted a study on the retail site location using GIS and the Analytical Hierarchy Process (AHP). Eylem Koc (2015) did an application of Analytical Hierarchy Process (AHP) in a real world of store location to get a priority development of store location. And then Farahani and Asgari (2006) did a combination of MCDM and covering technique in optimize model for facility location.

The Proposed Methodology in the paper is a development of the theory of covering navy harbor concept and the development of the concept of Fuzzy MCDM. Fuzzy MCDM theory was introduced by Liang and Wang (1994) and followed by Tzeng et al (2008) in paper about Vendor selection by integrated Fuzzy MCDM techniques with independent and interdependent relationships, and the next done by Jie Feng Ding (2013) in paper about selecting hub location for global shipping carrier. The set covering methodology was introduced by Duskin (1995), Heragu (1997), and followed up by Manfaat (1998) in paper about computer-based approach to

the effective utilization of spatial layout design experience and and the next done by Suharyo (2006) developed a set covering theory as part of the navy fleet placement. The creativity and the development of the methods in this research are:

1. The additional program in the form of Binner Matrix Decision Variable in theoretical concept set covering technique of navy harbor placement. Binner matrix is the decision-making variables that have price value of 0 (zero) or 1 (one). 0 (zero) means that the Navy Harbor is not elected , and 1 (one) means the Navy Harbor was selected to provide cover in the operating sectors with the aim of minimizing the hub-port harbor to cover more harbors. Decision 0 or 1 is an integer instead of fractional decision, since the selection of the Navy Harbor is the selection of a unity variables intact as a single Harbor unit.
2. Integration of Binner Matrix Decision Variable (BMDV) with Fuzzy MCDM concept is one form of creativity development methods in this paper. One thing that becomes critical point in site selection issue is suitability method applied to the condition of the real problems in the field. This is the main reason of the integration of these two concepts above. Because in choosing Navy Harbor locations, initial selection should be done is to minimize the number of Harbors in a single sector of operation, wherein the Harbor is selected to represent the Harbor more to cover the area of sector operations with a variable of cruising ship distance, the distance between the harbor and within the harbor to the operation sector. Basic exact method is the development of set covering technique of navy harbor placement methods. The next step is done by analyzing qualitative variables of the political, technical and economic aspects can be solved by the algorithm of Fuzzy MCDM with the results of the weighting and ranking the Navy Harbor candidates.

Conclusions

In this paper, a case study about placement the locations of Navy Harbors was investigated. The main problem in this paper is how to determine the location of appropriate Navy Harbor to be developed into a larger Navy Harbor. The Navy Harbor selected must be able to cover the other Navy Harbors based on the distance of cruising ship, the distance between Navy Harbors, the distance Harbor to operation sector, and by weighting on the political, technical and economic aspect. Variables in the Political, Technical and Economic aspects are: region vulnerability, sea crime, borders violation, society conflict, war ship compatibility, geography, geology, hydro-oceanography, port facilities, advanced development cost, operations cost were assessed.

In this paper, we presented the two-step procedures or methods that in each stage regarding the situation we used different tools and models. The two-step procedures are Binner Matrix Decision Variable including set covering navy harbor, and Fuzzy MCDM methods. The benefits of integrating two methods in this study is indeed simplification of solving problems in the field, because the development of Navy Harbor is unique and complex problem. Various variables are very influential both on quantitative and qualitative in decision-making. Integration of BMDV and Fuzzy MCDM models is able to solve these problems simply and systematically.

Authors' Statement

This paper is the result of the author research for the purposes of education only and development of operations research and modelling science, not a result of the policy of the Indonesian Navy institution, because the data used is confidential. The data in this study has been simulated in such a way, so it can be used for educational purposes only without reducing the substance of modelling and study interests.

Acknowledgements

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Design of Sustainable Ship Recycling Yard in Madura, Indonesia

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Keywords: Madura island, layout arrangement, sustainable, ship recycling.

Abstract. Ships older than 25 years are generally unable to be operated any longer due to new more stringent regulations developed by regulators, such as International Maritime Organization (IMO). When ships get older they become less efficient to be used, therefore ship owners choose to decommission them. The most effective and environmentally friendly solution for end-of-life ships is recycling. The ship's recycling process in Indonesia has not met the standard of existing rules and is not environmentally friendly as well as dangerous to the safety of the workers. The objective of this research is on how to design a ship's recycling yard which complies with all regulations and the existing condition in Indonesia. Aa a case study, the ship recycling yard in Tanjung Jati village, Madura island, in Indonesia is considered. Recycling activities must comply with all regulations and pay attention to the safety of workers as well as ensuring the absence of disadvantages and harmful waste which may pollute soil and the surrounding of seas by providing facilities and proper work procedures. This paper showcases the design of sustainable ship recycling yard with a maximum capacity of 25,000 DWT. All the ship recycling processes are based on the guidelines and the existing conditions. The layout arrangement and technology will prevent, reduce, minimize and pay attention to the safety of workers as well as ensuring proper management and treatment of harmful waste which pollutes soil and the surrounding of seas.

Introduction

The duration of ship operation is approximately 25-30 years. When ships get older not only the operational running costs increase but also they struggle to meet the requirements of new regulations. Recycling old vessels is very important for the renovation of current merchant fleet [1] and for sustainable development of marine industry [2]. In 2002, IMO ventured into new territory by embracing the regulation of ship recycling, bringing new rules for ship owners as well as for ship recycling facilities. One way to make former ship contains economic valuation is through recycling process to put in and reproduce materials from the former ships. Ships are built from a variety of materials and 90% of them are steel. The remaining parts are made from another components composed of hazardous materials to the environment. Nowadays, sustainable ship recycling has been the world's concern. Worldwide within the ship recycling industry, occupational health and safety have been discussed which are controversial topics. In the past, a public image of secrecy, stubbornness and an overwhelming reluctance to change has been felt by the international community from the ship dismantling industry [3]. The poisonous and dangerous cesspit (B3) may be based from various elements of ship's body, among other things, from the used paint, anti-rust materials etc. It may be from the remaning fuel left or shipload as well as from the materials applied in the particular task.

Due to the existing rules, sustainable ship recycling yard is necessary for Indonesia which fulfills the international or national requirements. In Indonesia, there were several ship breaking yards but they did not prioritize the safety of the workers and environment. Therefore, in this paper, a proper layout is designed for development of ship breaking yard into a sustainable ship recycling yard which suits the existing condition in Indonesia.

Sustainable Ship Recycling

According to IMO, ship recycling means the activity of complete or partial dismantling of a ship at a ship recycling facility in order to recover components and materials for reprocessing and reuse, whilst taking care of hazardous and others materials, and includes associated operations such as storage and treatment of components and material on site, but not their further processing or disposal in separate facilities [4]. Meanwhile, the definition of ship recycling yard is a place or facility of ship recycling which granted permit from an authorized party where the shipyard exists [5]. The ship recycling process may be held by beaching or mooring the ships with taking into account the safety and health of persons involved and the impact towards the surrounding environment.

Ships are generally built from a variety of materials and 90% of them is steel. The remaining materials are made from other components in which contains hazardous materials towards the environment. In mitigating hazardous materials requires assessment towards the function of each material. The particular assessment determines the method of continuing management required by the materials. The particular management method consists of:

1. Reuse: Material can be reused by observing the condition and the usage of feasible, simple maintenance may be needed;
2. Recycle: Material can be reused if recycle is being processed in advance;
3. Disposal: Material does not possess economic valuation, thus only disposal process is required.

The Ship Recycling Regulations

1. Basel Convention
   United Nations Environmental Programme (UNEP) Convention in Basel, 2003, also developed ship breaking yard model including activities in each zone. The primary function of ship breaking yard model according to the rule of Basel Convention is: limiting hazardous materials, the continuing segregation place from ship components, the temporary shelter of metal materials and hazardous materials, the closest disposal facility.
2. International Maritime Organization (IMO)
   The role of IMO in ship recycling pointed out by the existance of “Guidelines of Ship Recycling” whereby managing over the procedure for new ships and old ships in the process of ship recycling (identification procedure of hazardous material, the procedure of the making of sustainable transport); the preparatory precedure prior to recycle process, comprises of evaluation and the selection of ship recycling yard, the arrangement of ship recycling plan, the selection of facility and technology within sustainable recycling yard.
3. United Nation Envirenmental Programme (UNEP)
   UNED is a primary organization of the United Nations which works in the field of living environment. The role of UNEP in ship recycling is realised in standard rule over the supervision of the movement of second-hand hazardous materials through “The Basel Convention on The Control of Transboundary Movements of Hazardous Wastes and Their Disposal”.

4. International Labor Organization (ILO)
   Discuss the regulation over the protection for health and safety of workers who involed in the activity of ship breaking.

The regulation is expected to come into force in coming years and it is a concern for Indonesia because the Indonesian fleet is old, but there are no facilities which comply with the guidelines to recycle them [6].

Discussion

1. General

According to observations and field surveys, Indonesia has 3 ship breaking yards which are located in:

1. Tanjung Jati Village, Kamal District, Bangkalan Regency, Madura;
2. Cilincing, Northern Jakarta;
3. Tanjung Uncang, Batam.

The existence of ship breaking industry in Indonesia is still being categorized as ship breaking yard or place where the demolition and the breaking of ship's parts by using beaching method without taking into account environmental aspect and worker's safety. The existence of a ship breaking industry is not well-known in Indonesia. Henceforth, it causes lack of attention by the government for its development. Nowadays, ship recycling industry in Indonesia is only micro enterprise as a provider of services for ship dismantling. Meanwhile, this industry owns a large potential to be developed into an industry with a national scale. The largest ship breaking location in Indonesia is in Tanjung Jati village, Kamal District, Madura Island.

2. Ship Breaking yard in Kamal, Madura Island

Ship recycling industry as the case study of this research is located in Tanjung Jati Village, Kamal District, Bangkalan Regency, Madura Island. This location is selected due to its reputation as the largest ship breaking industry in Indonesia if observed in terms of the amplitude of territory. The geographical situation of this industry is on the shore of Madura Island situated nearly ±1 km from Surabaya-Madura harbor, which is Kamal Harbor.

Figure 1. The location of ship breaking yard in Madura.

This location is around 250 meters away from the western side to the eastern side with the length of 25 meters from the beach. There are 3 points of ship breaking locations. The land territory can be functioned as a camp for workers, the place for equipment and materials in production activity, and transportation access. For worker's transportation nor material handling, a part of the particular location is an empty land which is not being utilized.

The docking process is beaching, thus the flux and reflux impact the process to leverage a part of the ships into the land. The breaking process is held when the ship is in the flux and reflux zone. The ship sunk by maximizing the flux and reflux differences of this ship recycling industry is still using traditional equipment and in limited number to run its production activity. This matter is also being affected by the amplitude of land and unmanaged layout, the steel's

ship breaking used the manual cutting machine with oxy-gas acetylene and LPG. There is no storage and containment system to accommodate wastewater during the process of ship dismantling.

3. Layout Arrangement

The ship recycling layout is based on the location model that had been determined as the reference model. The selected layout model is developed based on the United Nations Environmental Programme (UNEP) Convention, Basel, 2003, which enabled material flow as a primary reference in framing this layout.

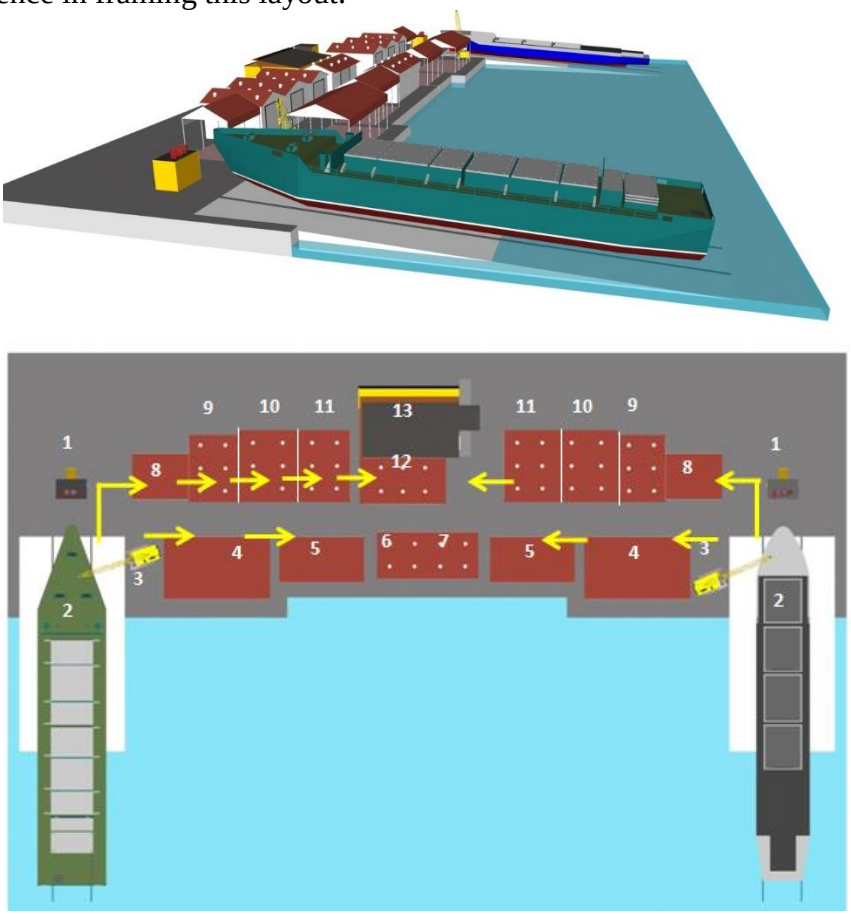

Figure 2. Layout arrangement.

Explanation:

1. Winch
2. Slipway
3. Crawler Mobile Crane
4. Primary Cutting
5. Secondary Cutting
6. Coating and decoating tools storage
7. Scrap storage
8. Sorting area
9. Reused storage (Non ferro and ferro)
10. Hazmat Storage (Liquid and non-liquid)
11. Waste Storage
12. Finishing Material Storage
13. Office

Conclusions

The ship-breaking yard in Madura is a kind of simple business, run by cutting the ship into scrap iron. It can also be seen from the lack of facilities and technologies used during the activities of the cutting process. To develop it into a sustainable ship recycling yard, proper

layout and facilities are required to support the safety of workers and environment. In the present study, the layout is designed based on the flow of material and the geographical conditions with a maximum capacity of 25,000 DWT.

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MARINE TRANSPORTATION AND LOGISTICS

Intermoda Analysis of Cattle Distribution: Case Study of Nusa Tenggara Timur to Jakarta

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Keywords: Cattle distribution, intermodal comparison, livestock vessel.

Abstract. Beef is the main commodity of meat in Indonesia, one of the regions with the highest consumption of beef is Jakarta. Because of the high consumption rate, Jakarta has high demand of cattles which primarily supplied from Indonesia's largest beef supplier region, specifically Nusa Tenggara Timur. However, the shipping condition from Nusa Tenggara Timur to Jakarta does not comply with animal welfare standard. Because of that, the KM Camara Nusantara 1 vessel is operated with the capacity of 500 cattles using Nusa Tenggara Timur – Jakarta route in order to reduce beef price in Jakarta. At the second and third delivery, the vessel is not loaded because the cattle owners prefer to use the old method of distribution. Because of the said reasons, a comparative analysis of the old distribution with livestock vessel method en route Nusa Tenggara Timur to Jakarta is needed. The purpose of this research is to find out the chosen method to deliver cattles from Nusa Tenggara Timur to Jakarta from 3 aspects; (1) the unit cost of shipping, (2) the delivery time from the farm to the slaughterhouse, and (3) the production of the beef. From the chosen method, an optimum operational pattern of cattle distribution from Nusa Tenggara Timur to Jakarta is obtained. The methods used in this research are the comparison and optimization methods by observing influential variables. From this research, the most profitable comparative result for cattle distribution from Nusa Tenggara Timur to Jakarta with the chosen method of using livestock vessel, port to port operation pattern, with Waingapu to Jakarta route for scenario 1 from Tenau Kupang as origin port resulted in total comparison of 9 billion rupiah, and for scenario 2 from Waingapu as origin port resulted in total comparison of 8,9 billion rupiah. With the optimization calculation, port to port operational pattern from Larantuka to Jakarta and from Waingapu to Jakarta is produced, as well as multiport operational pattern of Tenau Kupang - Ende - Jakarta and Maumere - Labuan Bajo - Jakarta. The total of 52 fleet with the capacity of 500 cattles each fleet in a year is needed in a year.

Introduction

Beef consumption reached 19 percent of the total national consumption of beef [9]. Beef consumption is likely rise from year to year. In 2006 reached 4.1 kg/capita/year increase to 5.1 kg/capita/year in 2007 [3]. Jakarta is one of the cities with the highest beef consumption, with an increase in the needs of around 2000 cattles per year. To comply needs of beef in Jakarta, should be get supply from different areas of beef suppliers, one of which namely Nusa Tenggara Timur (NTT) as a production center.

Current conditions are shipping beef from NTT – Jakarta using two alternative deliveries. The first uses a modified general cargo ship on the deck above the cargo, the deck is used to put

cattles, while the second alternative uses a motor sailing boat which then the cattles are transported by truck. The situation causes the cattle only has a limited space, so that 5 concepts of animal welfare is not applied [1]. This causes shrinkage cattle weight up to 20-30 percent or even die during the trip.

Because of this situation, the livestock vessel is operated with adequate facilities to support the needs of cattle. The livestock vessel is operated with the aim that the cattle were shipped from NTT - Jakarta did not experience stress which will affect the production of meat, minimizing the cost and time of delivery of the livestock vessel. This is to reduce prices beef in Jakarta, reducing the risk of death of cattle and shrinkage weight of cattle, and cattle shipments meet international standards[10].

The livestock vessel has been operating for 3 times the delivery of NTT - Jakarta. But the second shipment, the vessel is empty. The cattle owner prefers cattle shipments using the old mode of transportation. Based on these conditions need to do a comparative study of the distribution of cattle between the old condition of the environment with livestock vessels of NTT - Jakarta. Thus, in this study a comparison calculation modes for the distribution of cattle from NTT - Jakarta in terms of unit cost of shipping, cattle production, and delivery time, as well as determining the route of the selected optimum mode. The benefits of this research that provide input to the policy for selecting modes of transport for the distribution of cattle NTT - Jakarta, knowing efficiencies generated by the concept of the distribution of cattle ship cattle from NTT - Jakarta and provide advice to the government as the operating pattern of livestock vessel and for placement fleet of newly constructed livestock.

Analysis and Discussion

A. Scenario

The pattern of cattle distribution in general is cattle shipped from cattle farmers towards the port of origin using trucks with capacity for one truck is 8 cattles for sumba ongole kind with 450 kgs per cattle. Then from the port of origin to the port of destination are distribute using the sea mode with different capacity according to the type of transport. When cattles arrive at the port of destination, the cattle, distributed to the RPH or Slaughterhouses by using trucks with the capacity of the truck is 8 cattles per truck. The cattle directly distributed to RPH due to lack of land in Jakarta and surrounding areas for the process of fattening cattle, in addition the cattles required weight standards have been worth it if the cattle directly slaughtered [8]. The pattern of cattle distribution which is possible if in terms of the possibility of origin port for cattle loading and place destination port for cattle unloading, can be seen in the following image:

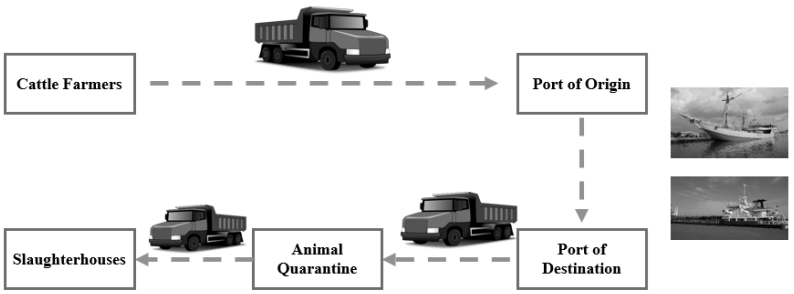

Figure 11. The pattern of cattle distribution in general.

In this research is divided into 2 scenarios based on a port of origin place of cattle loading are scenario 1 Tenau Kupang as a port of origin, and scenario 2 Waingapu as a port of origin.

B. Comparison Factors

Of each scenario obtained comparison analysis results which consist of 3 aspect are delivery time, unit cost of shipping, and comparisons of beef production, with calculation as follows:

1) Delivery Time

The components of total calculation delivery time is as follows:

1. Time from the cattle farmers to the port of origin, including:
   - Speed of the truck
   - Speed of loading and unloading of cattle into a truck
   - Distance traveled
2. Time from the port of origin to the port of destination, including:
   - Voyage time
   - Shipping distance
   - Speed of the ship
   - Speed of loading and unloading cattle
3. Time from port of destination to the slaughterhouses, including:
   - Speed of the truck
   - Speed of loading and unloading of cattle into a truck
   - Land distance

Based on the components of the calculation of the total delivery time, there are several components of the delivery time is negligible in terms of administration, are the process of filing in the office of animal husbandry and agriculture, and quarantine process.

There is a difference component of delivery time based on the mode with the following conditions:

- Process of filing documents in the office of Dinas Peternakan dan Pertanian to obtain licences does cattle weights are required the standards to distributed, the process need around 3 days, whereas livestock vessel facilitated into 1 day [4].
- Loading and unloading Processes based on the speed of loading and unloading. Conditions of loading and unloading of livestock vessel longer if compared to the general cargo ship and sailing boat motor due to better prioritize the animal welfare.
- Cattle's quarantine process is a process that aims to check the condition of the cattles are free from any diseases, the process around 14 days. While livestock vessel facilitated into 2 days to speed up the process of shipping cattle [8].

So obtained the comparison results of delivery time as follows:

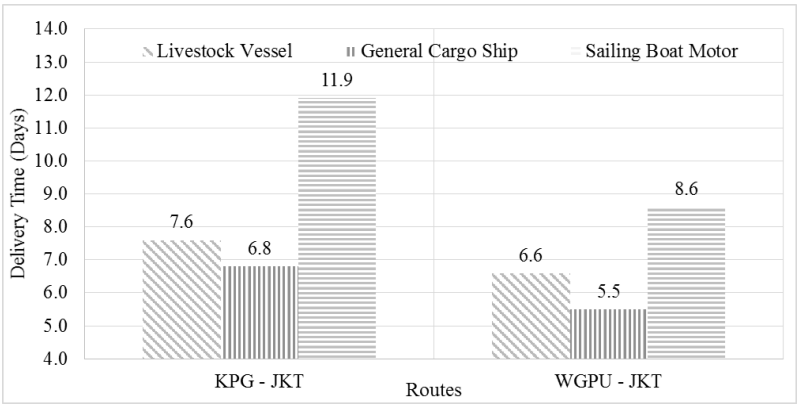

Figure 12. Chart of comparison distribution time of cattle (day/voyage).

From the time comparison can be exchanged by using the opportunity cost is opportunity cost of lost if the item is delayed for several days. So it can be inferred that when shipping goods

longer, then the opportunity cost of lost will be the more expensive items, likewise instead. In conclusion if the item faster to get then opportunity cost is getting a cheaper. With opportunity cost equation as follows:

Equation 1. Opportunity Cost

Opportunity Cost [Rp/cattle] = number of items x Price of item x loan rates (per day) x Long delays of item (days)

From these equations note that:

- The base interest rate of 12% per year credit was made in units of days so be 0.033% per day
- Need of cattle in Jakarta is 8568 cattles per day
- The price of cattle in Jakarta is Rp 14,600,000 per cattle

So obtained the time comparison exchanged to rupiahs:

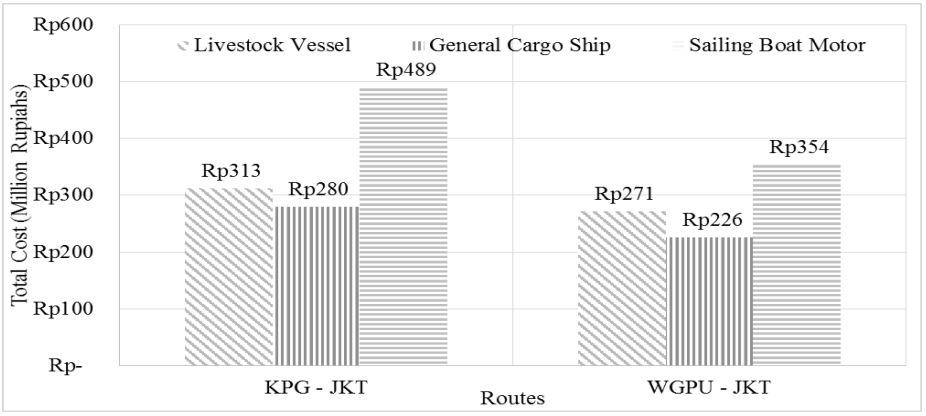

Figure 13. Chart of comparison time in rupiahs (opportunity cost).

From Figure 3 the cheapest is general cargo ship, due to the faster item arrived then the less opportunity cost, and the need for the item immediately fulfilled.

2) Unit Shipping Costs

The calculation of the total time can be calculated the cost required to distribute cattle. Shipping cost calculation components unit consists of:

1. Costs from cattle farmers to the port of origin, include:
   - Cost of hire truck
   - Fuel costs
   - Cost of truck driver
2. Costs from the port of origin to the port of destination, including:
   - Voyage Cost
   - Operational Cost
   - Capital Cost
   - Cargo Handling Cost
3. Cost from the port of destination to slaughterhouses, include:
   - Cost of hire truck
   - Fuel costs
   - Cost of truck driver

So it brings the total shipping cost calculation unit from cattle farmers to slaughterhouses as follows:

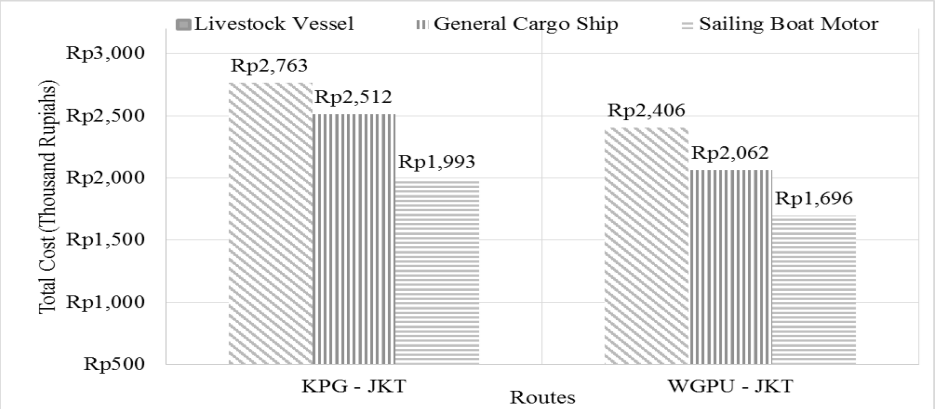

Figure 14. Chart of comparison unit cost of delivery + opportunity cost.

From Figure 4 it can be know that the cheapest unit cost of distribution the cattle from NTT – Jakarta is scenario 1 with the unit shipping costs is Rp 1,993,229.00. per cattle using sailing boat motor, and for scenario 2 with the unit shipping costs is Rp 1,696,269.00.

3) Beef production

Beef production are calculated on the distribution of cattle from NTT – Jakarta seen from several factors shrinking by the turn of the mode, are include:

1. The shrinking distribution of cattles from the cattle farmer to the port of origin, covering the land mode is trucks depending on the time of delivery and treatment during the trip [7].
2. Shrinkage from the port of origin to the port of destination, including:
   - Shrink based on the mode of transportation
   - Livestock Vessel appropriate animal welfare
   - General cargo ship not appropriate animal welfare
   - Sailing boat motor not appropriate animal welfare
3. Depreciation from the port of destination to slaughterhouses, including the land mode is truck depending the time of delivery and treatment during the trip [7].

The factors affecting the shrinkage weight cattle, according to a study conducted in the Division of Agricultural Sciences and Natural Resources, Oklahoma State University [5], are:

1. Feeding Type

The changes experienced by the cattle provided the condition of dry forage as feed on farms will shrinkage by as much as 3.5% after two-hour journey over the shrinking as much as 5.3% in cattles given fresh forage feed is that unlike on farms, the depreciation once for 7 days in transit.

2. Movement of Cattles

When cattle move in a stress conditions, they will shrinkage experience of weight. Is shrinkage every 30 minutes one group of cattles walking on the path, it is estimated will lose weight about 0.5%. This is related to the time taken at the time of loading and unloading cattle because cattle will run in accordance with the length of the heading on the paddock.

3. The Duration of the Trip

Time and distance are important factors. Weight shrinkage occurred when the initial transportation time and increased respectively. A cattle will lose weight as much as 1% of his weight for the first 3-4 hours of travel, and will lose 3% for 8 hours of the next trip if not fed during the trip.

4. Travel Conditions

By the time of loading and travel on short distance can cause shrinkage weights up to 3%. Loading and unloading condition that does not match can also cause excessive movement for more than 30 minutes, which will result in injuries and weight shrinkage. When the cattle is placed with other cattles came from the same farms, the cattles during the trip would feel like on his farm, and will experience shrink of 0.25% each of the 8 hour travel. While the cattle is placed with a cattle that came from different farms, the cattles felt foreign and experiencing the stress so that shrink by 1% each of the 8 hour travel.

So from the components of the calculation on the previous chapter was obtained by comparison of beef production per cattles for distribution from NTT – Jakarta obtained from the calculation of weighting factors of carcass beef produced with the following equation:

Equation 2. Factor of Carcass Beef

Factors of Carcass Beef = cattle's weight (kgs) x 55% x 66% = beef production (kgs) [2]

The equations obtained from beef production as follows:

Based on the Comparison of beef production can be exchanged to rupiahs with calculating the price of beef per kgs. The price of beef per kgs is obtained from: price of cattle per cattle divided by beef production per cattle.

From that calculation obtained beef price in rupiah per kgs, scenario 1 is the cheapest with ports of origin Tenau Kupang using livestock vessel mode with unit cost is Rp 106,000 per kgs, while for scenario 2 with port of origin Waingapu produces the same results with the previous scenario is livestock vessel with the unit cost is Rp 104,000 per kgs. That is because more of the beef produced by a cattle then beef price per kgs for one cattle would be cheaper.

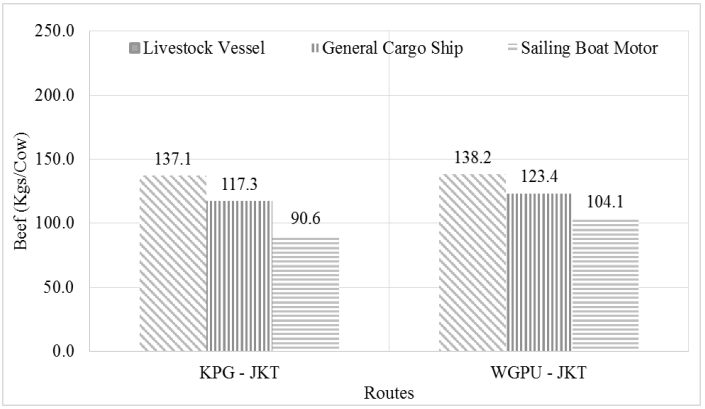

Figure 15. Chart of beef production per cattle based on scenario.

C. The Comparison Result of Selected Mode

From the third component of the calculation above, the selected mode is obtained by converting each component into same unit is converted in rupiahs. So it brings the result of each conversion of each component to the rupiahs and summation of each component based on mode, so the comparison is obtained as follows:

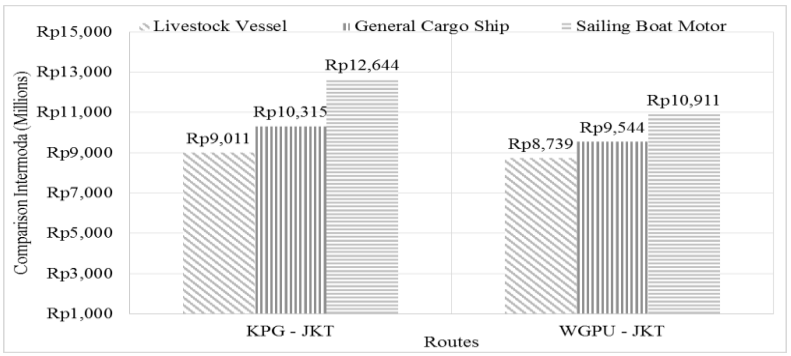

Figure 16. Chart of comparison intermode result in rupiahs.

Comparison of intermode converting each component in comparison to the rupiahs and total for each mode obtained the selected mode. The selected mode is a mode with a minimum of costs from Figure 7 know that from the port of origin Tenau Kupang and Waingapu result comparison of intermode in the same mode is livestock vessel. So it can be inferred the selected mode is livestock vessels, with a minimum cost.

D. The Operation Pattern of Selected Mode

Based on the concept of the model optimization, next can do the creation of capital that can illustrate an idea of how the pattern of operations that produce optimum cost to get minimum unit cost. The optimization performed by utilizing the help (tool) solver. On the model of this optimization will produce ships which will be assigned on a particular route.

In the process of running in the model, an alternative route to compare the multiport and port to port. And the next process, the capital will choose the route where the most optimum to provide value unit cost (Rp/cattles. Nm) minimum in each capital.

Optimization results can be accepted after the running process in the solver results stating that running is satisfied. the statement declared that the results obtained in the optimization process is the most optimum results.

Based on the results of running capital optimization, obtained summary data optimization results as follows:

Table 16. Optimization result.

Routes	Ship Assignment (Decision Variable) Livestock Vessel	Fleet Number Livestock Vessel
R2	1	1
R4	1	4
R16	1	43
R26	1	4

From table 1 is known that optimization results that produce minimum cost is selected alternate routes as follows:

1. Alternative Route 2: Larantuka – Jakarta, the number of ship is needed as many as 1 livestock vessel per year.
2. Alternative Route 4: Waingapu – Jakarta, the number of ship is needed as many as 4 livestock vessels per year.
3. Alternative Route 16: Tenau Kupang – Ende – Jakarta, the number of ship is needed as many as 43 livestock vessels per year.

4. Alternative Route 26: Maumere – Labuan Bajo – Jakarta, the number of ship is needed as many as 4 livestock vessels per year.

Based on the calculation from optimization result shows that the cheapest total cost on the alternative routes 2 due to port to port with total cost is Rp,064,165 9,216, with the amount transported is 5640 cattles per year.

Conclusions

Based on research that has been done then retrieved the following conclusions:

1. The existing condition of cattle distribution from NTT – Jakarta as follows:
   - Comparison using mode prior to livestock vessel are 70% general cargo ship and 30% sailing boat motor.
   - The existing route of mode general cargo ship and a sailing boat motor are from origin port namely Tenau Kupang and port of Tanjung Priok Jakarta as a destination, with a pattern of operation port to port. While operation pattern of mode livestock vessel is multiport with existing route Tenau Kupang – Waingapu – Jakarta.
   - Frequency of the existing shipping can be done for one fleet per year are general cargo ship as many as 48 times, sailing boat motor as many as 27 times, livestock vessel as many as 24 times.
   - Unit cost of shipping the existing mode from origin port to the slaughterhouses using general cargo ship is Rp 1,900,000, sailing boat motor is Rp 1,100,000, and livestock vessel Rp 600,000.
2. The results of the comparison of intermode cattle distribution from NTT – Jakarta are:
   - The cheapest unit cost of shipping are from origin port of Tenau Kupang scenario 1 with the results of the calculation is Rp 1,993,229 using mode sailing boat motor. While from origin port of Waingapu scenario 2 with the results of the calculation is Rp 1,696,018 with the same mode.
   - In terms of delivery time, the fastest time by ignoring the administrative time option are from origin port of Tenau Kupang scenario 1 using general cargo ship with total delivery time 6.8 days, while for scenario 2 with the origin port of Waingapu obtained total delivery time fastest with the results using the same mode is 5.5 days.
   - In terms of beef production, the least experienced shrinkage for scenario 1 with origin port of Tenau Kupang is using mode livestock vessel with cattles weight is 378 kgs per cattles, and the beef production amounted 137 kgs per cattles, while for scenario 2 with a similar mode produced cattles weight is 381 kgs per cattles and beef production amounted 138 kgs per cattles.
   - From the comparison of these three aspects in terms of unit costs of shipping, delivery time and beef production, which converted to the value of the rupiah or cashed the selected mode is livestock vessel with comparison results conversion to rupiah is Rp 9,010,160,084 for scenario 1, Rp 8.900.685.398 for scenario 2.
3. The operation pattern of the selected mode for optimum condition is livestock vessel obtained results optimization are operating pattern of port to port and multiport, with decattles as follows:
   - For the operating pattern of port to port obtained route 2 is Larantuka – Jakarta by the amount of the required fleet per year is 1 fleet and route 4 is Waingapu - Jakarta by the amount of the required fleet per year is 4 fleet.
   - For the operating pattern of multiport obtained route 16 is Tenau Kupang – Ende – Jakarta by the amount of the required fleet per year is 43 fleets and route 26 is Maumere – Labuan Bajo – Jakarta by the amount of the required fleet per year is 4 fleets.
   - Total overall fleet is needed per year is 52 livestock vessels.

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Supply Chains Management in the Planning of BBM (Fuel Oil) Distribution in Anambas Island of Kepri Province

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Keywords: Supply chains management, distribution, fuel oil (BBM).

Abstract. Anambas islands districts in the province Kepri. Problems distribution of fuel oil in Anambas very complex, among others scarcity resulting distribution is uneven and the absence of regulation of the government and relevant agencies, and also the difficulty of access to transport distribution is constrained by infrastructure within the island, demographics resulting in price exceeds the normal price of both fuel and non-subsidized makes no difference. The absence of gas stations (SPBU) and their only APMS (Labor agents Oil and Diesel). It will be solved by applying supply chains management for planning the distribution of fuel (petrol) in order to obtain settlement Anambas and pattern formation / fuel distribution system. Expected equitable distribution planned system and also help the community.

Introduction

The government of Anambas islands is one of the districts that exist in Riau province. The region of Anambas islands is located in 2'10'0" – 3'40'0" south latitude and 105'15'0" east longitude, on the northern part of Anambas islands districts directly adjacent with South China Sea/ Vietnam, on the southern part adjacent with Tambelan islands, on the western part adjacent with South China Sea /Malaysia and on the eastern part adjacent with Natuna sea. Anambas islands ditricts are relying on water trasportation as a transportation that connects an island to the other islands, transportation operations used fuel oil (BBM) that in fact always have a problem to obtain it. This will hinder citizen activities in the benefits of transportation.

Fuel oil scarcity especially in anambas islands when the price become higher or price is higher beyond incident caused by some factor, which are distribution problems about how to manage fuel oil distribution (BBM), what kind of intitutions or instance that affects fuel oil distribution, and how the proper distribution system based regions condition on each district. From some of that factor, each of them gave an impact. Direct impact that could cause by an error in fuel oil distribution system is fuel oil scarcity which resulted in unrest social, and it can cause *panic buying* that could hinder economic and social life. As indirect impact could cause higher price on item price and services related to fuel oil. Another problem is the citizen of Anambas island districts are really hard to obtain fuel oil, especially gasoline because it is not sell freely in this district. Until now Anambas islands district have not had any filling station (SPBU). Even gasoline sold in retail could not be found in Anambas. Citizen obtained the gasoline in anambas from jetty. Jetty does not sell every day and does not has special schedule to sell gasoline. The gasoline sale sells unexpectedly without any notice by the owner of the jetty and the quickest buyer will get the fuel first.

An effective s*upply chain* is a *supply chain* that has planned where the plan started from *supply chain design* continued by implementation and evaluation step and followed by *continous improvement*. According to Schroeder (2000) in rangkury (2004) *Supply Chain*

Management (SCM) is plan, design, and control the flow of material and information along the supply chain with goals customer satisfaction for now and in the future dengan tujuan kepuasan konsumen sekarang dan di masa depan. Acoording to Simchi-Levi et al. (2000) *supply chain management* is an approach in integrating various organizations that organize the procurement or distribution of items, those are *supplier, manufacturer, warehouse* and *stores* until those items are able to produce and distribute in right quantities, right location, right time and the most minimal cost. According to those descriptions, *Supply Chain Management* (SCM) is a method or tools as supervise or manage organization or companies to the flow of material, financial, and information along the supply chain with goals the products and services can be delivered to last user.

Method and Results

Quantitative Descriptive. This analysis used to know or describe tendency of converging data in the form of frequency tables or graphs. Quantitative Descriptive analysis is for presenting findings of data such as the proportion of the number of vehicles and the amount of fuel oil consumption. Method used in vehicle fuel oil consumption calculation is using speedometer and following formula formulation:

IE = KE x JK x HT (1)

Description:

IE = Energy intensity per vehicle per year (Liters/Year),

KE = Energy consumption per Km Fuel mileage (Liters/Km),

JK = Mileage vehicles per day (Km/Day),

HT = The amount of working days in a year (Day/Year).

The formula used to calculate the fuel consumption of fishing vessels in the KKA in this study are (assuming the boat using the sail):

Class III : K = 17,26875 x n (2)

Explanation :

K = Fuel consumption of the whole fishing vessels 17,26875 = Fuel consumption per vessel {720 minutes (12 hours): 128 minutes (2 hours 8 minutes)} x 3.07 liters.

Trend analysis

Trend analysis conducted to estimate fuel needs in the coming year , so the demand planning and fuel supply can be predicted and policy mapping fuel distribution patterns can be done well. One method of forecasting with simple regression line is by using a Least Square method. The equation used in the method of least squares are:

$$\hat{Y} = a + bx \quad (3)$$

where:

Ŷ = The value of variable Y based on the regression line

a = Constant

b = coefficient of linear regression directions

x = independent variable x

As for the equation a and b are:

$$a = \frac{\sum y.\sum x^2 - \sum x.\sum xy}{n.\sum x^2 - (\sum x)^2} \quad (4)$$

$$b = \frac{n.\sum x.y - \sum x \sum y}{n.\sum x^2 - (\sum x)^2} \quad (5)$$

When the coefficient b has been calculated in advance the coefficient a can be determined by another equation.

$$a = \bar{Y} - b\bar{X} \quad (6)$$

$\bar{Y}$ and $\bar{X}$ each are an average for the variable Y and X.

Table 1. Data the amount of vehicles in operation at anambas island districts of the year 2012.

No	Ditricts	Vehicle						
		Taxi Bike	**Water Trans**	**Two-Wheeled**	**Three-Wheeled**	**Four-Wheeled**	**Roda 6**	**Alat Berat**
1	Kec. Siantan (Tarempa)	114	300	2300	25	20	5	0
2	Kec. Siantan Selatan	0	210	127	0	0	0	0
3	Kec. Siantan Timur	0	828	65	3	0	0	0
4	Kec. Siantan Tengah	0	430	125	0	0	0	0
5	Kec. Palmatak	25	995	508	10	30	15	4
6	Kec. Jemaja (Letung)	20	401	525	12	30	15	0
7	Kec. Jemaja Timur	20	101	430	10	10	5	5
JUMLAH		**179**	**3265**	**4080**	**60**	**90**	**40**	**9**

Source: Department of transportation anambas districts 2013

System Distribution and Consumption Pattern of Fuel (BBM) in Anambas Island

The data on the fuel distribution system in Anambas Island are needed to know the strengths and weaknesses of the distribution to obtain a suggestion form the fuel distribution system appropriately in Anambas districts. This data will be processed qualitatively using SWOT analysis. Anambas islands ditricts obtain the fuel oil supply point from fuel oil terminal that is located in Natuna districts by supplier institution that is 3 APMS and 1 AMT. This cause Anambas islands districts have not had any filling station until now.

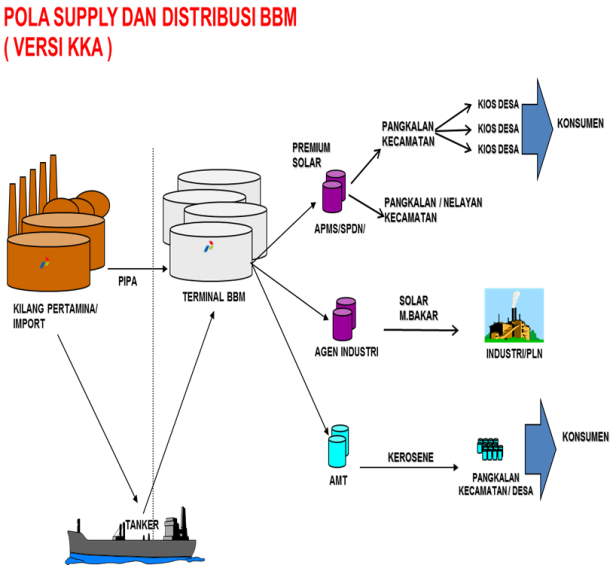

Figure 1. Trend analysis of fuel gasoline requirement in KKA.

Fuel oil supplier who sold kerosene type of fuel also still join with Natuna ditricts. Furthermore, the flow distribution of kerosene in Anambas is as follows:

1. Kerosene Agent BKG / Bandi Tpi Delivery Order (DO) to Pertamina.
2. Obtain approval from Pertamina.
3. Kerosene Agent BKG / Bandi Tpi contact the kerosene jetty in Anambas Island Districts.
4. Kerosene jetty take / transporting kerosene from straits of Lampa depot, then distributed to consumers / citizens.

5. Distribution of allocation kerosene based on kerosene user data filed by the district and registered on the jetty.
6. Taking kerosene on the jetty using control cards incurred by districts

Table 2. The amount of fuel oil requirement in KKA year 2013.

Vehicle	Requirement
Two-Wheeled	1131605
Taxi bike	61747.2
Three-Wheeled	26127.36
Four-Wheeled	3736.314
Speedboat	703258.9
Genset	81490.42
Total	**2007965**

Vehicle	Requirement
Two-Wheeled	1554897
Taxi bike	69644.67
Three-Wheeled	83278.65
Four-Wheeled	4611.524
Speedboat	806397.1
Genset	93441.6
Total	**2612271**

According to the table above, the required amount of gasoline in the KKA in 2013 is 2,612,271 liters / 2612.3 kilo liters per year. This amount does not include the requirement for speed boat and gasoline generator in Central Siantan and Eastern Jemaja. When compared with the quota gasoline fuel in KKA in 2013 that there is a shortage quota 2355,642 256.63 kilo liters on premium fuel in KKA.

After processing the data, obtained an equation Y = 2310118 + 604306X. Based on these equations, the prediction of the requirement gasoline fuel in KKA up to 5 years (2014-2018) are as follows:

Table 3. The amount of fuel requirement in KKA.

Year	Liters	Kilo Liters
Y2014	3518730	3518.73
Y2015	4123036	4123.036
Y2016	4727342	4727.342
Y2017	5331648	5331.648
Y2018	5935954	5935.954

According to the table above, the requirement for premium fuel in 2017 KKA is 5331,648 kilo liter. The pattern of consumption of fuel oil (BBM) in a region greatly influenced by the amount and types of transportation model that are actively operating in the region. The greater the amount of transport operations, the amount of fuel oil (BBM) that is required will be increased. Vice versa, the fewer the number of transportation model operating, the less amount of fuel will be required.

For the distribution pattern will provide information about the distribution channels needed by the region. The distribution pattern is not only influenced by the volume supplies, but also person who behind it, the mechanism of each channel and the channel location. The volume of supplies "enough / more" will make it easier for people to obtain fuel, but not for the seller because it will cause a loss to the costs already incurred.

Easy mechanism and the exact location will encourage customers to come to the channel. The location also can affect the selling price of fuel due to the additional costs incurred according to the distance of the main suppliers.

The flow of supply and distribution systems can still be used to KKA considered infrastructure that support ground transportation between islands. In addition, the distribution system used by APMS to the jetty to be forwarded to the community is a closed distribution system. The distribution system is suitable to distribute subsidized items or certain items that have a limited supply but high demand thus more controllable. The strength factors that support KKA to continue the flow of the supply and distribution system ongoing are: The system has been established which is already available the APMS and well- coordinated jetty. Data about the amout of fuel oil user.

Conclusions

Steps that can be done by KKA to continue the flow of supply and fuel oil distribution system become better that is:

1) Perform another registering of fuel users. The government should provide an accurate database on the number of two-wheeled vehicles, taxi bike three-wheeled vehicle, four-wheeled vehicles, six-wheeled vehicles, heavy equipment, generators, speedboat complete with horse power, fishing vessel complete with horse power, and other facilities that requires fuel. Data is arranged by district and village levels for each vehicle would require a different fuel based on its location.
2) Calculate the fuel requirement. These activities require a plan and the initial steps will be harder but at later steps after the initial data obtained, the analysis will be easier. At the first analysis of the fuel requirement have to conduct a survey related to land and sea transportation systems and the use of heavy equipment. If the initial data has been obtained, the next stages will be easier so this should be considered to implemented in KKA.
3) Determine the stock is safe. KKA requires secure fuel stocks to anticipate in case the supply is slow.
4) Build a storage or fuel storehouses. Storage warehouse can be built on APMS, or by district so that people do not need to store fuel at home.

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Conceptual Design of Livestock Terminal Development: A Case Study of Port of Kalbut Situbondo

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Keywords: Livestock, port conceptual design, cost benefit analysis.

Abstract. One of the central cattle population in Indonesia is located on the island of Madura, particularly in Sapudi Island. From the data obtained from the UPP Kalbut Situbondo, the number of cattle shipments from Sapudi to Situbondo are about 60-70 cattle per week. While shipments during the Idul Adha is up to 100 cattle per week. However, cattle loading and unloading activities at the Kalbut Port is done by a traditional way, by throwing cattle into the sea and then pulled ashore. Unloading process that exist, can be inflict a financial loss to farmers. That process can cause major injuries to the livestock, livestock may also experience weight shrinkage. Development of the port became one of the options to solve the problem. There are three alternative development of the port, that can improve Kalbut Port into standardized Cattle Terminal. The following details show the cost of building for each alternative. Alternative 1, namely the construction of the dock with a construction cost of Rp. 53,259 billion. Alternative 2 is dredging at a cost of Rp 1,894 billion. Alternative 3 is the construction of a floating dock HDPE with construction costs Rp 274.36 million and the construction of two breasting Dolphin with construction costs Rp 1,141 billion. HDPE floating dock construction and breasting dolphin construction (alternative 3), are feasible solutions that can be applied with total construction cost Rp 1,416 billion. Benefit Cost Ratio (BCR) analysis is used to determine the feasibility of development. From the analysis, BCR values obtained is 1,02 in the year 2023. From these results can be concluded that Kalbut Port development into standardized livestock terminal feasible to be constructed.

Introduction

Port of Kalbut, is located in the Semiring village, Mangaran district, Situbondo,Indonesia. This port is providing berthing facilities to small ships that serve Madura islands, such as Kangean, Sepudi and Raas. From the data obtained from the UPP Kalbut Situbondo, the number of cattle shipments from Sapudi to Situbondo are about 60-70 cattle per week. Shipping of cattle will increase by nearly 30% on the eve of the feast of sacrifice (Idul Adha) with the delivery of 100 cattle per week [1]. Loading and unloading activities at the Port Kalbut have less attention to aspects of animal welfare. The loading and unloading of livestock is done by throwing the cattle from the ship directly into the sea without the help of tools or equipments to help the process. After swimming, the cows are collected on the seashore and then forcibly taken to a quarantine area (Fig.1).

Loading and unloading activities of livestock which are not animal welfare standart cause the cow to lose some weight during the process and also potentially injured it [2]. The main purpose of the special terminal namely livestock terminal is to support the increased volume of livestock shipping and distribution, also to promote the animal welfare handling process

procedure. Based on the current condition at Port of Kalbut, the conceptual design of livestok terminal development is needed to support the idea.

Figure 1. Cattle unloading process at port of Kalbut.

Conceptual Design of Livestock Terminal Development

From the data obtained from the UPP Kalbut, mentioned that shipments of cattle from Sapudi Island to Port Kalbut in 2012 was 3,797 cows. This number continues to increase each year and in 2015 amounted to 6,931 cows. Not only serve the activities of loading and unloading livestock, Port Kalbut also serve loading and unloading of passengers and goods. Not only serve the activities of loading and unloading livestock, Port Kalbut also serve loading and unloading of passengers and goods. Ship route from Port Kalbut is heading to the island of Madura Island and also Sapudi and Kangean island. Shipcall in Port most contributed by the passenger ship coming. Forecasting data shows an increase in the volume of shipments of cattle in 2015 amounted from 6,931 to 17, 305 cattle at 2025 (Fig.3).

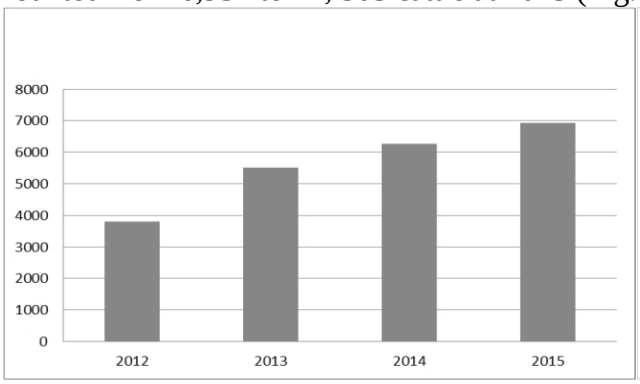

Figure 2. Number of cattle unloading.

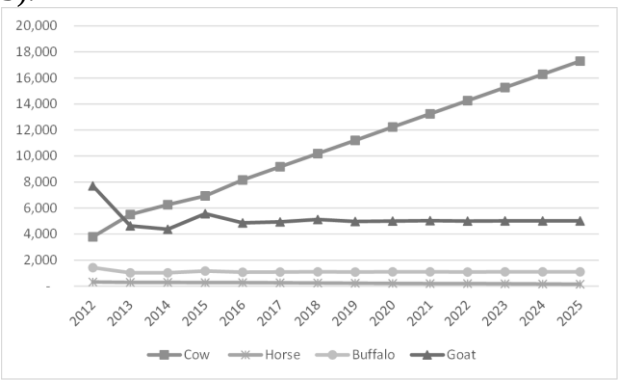

Figure 3. Number of cattle forecasting.

In this research there are three alternative scenarios that are likely to be realized in the development of the Port Kalbut. (1) The first scenario is to construct additional concrete piers, (2) second is dredging the berthing area and (3) third to construct HDPE floating platform equipped with breasting dolphin. The first scenario is the construction of additional concrete piers. This option was made because by build this new pier, livestock ship can directly berth and unloading the cattle into new pier and avoid unloading cattle using traditional ways (Fig.4). The berthing facilities dimension and development cost can be seen on Table 1 & Table 2.

Table 1. Berthing facilities dimension.

No	Item	Unit	Number
1	Jetty length	m	185
2	Jetty width	m	30
3	Pile	unit	222
4	Completion Time	month	12

Table 2. Berthing facilities development cost.

No	Item	Unit	Volume	Unit Price (Rp)	Total (Rp)
1	Structural Reinforced Concrete fc'35 MPa	m^3	5,550	7,500,000	41,625,000,000
2	Formwork	m^2	5,550	272,383	1,511,725,800
3	Reinforcement Concrete inside pile	unit	222	11,340,175	2,517,518,850
4	Pile Procurement	unit	222	20,500,000	4,551,000,000
5	Pile driving	unit	222	7,357,135	1,633,284,000
6	Pile mobilization	unit	222	1,731,544	384,402,720
7	Concrete cover for pile	m	185	1,389,428	257,044,269
8	Fender	unit	13	60,000,000	780,000,000
9	Bollard	unit	13	24,000,000	312,000,000
Total Cost					**53,571,975,639**

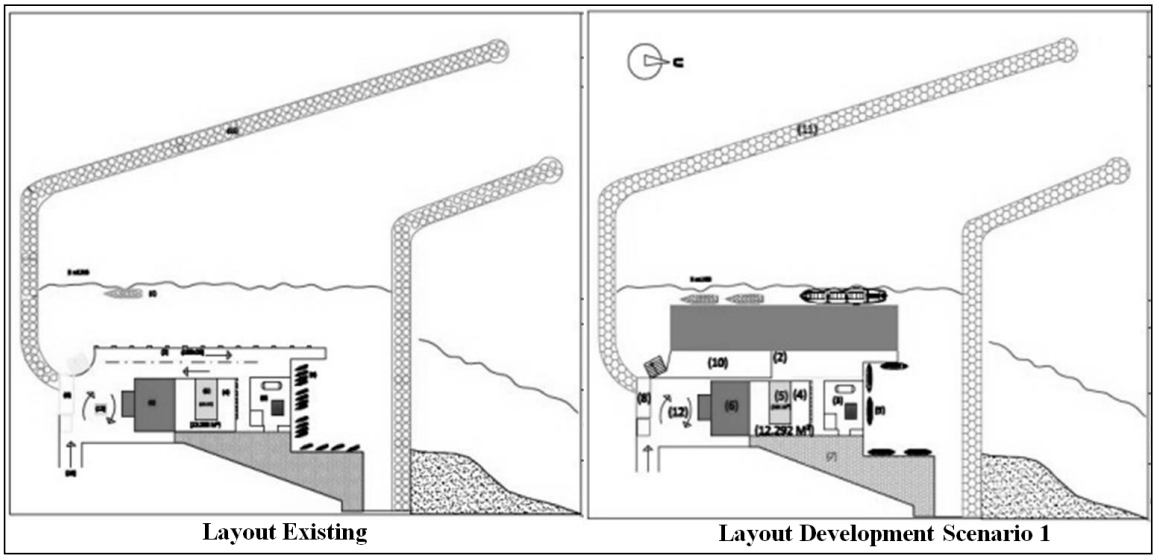

Figure 4. Layout of existing and development of Scenario 1.

The second scenario is to dredge the berthing water area by 1-2 m, using dredging standarize [3]. This option was made because one of the reason why the unloading process of cattle conducted in a way that dangerous to animals, are the cattle ship cannot berth at the pier because the shallow water area in front of existing piers. The dredging dimension and cost can be seen on Table 3 & Table 4.

Table 3. Dredging dimension.

No	Item	Unit	Number
1	Dredging length	m	185
2	Dredging width	m	35
3	Dredging depth	m	3
4	Dredging volume	m^3	19,425

Table 4. Dredging cost.

No	Item	Total Cost (Rp)
1	Preliminary Survey and Sign placement	55,300,000
2	Dredging	673,692,230
3	Pre-dredge Survey	502,472,250
4	Interim Survey	300,000,000
5	Post dredge Survey	256,200,000
Total Cost		**1,894,104,750**

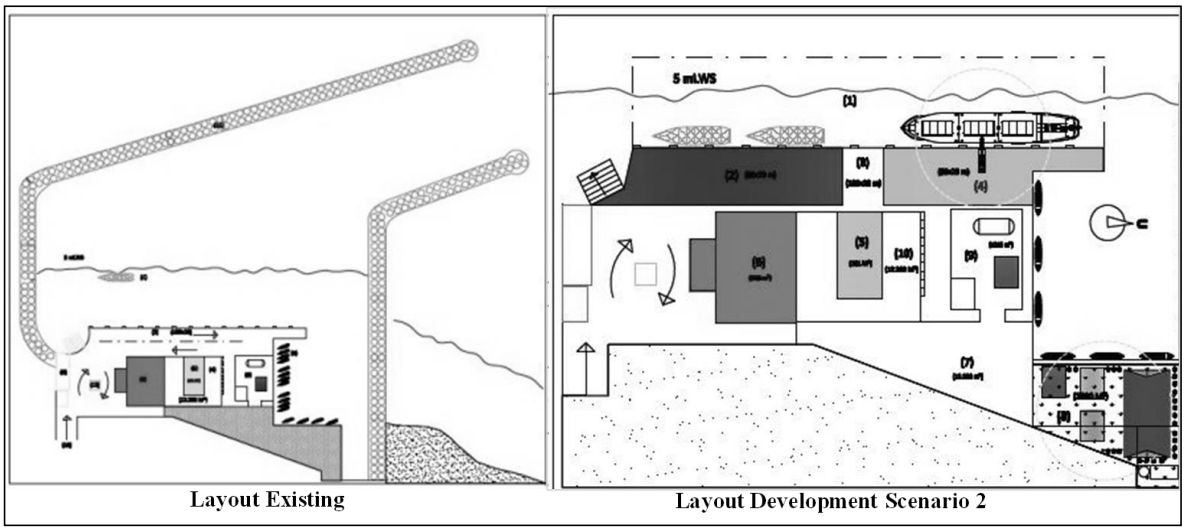

Figure 5. Layout of dredging of Scenario 2.

Floating piers HDPE (High Density Polyethylene) is a third alternative scenario for the development of the port. Floating dock HDPE made to anticipate the tide, so by using a floating pier, the platforms can flexible adjusting its height to the water level elevation. As a berthing facility, floating pier can't receive horizontal load due to moored force from the ship. To overcome that problem, the floating pier will be equipped with berthing and mooring dolphin (Fig.6). The dredging HDPE specification, dimension and cost can be seen on Table 5, Table 6 Table 7 and Table 8.

Table 5. Specification of HDPE floating pier.

No	Item	Number	Unit
1	Material	HMW HDPE	-
2	Dimension	500 x 500 x 400 (P x L x T)	mm
3	Weight	7	kg
4	Buoyancy	350	kg/m2
5	Lifetime	20	years

Table 6. Construction cost HDPE floating pier.

No	Item	Unit	Volume	Unit Price (Rp)	Total (Rp)
1	Floating Cube HDPE	pcs	186	1,300,000	241,800,000
2	Cattle way fence	m	5,550	130,000	7,280,000
3	Passenger way fence	m	222	130,000	7,280,000
4	Worker	ls	1	1,300,000	18,000,000
Total Cost					**274,360,000**

Table 7. Construction cost berthing dolphin.

No	Item	Unit	Volume	Unit Price (Rp)	Total (Rp)
1	Structural Reinforced Concrete fc'35 MPa	m^3	75	7,500,000	562,500,000
2	Reinforcement Concrete inside pile	unit	12	11,340,175	136,082,100
3	Pile Procurement	unit	12	20,500,000	246,000,000
4	Pile driving	unit	12	7,357,135	92,358,000
5	Pile mobilization	unit	12	1,731,544	30,876,000
6	Fender	unit	2	13,000,000	26,000,000
7	Bollard	unit	2	24,000,000	48,000,000
Total Cost					**1,141,816,100**

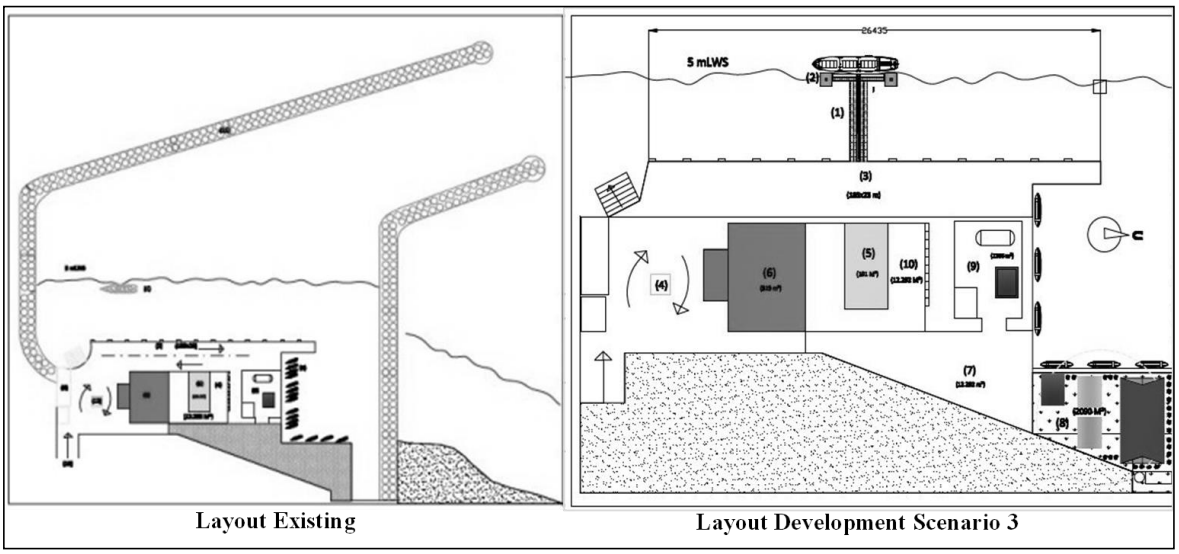

Figure 6. Layout of HDPE floating piers Scenario 3.

The evaluation focused on the loading and unloading system of livestock that is incompatible with the animal welfare, that is by thrown into the sea. Layout in Fig.4 are garbarata that designed as an equipment to transfer cattle from ship to shore. The garbarata is equipped with a crane to set the height of garbarata to fit the cow height that exit from the ship. And also digital scales to determine the weight of cattle on arrival in port. In the picture is the dimension of garbarata are based on the size of Madura cattle in general [4].

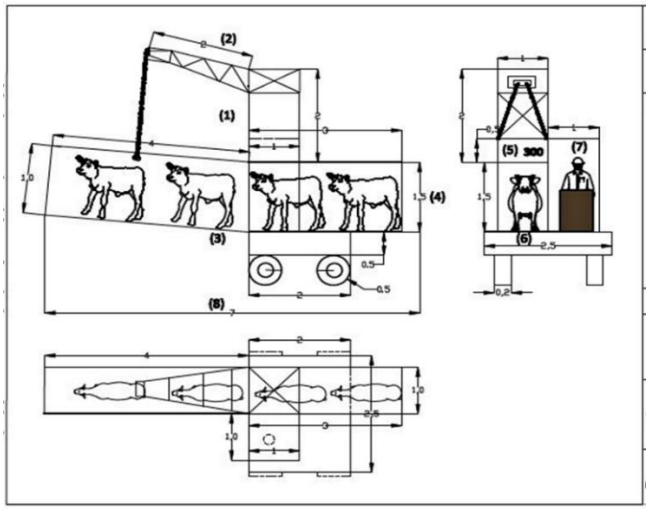

Figure 7. Design of garbarata for cattle.

Table 8. Dimension of garbarata.

No	Variable	Size	Unit
1	Garbarata Length	7	m
2	Garbarata Height	1.5	m
3	Garbarata Width	1	m
4	Number of crane	2	bh
5	Crane height	2	m
6	Crane length	4	m
7	Crane width	1.5	m

Cost Benefit Analysis

Cost Benefit Analysis is very general analysis that used to evaluate feasibility of government projects. Cost benefit ratio (CBR) is an indicator of decision-making, which the CBR <1 model is not feasible, CBR> 1 models feasible, and CBR = 1 model does not make an impact, so it is necessary to consider other things to decide the model is feasible or not.

a) Cost

Kalbut port developed with three development alternatives,are construction of additional concrete pier with an investment of USD 31 652 billion, development of the port by dredging with an investment of Rp 1,894 billion and port development with the construction of a floating dock HDPE and breasting dolphin with an investment of Rp 1,416 billion. From all of these alternatives, the selected port development by considering the minimum cost is the construction of a floating dock HDPE with breasting dolphin.

b) Benefit

In the development of the Port Kalbut, there are some parties who get direct benefit from this activities include: shipper / consignee, forwarder, passengers, and Port Kalbut itself. The benefits derived from these cattle port development are:

i. Minimize the risk of livestock losses due to loading and unloading that is not meet the standard of animal welfare, cause increasing the cost of care

ii. Minimizing the cost of depreciation of cattle. Benefit calculation is based on calculations derived from the benefits gained from the development of port. Before the development of the port, the additional cost, comes from maintenance costs due to the activities of loading and unloading of livestock that is incompatible with the concept of animal welfare. Depreciation costs of livestock because of weight loss occurs because of transportation and loading and unloading activities of livestock. Depreciation costs are taken by the percentage is approximately 2.5% of total body weight.

c) Cost Benefit ratio

From the CBR analysis that has been done, it can be concluded that in the year of 2023 benefited from the development of this port can be much more than development costs incurred. This may imply that in the medium and long term, investment in the development of this port can provide benefits for all parties.

Table 9. Cost benefit ratio.

Tahun	Total Cost (Rp)	Total Benefit (Rp)	CBR
2016	1,416,376,100.00	775,627,500	0.55
2017		872,109,500	0.62
2018		968,591,500	0.68
2019		1,065,073,500	0.75
2020		1,161,555,500	0.82
2021		1,258,037,500	0.89
2022		1,354,519,500	0.96
2023		1,451,001,500	1.02
2024		1,547,483,500	1.09
2025		1,643,965,500	1.16

Conclusions

Based on the analysis that has been done, some of the conclusions of the analysis are:

1. The construction of a HDPE floating pier and breasting dolphin, is the most appropriate development scenario from an economic standpoint as well as efficiency. The total

investment cost Kalbut Port development with the construction of a floating dock HDPE and breasting dolphin Rp Rp 1,416 billion (scenario 3)

2. The layout development of new docks, is with establishment floatiang head jetty pier with dimensions of 20 m long and wide and 2 m. Floating Pier linked to the existing pier by a trestle along 28 m and a width of 5 m. Trestle has two functions, namely livestock and passenger lines, which is fenced on both sides with a total length of fence 56 m. Dimension of 2 breasting dolphin square shape with each cover are 25 m² and using the slab structure on pile
3. The value of Cost Benefit Ratio (CBR) is 0.49 in 2016 and increased to 1.03 in 2025. From the results of the CBR analysis, the Port of Kalbut is feasible to develop using scenario 3

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Transportation Model of POME (Palm Oil Mill Effluent): A Case Study of Palm Biogas Power Plant in Riau

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Keywords: transportation, Palm Oil Mill Effluent (POME), palm biogas power plant, Riau

Abstract. 78% of Tandun Biogas Power Plant source of energy is from Palm Oil Mill Effluent (POME), supplied by two palm oil manufactures. Those two manufactures are palm oil manufactures Sei Pagar and Tanah Putih. Each of the manufacture can supply 60.000 tons and 30.000 tons POME per year, so that it will cover the main material of electrical power production in Tandun Biogas Power Plant. The purposes of this research are to reccomend the optimum transportation model for the distribution of POME from manufacture to power plant, whisch include problems of optimum route, type of ship, main dimension, cost and intermodal with minimum cost as criteria. The result show that the optimum transportation model for POME distribution is using Self Propelled Oil Barge (SPOB) with 1.500 tons capacity in each alternative routes. Regarding the optimization results, "port to port" have been decided as optimum route, Self Propelled Container Barge (SPCB) and Landing Craft Tank (LCT) have higher total cost in comparasion with SPOB. SPOB remain optimum even if it compares with Tanker Trucks. The total cost of transportation model that have been chosen is around Rp 8.035 millions. Tons of POME which have been supplied will turn into 9 millions kWh electricity units and it become Rp 8.775 millions of revenue.

Introduction

This year, palm oil industry productions in Indonesia had been predicted increase rapidly. Indonesia is one of the big three palm oil exporter in the world with Brunei Darussalam and Malaysia. Almost all of Indonesia's surface produce palm oil, although, the highest palm oil productions are in Kalimantan and Sumatera.

Both side effects, positive and negative, had been occurred because of increasing number of palm oil manufactures. Obviously, the palm oil production will increase as a positive effect. However, the amount of residues from the chemical process will also increase. The residue of palm oil manufacturing divide into two types which are liquid residue and solid residue. The liquid residue, called a Palm Oil Mill Effluent (POME), is not hazardous subtance, but it contains methane gas which causes green house effect.

A few years later, methane gas of POME had been defined as a benefical subtance if it process in its procedures. This result in Chemical Oxygen Demand (COD) forming which leads to electricity resources. To begin with, methane should be filtered by purification method in order to produce electricity.

Those research results become a reason to build biogas power plant so that POME could be recycled. In recent years, there are many biogas power plants, named PLTBG, had been built in Nort Sumatera, Riau and Jambi. There are five of them in Sumatera. This issue had been heard by the government and they believe that it must be the best solution to maintains environment from damage.

There are many palm oil fields and manufactures spread all over Riau and its islands. So, it becomes an excuse to find the most optimum transportation model of POME from palm oil manufactures to biogas power plants. Depend on the fact that current transportation model of POME which is used inland transport, the researchers try to make a comparasion what if use inland waterways to distribute POME. This research will give solutions for transportation model use inland transportation waterways in Riau.

Transportation Model Analysis

Palm oil manufacturing produces two types of residue which are liquid residue and solid residue. The picture below provides data of the amount of each residue that occurs from manufacturing process. From 1 ton TBS (fresh fruit bunch) of manufacturing process produce around 600-700 kg POME, 190 kg of palm fibers and shells, and 230 kg TKKS (empty fruit bunch) (Fig.1). The biogas was produced from liquid residue of palm oil manufacturing and it converts into electricity in PLTBG [7].

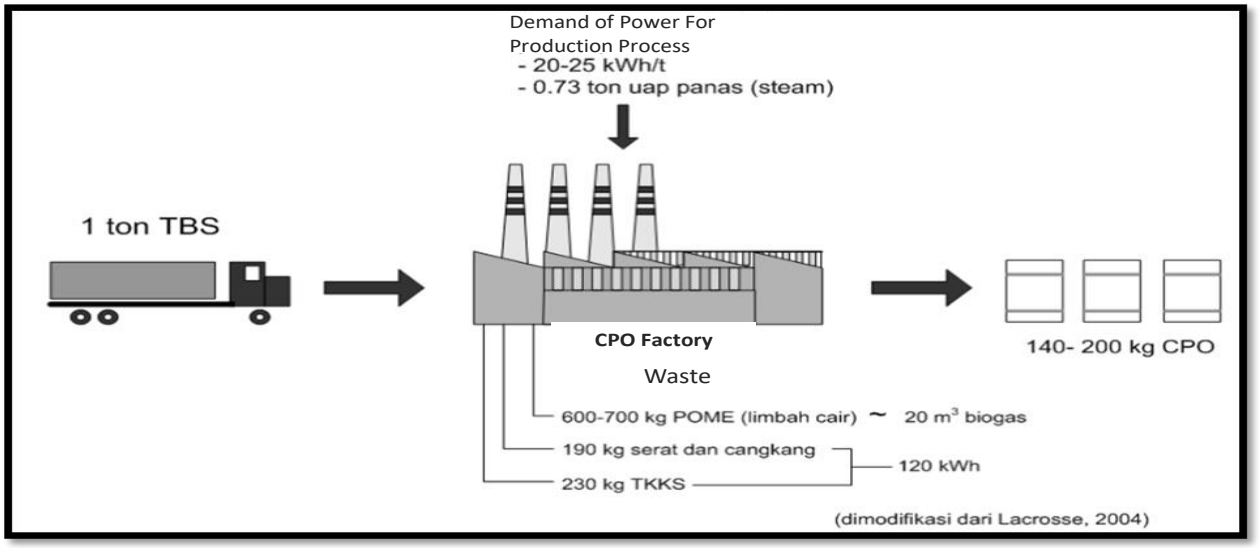

Figure 1. Palm oil manufacturing.

Supply and Demand Analysis

The capacities of palm oil manufactures in the distric is shown on this table 1 below.

Table 1. Location and capacity of PKS.

No	District	Palm Oil Manufactures	Capacity (Ton TBS/Hour)	TBS Production (Ton/Day)	POME Production (Ton/Day)	Density (Ton/m3)	Volume (m3/Day)
1	Kampar	Sei Galuh	60				
2	Kampar	Sei Pagar	30	150	90	0,9	100
3	Kampar	Terantam	60				
4	Kampar	Sei Garo	30				
5	Kampar	Tandun	40	200	120	0,9	133
6	Rokan Hulu	Sei Rokan	60				
7	Rokan Hulu	Sei Intan	30				
8	Rokan Hulu	Sei Tapung	60				
9	Rokan Hilir	Tanah Putih	60	300	180	0,9	200
10	Rokan Hilir	Tanjung Medan	30				
11	Siak	Sei Buatan	60	300	180	0,9	200
12	Siak	Lubuk Dalam	45				
Total Capacity			565				

PLTBG Tandun had been supplied by palm oil manufactures Tandun since the first operation, but only 22% of the total demand that had been covered by it, about 36.000 tons POME per year. As the result, PLTBG Tandun need 129.564 tons of POME per year to maximize its productivity. Depends on location and capacity of each palm oil manufactures , there are 3 most possible palm oil manufactures that will cover 78% demand of PLTBG Tandun which are palm oil manufactures Sei Pagar, palm oil manufactures Sei Buatan and palm oil manufactures Tanah Putih. Those palm oil manufactures is located near a river.

Ship and Route Alternatives

Transportation Model of POME in this research use inland waterway transport. The ship will sail through rivers. There are 3 rivers in this route, they are Rokan Hilir, Siak and Kampar river. The alternatives route is shown on this picture below.

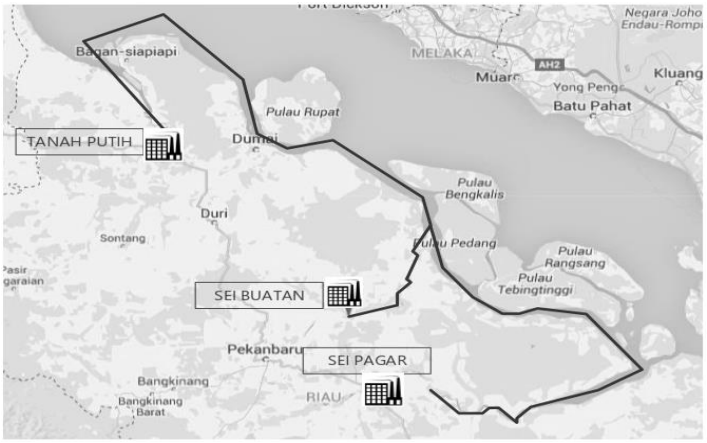

Figure 2. Alternative route map.

PKS Sei Buatan had been decided as hub port (destination), so palm oil manufactures Sei Pagar and palm oil manufactures Sei Tanah Putih become origin port. The transhipment was caused by PLTBG Tandun location which is in the center of Riau.

a. Route A1 :
   palm oil manufactures Tanah Putih (O) – palm oil manufactures Sei Buatan (D)
b. Route A2 :
   palm oil manufactures Sei Pagar (O) – palm oil manufactures Sei Buatan (D)
c. Route B :
   palm oil manufactures Tanah Putih (O) – palm oil manufactures Sei Pagar (O/D) – palm oil manufactures Sei Buatan (D)

Alternative ships that have been use are Self Propelled Oil Barge (SPOB), Self Propelled Container Barge (SPCB) and Landing Craft Tank (LCT).
The optimization process in this research determine optimum main dimension of the ship to get minimum total cost. Definitely, the optimization result decide what type of ship and which route is optimum for POME distribution in Riau.

Mathematic Model

Objective Function
Minimum TC = $\sum_{i=1}^{3} TC_i . X_i$
where,
TCi = Ship total cost,
$TC_i = RT_i . VC_i + N_i . FC_i$
VCi = Ship voyage cost,

$VC_1 = FOC_1 + PC_1$
$VC_2 = FOC_2 + PC_2 + ISO_2$
$VC_3 = FOC_3 + PC_3 + ISO_3$
FCi = Ship fixed cost a year (time charter hire),
PC_1 = Port cost,
ISO_i = ISO Tank charter cost,
N_i= Number of ship,
RT_i = Number of ship roundtrip,
X_i = binary ; 0 or 1
; i = 1, 2, 3 (1=SPOB, 2=SPCB, 3=LCT)

Decision Variable
P_i= Ship Payload i,
; i = 1, 2, 3 (1=SPOB, 2=SPCB, 3=LCT)

Constraint

$$\sum_{i=1}^{3} X_i = 1$$

DWTi =110%.Pi
; i = 1, 2, 3 (1=SPOB, 2=SPCB, 3=LCT)

Optimization Result

Route A1, in this route, the ship sail from PKS Tanah Putih (origin) to PKS Sei Buatan (destination). The distance between these two port is 252 nautical miles. It takes 45,34 hours for a trip with average velocity around 50% of 11 knots.

Figure 3. Route A1 (port to port).

The optimum payload of each alternative ships in this route are 1.500 tons for SPOB, 45 TEUs for SPCB and 37 TEUs for LCT. Self Propelled Oil Barge had been chosen as the most optimum ship that cost around Rp 4.909 millions. Number of ship needed in this route is one ship only.

Route A2, In this route, the ship sail from PKS Sei Pagar (origin) to PKS Sei Buatan (destination). The distance between these two port is 291 nautical miles. It takes 52,44 hours for a trip with average velocity around 50% of 11 knots.

The optimum payload of each alternative ships in this route are 1.500 tons for SPOB, 45 TEUs for SPCB and 37 TEUs for LCT. Self Propelled Oil Barge had been chosen as the most optimum ship that cost around Rp 3.125 millions. Number of ship needed in this route is one ship only. The optimization result shows that the most optimum ship to distribute POME is Self Propelled Oil Barge (SPOB) with port to port route.

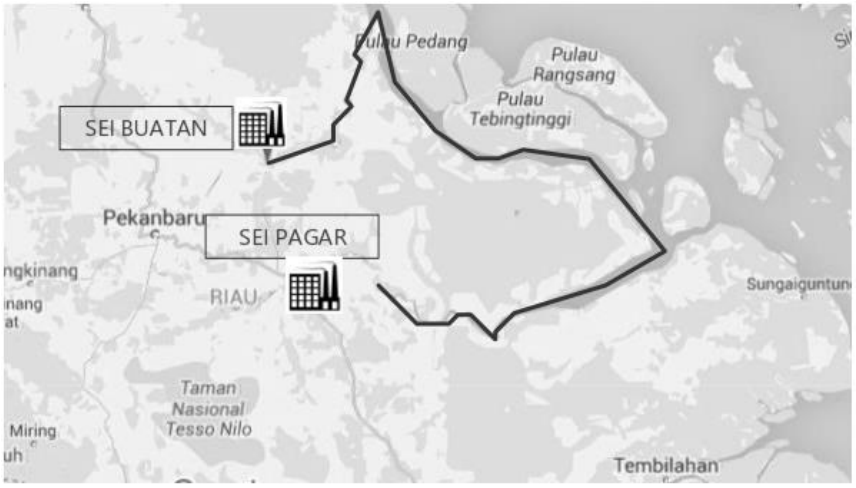

Figure 4. Route A2 (port to port).

Table 2. Optimization result.

Route	Cargo Flow (ton)	Distance (Nm)	Number of Ship	Payload (ton)	Frequency (RT)	Ship Cost / Year (Rp)
Port to Port	60.000	252	1	1.500	40	Rp4.909.899.006,59
Port to Port	30.000	291	1	1.500	20	Rp3.125.904.035,10
Multiport	90.850	728	2	1.500	60	Rp13.074.457.196,38

The comparasion between inland transport and inland waterways transport which had been determined is shown on this graph below. It is noticeable that inland transport (tanker truck) have higher unit cost in comparison with inland waterways transport (ship).

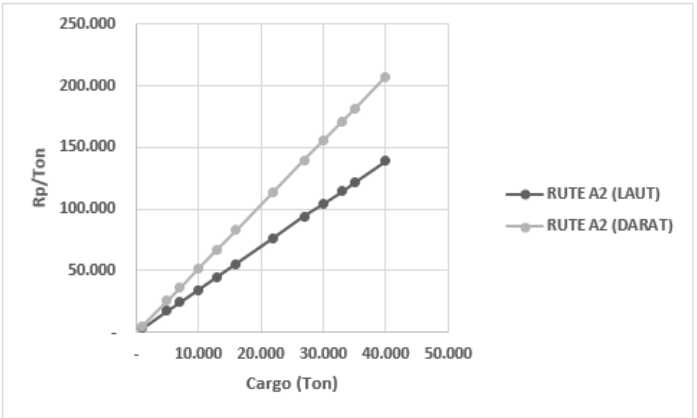

Figure 5. Unit cost comparative.

Figure 5 illustrate the unit cost comparasion between inland waterways transport and inland transport in Route A2. The x axis is define as total cargo (ton) per year that had been supplied.

Investation Analysis

The transportation model of POME that had been decided as the most optimum model is cost around Rp 8.035 millions. That cost is including charter cost of ship and voyage cost of the ship a year with total 2 ships, one in each route.

90.000 tons of POME supply by PKS to PLTBG Tandun per year. Based on data above 600 kg of POME produce electrical power around 60 kWh, so total elctrical power that PLTBG Tandun produces around 9 millions kWh a year.

Table 4. Energy conversion.

	Type of Residue	Amount	Energy
1 ton CPO	Fiber	120 Kg	2637 kkal/Kg
	Shell	60 Kg	4105 kkal/Kg
	TKKS	230 Kg	4492 kkal/Kg
	POME	600 Kg	60 kWh
600 Kg POME	20 m3CH4(Methane Gas)	1 m3 CH4	3 kWh

Table 5. Cost calculation.

POME/Year	90.000	ton
Electrical Power	9.000.000	kWh
Electricity Usage/ton TBS	20	kWh
TBS/Year	150.000	ton
Manufacturing Usage	3.000.000	kWh
Electrical Power to sell	6.000.000	kWh
Electricity Price [5]	Rp975	/kWh
Revenue	Rp5.850.000.000	
Savings	Rp2.925.000.000	
Total	Rp8.775.000.000	
Ship cost	Rp8.035.803.042	
Gross Profit	Rp739.196.958	

Conclusions

1. The optimum transportation model for POME distribution from manufacture to Tandun Biogas Power Plant is inland waterways transport. The difference of distribution cost compare to existing transportation modes is around IDR 28.753 millions.
2. The optimum mode is Self Propelled Oil Barge (SPOB) which have 1.500 tons of capacity. Main dimension of SPOB, as follows: length between perpendicular (LPP) = 57,15 meter, Breadth (B) = 13,16 meter, Height (H) = 5 meter dan Draught (T) = 4,2 meter.

a. Route A1, ship voyages are 40 roundtrip per year, total cargo 60.000 tons and total cost Rp 4.909.899.006.
b. Route A2, ship voyages are 20 roundtrip per year, total cargo 30.000 tons and total cost Rp 3.125.904.035.

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SHIPS AND OFFSHORE STRUCTURES

The Design of Cement Carrier Using Reinforced Concrete Material, Route Pangkep – Sorong

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Keywords: Cement Carrier, Reinforced Concrete, Cement, Pangkep, Sorong

Abstract. Cement is the first commodity in infrastructure sector. Inside RAPBN INDOSESIA 2015, Indonesia have a goal to make infrastructure sector more advance in every region. Because of that demand of cement become more higher, but there still any region that lack supply of cement, for example is Papua. In Papua the price of cement is very expensive. The main reason is because Papua doesn't have a factory to produce cement and the high cost for transportation or distribution, because the cement load by package form. Because of that PT. Semen Indonesia have a plan to make a packing plant in Sorong, West Papua for load the cement in bulk form which is have more low cost than package form. All in all to make cement have a low price in Papua, Papua need cement carrier that can bring cement in bulk form and do the package process in Sorong. To make sure the low cost in cement distribution, the cement carrier will be builded by reinforced concrete material and not a steel. By using parent design approach method with MV. SAWAHLUNTO a self discharged cement carrier from PT. Indobaruna Bulk Transport as the parent ship, cement carrier size is Lpp =106.22 m, B = 23.8 m, T = 6.52 m, H = 9 m and Vs = 12 knot.

Introduction

Indonesian government have developed RAPBN 2015, the framework of Indonesia development plans which assert that in 2015 the state budget will be focusing on infrastructure and food. Indonesian President Joko Widodo said infrastructure development in Indonesia at this time should be increased and can become more productive, especially in the eastern part of Indonesia. This infrastructure development will certainly lead to a high demand for raw materials such as cement.

Indonesian eastern region has supplied cement demand is still limited to eastern Indonesia, and then coupled with the increased demand for cement every year. This caused the price of cement in eastern Indonesia soared. Currently, the demand for cement in Papua supplied from facilities packing plant in East Java and South Sulawesi. When cement reached the ports in the region of Papua, cement price can reached Rp. 85.000,00 up to hundreds of thousands rupiah whose starting price of about Rp. 50,000 [8]. This is also due to lack of transport and lack of a cement factory in the region.

Until now, the PT Semen Indonesia has made investment planning in Papua to build a packing plant capacity of 300 thousand tons. Packing plant is a cement packing facilities, so that semen marketed in the territory of Papua will be adversely affected and the price of cement products will decrease as packaged near the location of marketing. Therefore, it needs planning in the transportation and distribution of cement as well as means of transportation such as ships. Currently the cement delivery to Papua served by pioneer ships or general cargo ships

from southern Sulawesi or East Java. The use these ships is due to cement unloading cargo in the form of packs or per-sack. Because of the investment plan of development in Papua, the packing plant for cement distribution can be done in bulk to minimize transportation.

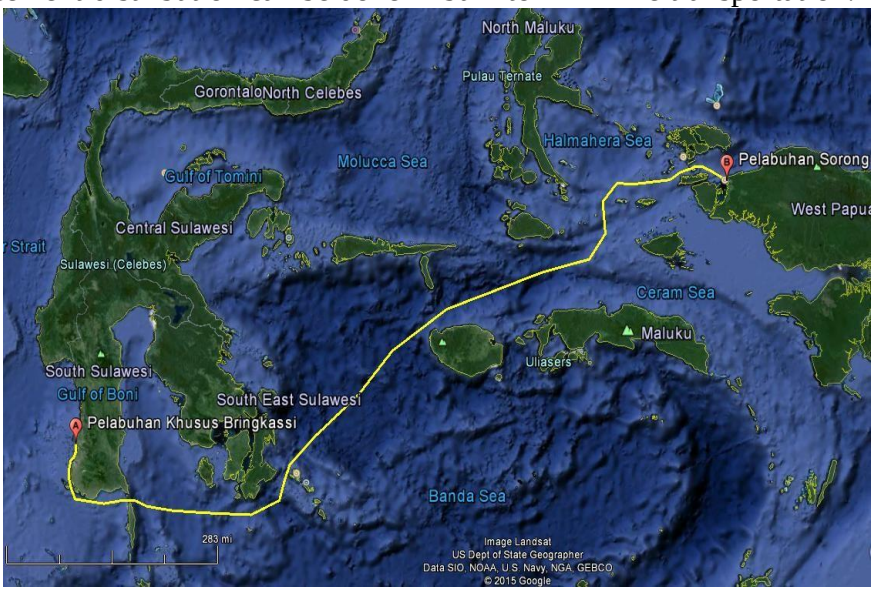

Fig.1 Shipping Route of Pangkep-Sorong (Google Earth Pro)

The cost factor of the ship must also be noticed, because the ship's production costs will affect cement's transportation costs. Building a ship with reinforced concrete materials is one of the solutions to reduce the cost is cheaper than the use of steel, so the cement's transportation cost will have more lower price than before. With the cost of transportaion is more cheaper and cement cargo in bulk form, it will have a major impact to minimize high cement prices in the region Papua. Based the above problems the design of *cement carrier* and perform economic analysis with the view point of the production cost efficient and effective way to support the needs of cement in Papua.

Cement

Cement industry is the result of a range of raw materials: limestone / lime as the main material and loam / clay or other materials with the end result in the form of solid powder / bulk, regardless of the manufacturing process if the cement is mixed with water it will harden or petrification. Cement is usually the most commonly used is cement ash or commonly called Portland cement. When cement is mixed with water, then formed concrete. In a general sense, the cement is a binder, a substance that can be set and harden freely, and can bind other materials. This following are the types of cement:

- Gray cement or can be called Portland cement, cement is a bluish gray cement, the main ingredient is formed from limestone / lime Cement is used as an adhesive.
- White Cement is pure cement from ash cement used to work on the final (finishing). Cement is made from the main calcite (calcite) pure limestone.
- Oil Well Cement could be called as cement sumut oil, cement is a special cement used in the drilling of oil or natural gas.
- Mixed & Fly Ash Cement is a cement mix the ashes with Pozzolan buata. Artificial Pozolon is a byproduct of burning coal. Cement is used as an ingredient in concrete, so it becomes harder.

Self-Discharged Cement Carrier

Distribution of cement or other similar products generating capacities of new vessels from the conversion of bulk carriers into a ship carrying cement self-unloaders. Self-discharge cement carriers not require loading and unloading equipment from the port and has a cargo handling it self in a closed system, using a system of fluid in the load space to organize unloading cargo. Cement carrier requires special handling for the loading and unloading system, which is where all the loading and unloading system has automated work system.

Pneumatic Loading System

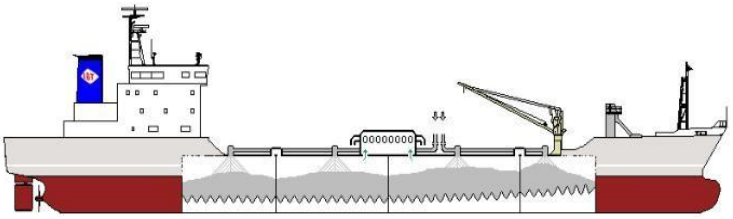

Fig.2 Pneumatic Loading System [2]

Using a pneumatic system to load the charge of cement is relatively easier and quicker, cement piped from the silo to the ship by using existing compressor on board, after the cement is distributed to each cargo hactch on board. For the process of loading using pneumatic system measures the following steps, cement contained in ship's cargo hatch collected to the end of hatch placed in unloader room installed using water slider and conveyor flow in ship's cargo hatch, after the cement was appointed to the blow tank by using bucket elevators, and cement were fired towards the silo with high pressure air.

Mechanics Loading System

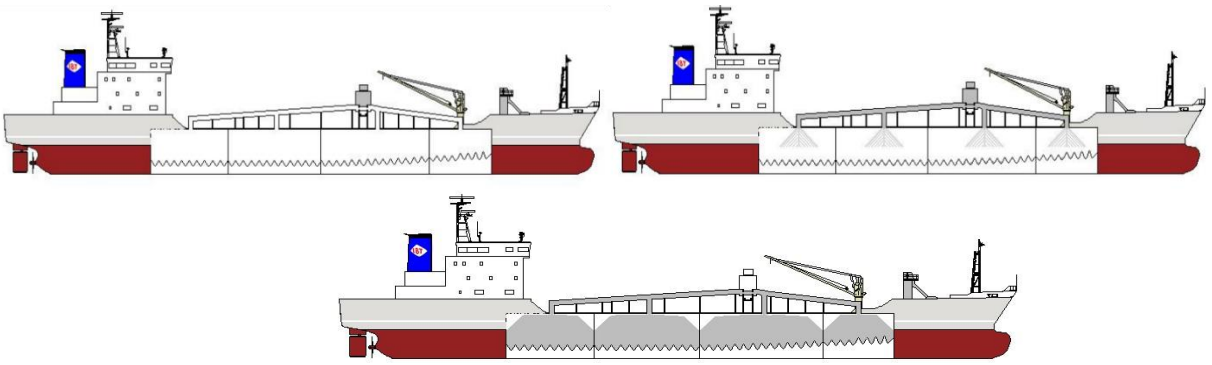

Fig.2 Mechanics System [2]

For loading cement mechanically, the first thing that happens is the cement from silos or from a truck in place on the conveyor belt to be passed on to distribution tanks in the vessel, after it passes through the water cement slider toward cargo hatch.

Research Methodology

In general, the process of design and construction of ships using the method of spiral design, or a design innovation to the pre-existing vessels, with engineering design to obtain a more optimal design.

The design of cement carrier usin reinforced conrete will using pre-eliminary design concept, where the trchnical analysis and economic analysis will be calculate. Parent design approach is one method in designing the ship by way of comparison or comparison, that is by content were a ship that is used as a reference comparator vessel that has the same

characteristics with the vessel to be designed. In this case the designers already have a reference vessel similar to the vessel to be designed and proven to have a good performance.

The methodology used in this final project can be seen from the flow diagram (flow chart) is as follows:

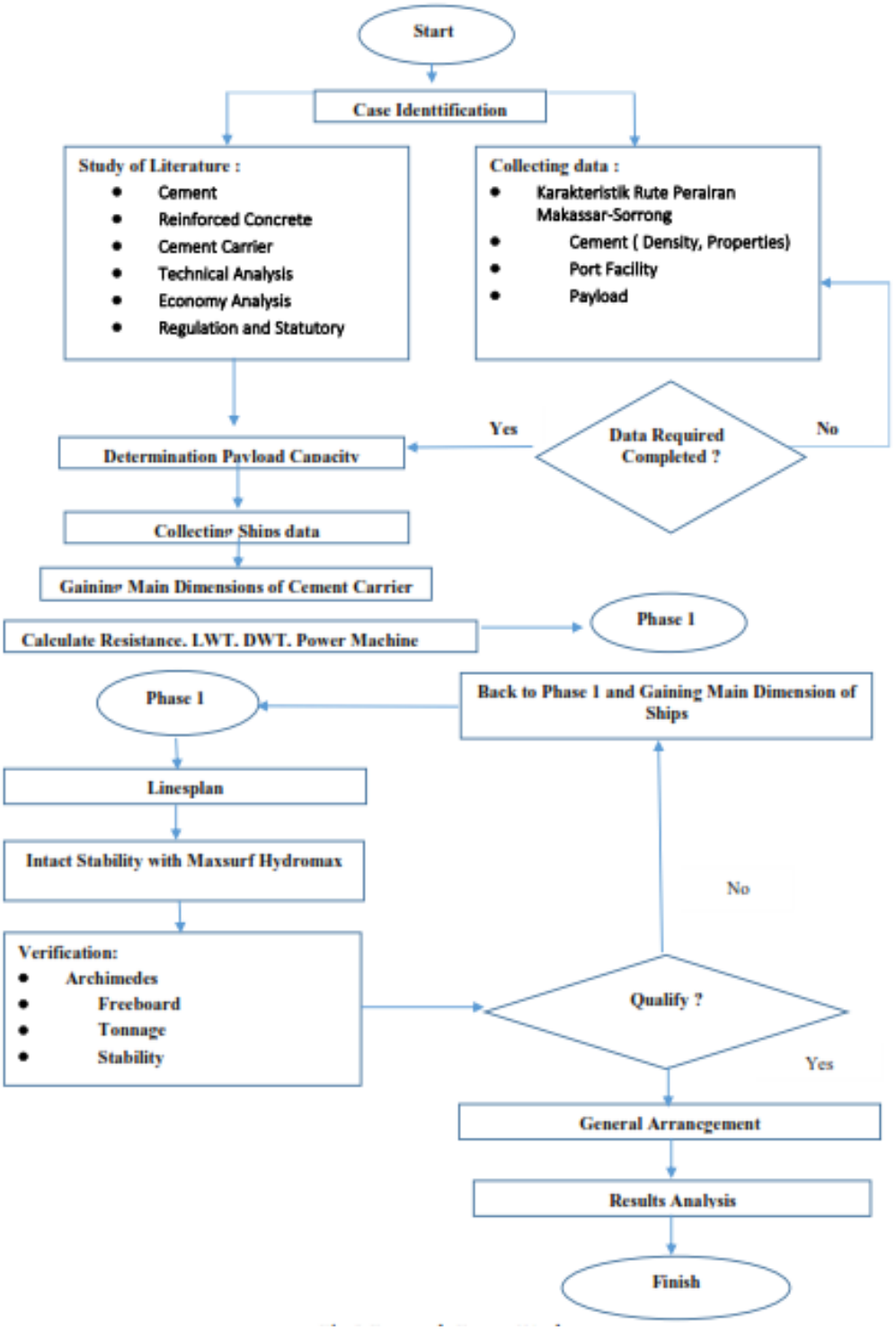

Fig.3 Research Frame Work

Design Process

Owner Requirements and Main Dimension

Owner Requirements based on the data of cement demand in West Papua. This data was obtained from a number of news that annual cement demand in West Papua and the amount of cement normally carried cargo to the port of Sorong, West Papua.

Table 1 Data of Cement Demand in West Papua

Region	Demand [tonne/year]	Demand [tonne/month]
Papua	500000	41666.
West Papua	325000	27083
Sorong	144000	12000
The cement will be shipped with 4 times delivery		
Papua	125000	10416
West Papua	81250	6770
Sorong	36000	3000

As can be seen in Table 1, to meet the needs of cement in West Papua, the required minimum6770.83 tons / month, if in one month the shipment made four trips delivery. Having obtained the required minimum payload, then the data ofcement carrier vessels that have passed the minimum payload can be search, but it should be remembered for cement carrier made from reinforced concrete there will be a reduction in weight due to the payload cargo ship. So the search data is searched ships which have much larger payload than demand. Having collected ship data, then the determination of the main dimensions with *parent design approach* method. Parent design approach can be used, because the similarity of owner requirements within Indonesian shipping area and completeness of the data, the chosen MV. Sawahlunto to be a reference design of the ship.

Table 2. MV Sawahlunto.

Ship Particulars	
Name of vessel	Mv. Sawah Lunto
Flag	Indonesia
Owners	PT Indobaruna Bulk Transport
Ship Bulder	Fukuoka Shipbuilding yard, Fukuoka city, Japan
Launched date	2014
Type of Vessel	Cement Carrier
LOA (m)	109.9
LPP (m)	106
B (m)	23.8
H (m)	9
DWT (MT)	9650
T (m)	6.52
Speed max. (knot)	12

Technical Analysis

Technical analysis is intended to measure the ability of ships and ship characteristics in Technical analysis is intended to measure the ability of ships and ship characteristics in operation. Basically technical analysis that will be performed on the ship as the ship design approach in general, but because cement carrier made of reinforced concrete, it is necessary to further technical analyzes related to the weight resulting from the material reinforced concrete. In calculating the weight of reinforced concrete, the first thing to do is to sketch the cross section of a cement carrier made from reinforced concrete, construction sketch cross section taken on the part of the frame 96 area midship section. Frame 96 is taken as an analysis of heavy reinforced concrete calculation due to the dominant weight of the vessel is obtained from the parallel middle body. Sketch of midship construction can determine how much volume in each part of the ship made of reinforced concrete. Another important thing to note is, the determination of thick reinforced concrete needed for each part of the ship, Determination of thick reinforced concrete in this study obtained by using minimum thick reinforced concrete that had been arranged by Lloyds Register rules regulation, offshore unit, Part , Ch. 4/2.

Table 3. Reinforced Concrete Weight Ship's Part

Reinforced Concrete Weight		
Reinforced Concrete Ship Parts	**Area [m^2]**	**Volume [m^3]**
Hull area under ship'draft	3332.61	299.9352335
Hull area above ship'draft	526.85	47.416608
Deck area	2509.793737	225.8814364
Inner bottom	2284.8	205.632
Longitudinal Bulkhead	561.6	50.544
Web frame	-	16.0056
Transverse Bulkhead	1713.6	154.224
Slab top	-	69.12
Slab bottom	-	138.24
Strong beam	-	21.69288
Total Volume		1228.6918
Total Rc Weight (Total Volume x 2.56)		3145.45 ton

Displacement Correction

After getting the results weight of steel and equipment on the barge, then the components of LWT has been obtained. LWT then added together with DWT to obtain the weight displacement. LWT + DWT value is compared with the value of displacement is the result of the formula approach LxBxTxCbxρ. The difference in weight between the LWT+DWT and Dispacement must be in the range of 1% to 3%and the difference will be the heavy weight of the ship reserves.

Table 4. LWT, DWT and Margin Check Analysis

ITEM	**W [tonne]**
Lightweight (LWT) Estimation	
Machinery Plan Weight	170.98
Equipment & Outfitting Weight	597.47
Reinforced Concrete and SteelWeight	4403.82
Total Weight of LWT	

Deadweight (DWT) Estimation	
Payload	8400
Crew and Consumable	168.80
Total Weight of DWT	8568.80
Total of LWT and DWT	13723.08
Margin Check	
Displacement Design	13805.17
Margin (Displacement and (DWT + LWT)	82.09

Lines Plan and General Arrangement

After the main dimensions of cement carrier has been obtained and other technical analysis results in accordance with the owner requirements and have passed the minimum values which have been determined by the rules and design approach criteria, lines plan and general arrangement cement carrier using reinforced concrete as the material can be made.

Cement carrier lines plan designed using maxsurf software and autocad. Cement carrier general arrangement designed using cad software Autocad. The first note thing to do to design general arrangement is to decide frame spacing of cement carrier, frame spacing is taken 600 mm.

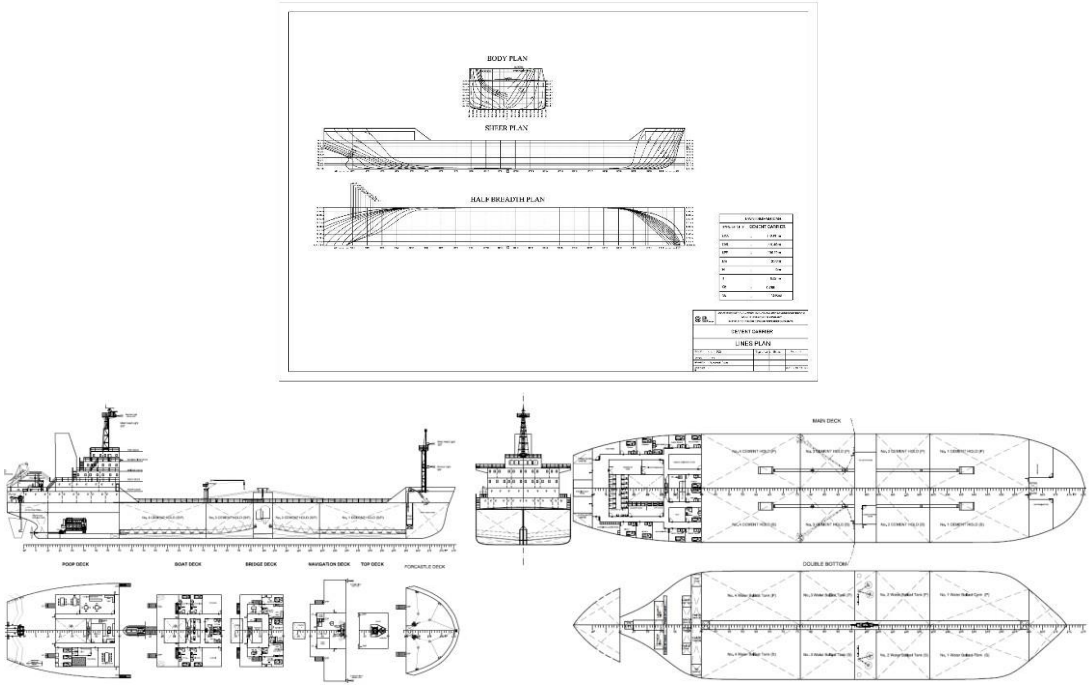

Fig.3 Cement Carrier Lines Plan and General Arrangement

Conclusions

This article analyzed design of cement carrier using reinforced conrete as the material with shipping route Pangkep to Sorong. Cement demand in Papua has been analyzed to decide owner requirements of the ship, after that, technical analysis conducted with pre-eliminary design. Conclusions that can be drawn is, with the demand of cement in papua and with the four times shipping distribute cement to papua in month, payload is taken 8400 tonnes. Using parent base design methods, the main dimensions of cement carrier as follows: L (length) = 106.22 [m] B (Width) = 23.8 [m] H (High) = 9 [m] T (Loaded) = 6.52 [m]. From the results of technical analysis obtained design of lines plan and general arranegent of cement carrier made of reinforced concrete. Cement carrier use self discharging pneumatic system for loading and discharge condition.

As a further consideration in designing of the ship made by concrete in this study. It is important to noted in this article used the most concrete standard weight. For further research lightweight concrete technology that matches the endurance and watertightness as fiber reinforced concrete should be used. Further technical analysis is required to determine the stress that occur in ship construction made from concrete to determine the thickness of concrete and reinforcement required to resist tensile strenght. In this article the ship longitudinal strength with concrete materials is not analyzed, so analyzing wire mesh fo the ship contruction is to be noted. Also It takes a more complete economic analysis in the construction of the ship using concrete materials and in vessel operating costs.

All of these results allow it to conduct future planning to build a ship using concrete material and to take further research to using another composite material combined with concrete material to reduce the weight produced by reinforced concrete.

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Effects of Application of a Stern Foil on the Seakeeping Performance: A Case Study of Orela Crew Boat

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Keywords: Crew boat, laboratory experiments, numerical simulations, seakeeping, stern foil.

Abstract. Effects of application of a stern foil on the seakeeping performance are investigated by considering the Orela crew boat as a case study. Experiments were performed to determine the heave and pitch RAO's for the cases with and without stern foil. The experimental results are used to verify the results obtained from numerical simulations. The stern foil improves the seakeeping performance of the boat. Using a stern foil, the heave and pitch significant heights in a sea state with H_s = 2.0 m decrease 6.3% and 9.8%, respectively.

Introduction

A well-known application of a stern foil is the so-called hull vane®, invented by van Oossanen in 1992 and patented in 2002, which is a fixed hydrofoil attached to the ship at the stern below the transom. The mechanism of the hull vane® consists of generating a force in the forward direction (additional thrust), reducing the running trim (generating a bow-down moment), reducing the transom wave, reducing the pitching motion and reducing the added resistance in waves [1]. Shortly, it reduces the ship resistance and the ship motions, resulting in a reduced fuel consumption and a higher comfort level for the crew and passengers.

The working principle of the hull vane® and its applications to different vessels are reported in [1-4]. In [2], effects of the hull vane® on the motions of ferries and RoPax vessels are reported. It was found that the hull vane® reduced the pitch motion but its effect on the heave motion depended on the wave frequency and the resulting phase shift between the heave and the pitch motions.

Effects of the hull vane® on the fuel consumption and seakeeping performance are reported in [3]. CFD simulations were performed where the hull vane was applied to a 108-m Hollands-class ocean-going patrol vessel (OPV) of the Royal Netherlands Navy. At the speed where most fuel was consumed (17.5 knots), fuel saving of 15.3 % was reported (compared to the case without vane). On yearly basis and for all speed ranges, a reduction of 12.5% fuel consumption was achieved. Considering the seakeeping, the vertical acceleration (on the helicopter deck) and the pitching motion were reduced, consistent with the results reported in [2].

A study utilizing computational fluid dynamics (CFD), which compared the performance of hull vane®, interceptors, trim wedges and ballasting, is reported in [4]. The devices and ballasting were applied to a 50-m patrol vessel at speeds between 8.6 and 34.4 knots ($0.2 < Fn < 0.8$). At Froude number $Fn < 0.2$ (relatively low speed) the hull vane® results in an increase of the ship resistance, as expected. At Froude number $0.2 < Fn < 0.4$ the hull vane results in a bow-down running trim. In all the Froude-number ranges being considered, the hull vane® reduces the bow-up running trim. It was concluded that among all the trim correction devices considered, the hull vane® was the most efficient device in reducing the ship resistance and in reducing the pitch motion ($0.2 < Fn < 0.8$).

The effectiveness of the vane/foil in reducing the ship resistance and ship motions depends on the optimum effects it makes on the magnitude and orientation of the generated lift, the running trim, the stern waves and the added resistance in waves. Furthermore, the dimension of the optimum foil depends on the dimension and type of ship being considered and the type of foil being used.

The purpose of the present study is to investigate the use of NACA 64(1)212 foil as stern foil applied to a crew boat. The focus is on the effects of the stern foil on the seakeeping performance. Its effects on the ship resistance are reported in [5]. Results of the present study can enrich the literature on the application of a stern foil/hull vane® as a fuel-saving device, which additionally can increase the level of comfort for the crew and passengers.

A crew boat usually brings a crew and/or logistics from the shore to an offshore platform and later picks them back from the platform to the shore. It has a relatively high-dense and regular schedule and, therefore, usually has a relatively high speed. (The ship's speed and fuel consumption are of great concern.) The Orela crew boat is considered, which is a semi-planing boat with a target top speed of 28 knots (Froude number $Fn = 0.73$). (See e.g. [6] for a discussion of the seakeeping behaviour of high speed crafts.) The principal dimension of the boat is summarised in Table 1.

The optimum foil size with maximum lift-to-drag ratio is obtained from CFD-simulations of foil alone. In the simulations, the foil's span is fixed (8 m; the same as the boat's beam). It is found that the optimum chord length is 1.2 m (aspect ratio of 6.67).

The foil is attached to the ship's hull at the transom by using two struts, which are NACA 0010 symmetrical foils with chord length of 1.2 m (the same as that for the stern foil), at a submerged position of 0.853 T = 1.45 m below the water line (T is the draft).

Table 1. Principal dimension of the orela crew boat.

Length overall (L_{oa})	40.00 m
Length between perpendiculars (L_{pp})	39.90 m
Beam (B)	8.00 m
Height (H)	4.40 m
Draft (T)	1.70 m
Displacement (Δ)	242.72 ton

Method

To study the seakeeping performance of the boat, experiments were performed at the Hydrodynamic Laboratory of the Faculty of Marine Technology, ITS Surabaya, Indonesia. The dimension of the towing tank is as follows: length = 50.0 m, breadth = 3.0 m and water depth = 2.0 m. The experimental results are used to verify the results obtained from numerical simulations.

I. Experiments

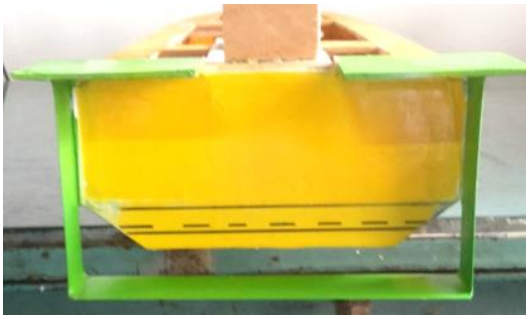
A scaled model of the boat was made from a fibre-glass reinforced plastics (FRP) with a geometrical scale of 1:40 (Froude-similarity). Tests with regular waves were conducted to determine the heave and pitch RAO's of the boat with zero-speed and with 22-knots speed in a heading sea (180° heading angle). The ship model is shown in Fig. 1. The measuring instruments (load cell, transducer) were calibrated before running a test. The heave and pitch motions were recorded for boat with and without stern foil. The seakeeping test parameters are summarised in Table 2.

The heave and pitch RAO's are then determined. For tests with a moving ship, the frequency axis is the frequency encounter, which is calculated as follows:

$$\omega_e = \omega\left(1 - \frac{\omega V_s}{g}\cos\mu\right) \quad (1)$$

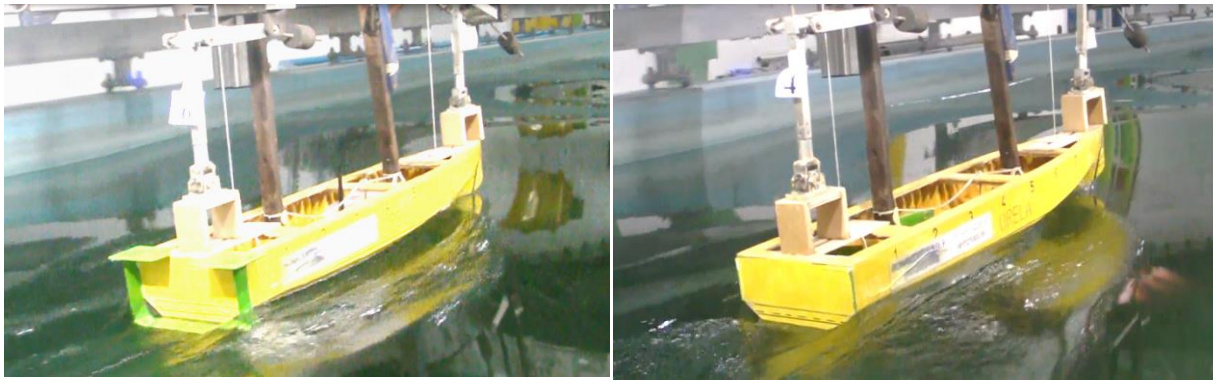
where ω_e is the encounter frequency, ω is the wave frequency, V_s is the ship speed, g is the gravitational acceleration and μ is the wave heading.

(a)



(b)

Figure 1. Model of the crew boat with stern foil (scale 1:40): (a) side view and (b) aft view.



(a) (b)

Figure 2. Seakeeping test with wave amplitude a = 1.2 cm (full-scale = 0.48 m) and wave period T = 1.1 s (full-scale =7.0 s): (a) with stern foil and (b) without stern foil.

Table 2. Seakeeping test parameters.

Wave Period [s]	Wave Amplitude [cm]	Heading Angle [deg]	Ship Speed [knots]
0.5	1.2	180	0
0.7			
0.9			22
1.1			
1.3			

II. Numerical simulations

The experimental heave and pitch RAO's are compared with those obtained from numerical simulations based on potential theory. The simulations were done in a stand-alone computer with Intel® Core (TM) i5-2450M CPU @ 2.50 GHz processor, 4.00 GB RAM using 64-bit Windows 10 Pro© OS. To ensure independency of the results from the number of cells (elements) used in the simulations, tests were performed to comply with the grid-independence criterion. This is defined as that the difference between two subsequently calculated area under the RAO curve is less than 2 % where the number of cells in the latter simulation is approximately twice of that in the former.

To determine the ship response in irregular waves, the calculated RAO from the numerical simulation is utilised with the sea waves modeled using ITTC spectrum [7]. The significant heave and pitch heights are calculated for different sea states utilising the response spectrum:

$$R_s = 4.0\sqrt{m_{0;r}} \tag{2}$$

where R_s is the significant response height, and $m_{0;r}$ is the area under the response spectrum.

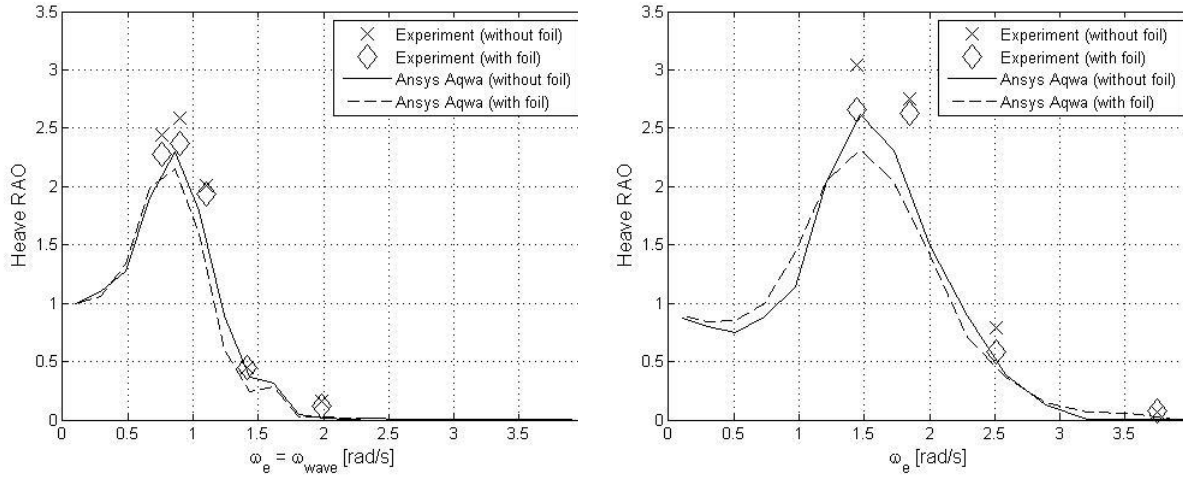
Results and Discussion

I. Heave and pitch RAO's

Figure 3a shows a comparison of heave RAO's for zero-speed ship with and without stern foil obtained from experiments and numerical simulations. The frequency with maximum RAO-value is approximately 0.96 rad/s. Figure 1 shows that the addition of a stern foil results in a decrease of the heave RAO in the frequency range with significant response ($0.8 < \omega_e <$ 1.5 rad/s). The RAO-values obtained from the numerical simulations are generally smaller than those obtained from the experiments, ascribed to overestimation of damping effect in the numerical model.

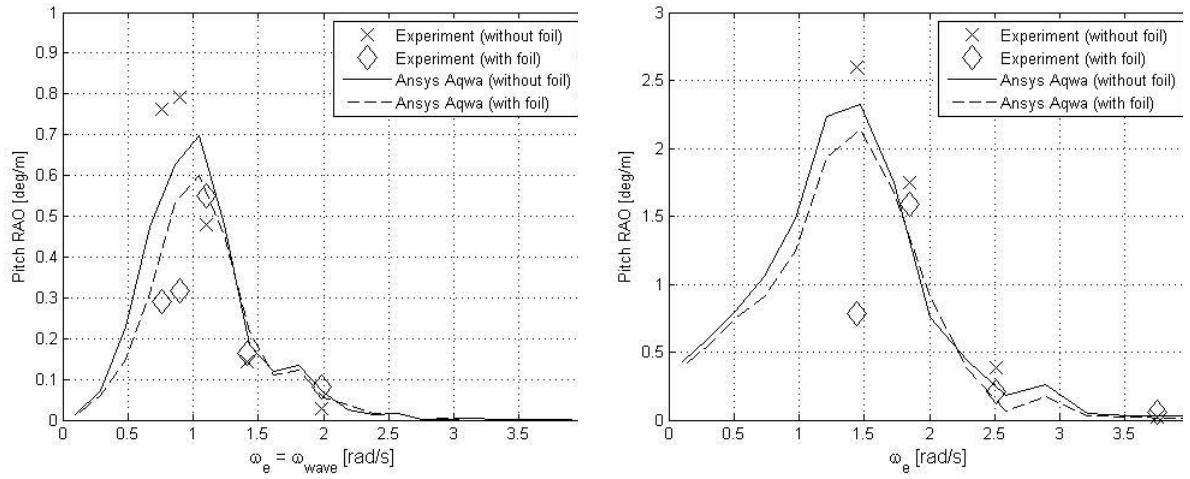
Figure 3b shows similar plots as shown in Fig. 3a for ship speed of 22 knots (Froude number Fn = 0.572). The frequency with maximum RAO-value is approximately 1.46 rad/s, which is larger than that for zero-speed, as expected. As for the case of zero speed, the installation of the stern foil results in a decrease of the heave RAO in the frequency range with significant response. However, because of the use of spectral analysis, no information about the phase shift between the heave and pitch motions can be reported to compare the result with that obtained in [2]. In addition, due to the ship speed (ship moving in a head sea), the magnitude of the heave RAO increases and the frequency range with significant response becomes broader compared to that with zero-speed ship.

Results for the pitch RAO can also be presented in a similar way as for the heave response (see Figs. 4a and b). The addition of the stern foil results in a decrease of the pitch RAO, consistent with the results reported in [1-4].



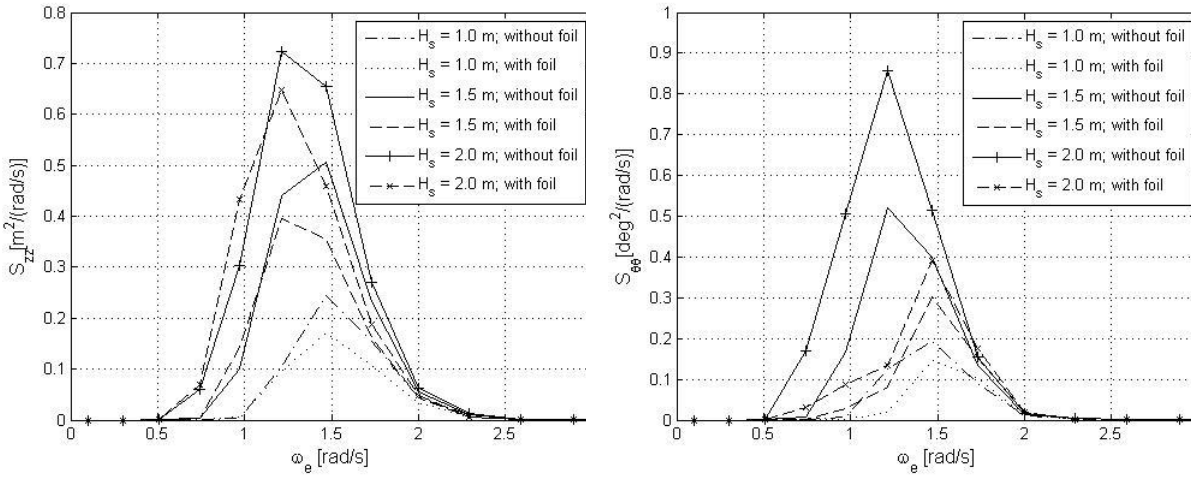
(a) (b)

Figure 3. Heave RAO's for zero speed (a) and 22-knots ship speed (b).



(a) (b)

Figure 4. Pitch RAO's for zero speed (a) and 22-knots ship speed (b).



(a) (b)

Figure 5. Heave (a) and pitch (b) spectra for 22-knots ship speed (Froude number *Fn* = 0.572).

Table 3. Significant heights of heave and pitch for different sea states.

H_s [m]	Significant heave height [m]		Significant pitch height [deg]	
	Without foil	With foil	Without foil	With foil
0.5	0.432	0.361	0.307	0.308
1.0	1.63	1.42	1.44	1.20
1.5	2.55	2.32	1.80	1.62
2.0	3.17	2.97	1.84	1.66

II. Heave and pitch spectra

The decrease of heave and pitch responses due to the stern foil can be illustrated by calculating the heave and pitch spectra for different sea states (see Fig. 5). To characterize the responses, the significant heights of the heave and pitch motions can be calculated from the heave and pitch spectra (see Eq. 2).

Table 3 summarises the significant heights of heave and pitch motions for different sea states. It is shown that, as the significant wave height increases, the significant heights of the heave and pitch also increase, as expected. The application of the stern foil results in a decrease of the significant heights of the heave and pitch motions. For example, in a sea state with H_s = 2.0 m (the highest sea state being considered), the significant heave is 3.17 m for the case without stern foil and 2.97 m for the case with stern foil, showing a decrease of approximately 6.3%. In the same sea state, the significant pitch decreases 9.8%.

Conclusions

Application of a stern foil results in better heave and pitch characteristics of the Orela crew boat. The significant height of heave in a sea state with significant wave height H_s = 2.0 m is 3.17 m for boat without stern foil and 2.97 m for boat with stern foil. The decrerase of the significant height of heave due to the stern foil is approximately 6.3%. Furthermore, the significant height of pitch in the same sea state is 1.84 degrees for boat without stern foil and 1.66 degrees for boat with stern foil. The decrease of significant height of pitch is approximately 9.8%.

Acknowledgement

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Experimental Study on Two Rigid Cylinders Wrapped Around by Triple Helical Rods with Gaps for Side-by-side Arrangement

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Keywords: Side-by-side cylinders, interference, triple helical rods with gap, drag force.

Abstract. This paper presents the experiment result in wind tunnel on the interference of two rigid cylinders wrapped around by triple helical rods with gap. The model cylinders were installed with both ends were fixed supported. The model was tested at Reynolds number (Re) of 3.9×10^4 with distance between cylinder variations of 1.75D, 2.0D, and 2.50D, where D stands for the cylinder diameter. The results showed that due to strong interference of the two cylinders, larger drag coefficient (C_D) occurred in both cylinders for all distance variation tested. For the distance of 2.0D, the C_D increased larger than other cases. The C_D on the lower and upper cylinders increased by 55.8 % and 55.5 % respectively than the case of a single cylinder.

Introduction

Vortex shedding is a phenomenon that always occurs on component of offshore structures (especially cylindrical components) that is exposed to water flow such as conductors, risers, mooring lines, spar's body and subsea pipelines. This phenomenon causes continuous excitation forces acting on structure and under certain condition may cause vibration of structure which is called *vortex induced vibration* (VIV).

Many studies have been done to reduce the VIV and induced fluid forces on cylinders. Prastianto et al. [1], Sugiwanto et al. [2] and Arianti et al. [3] have numerically and experimentally investigated a model of triple helical rods wrapped around on a cylinder with certain gap to reduce both, VIV and drag force. On their numerical study, Sugiwanto et al. [2] showed that the model was successfully reduce the drag by 50.42 % at Re = 105 than that of a bare cylinder case. Meanwhile, by their experimental work, Prastianto et al. [1] proved that a cylinder with the triple helical rods with gap could reduce the drag by 50 % at lower Re of 2.36 × 104. With the same model, Arianti et al. [3] experimentally investigated that the device could reduce the cross flow vibration by 49.28 % at Re = 3.5 × 104.

However, the characteristic of fluid flow pattern, induced fluid forces, and responses of a single cylinder due to its interaction with the fluid flow will be completely different than the case of multiple cylinders. It partly depends on distance among cylinders and its relative position [4]. Investigations have been done on the characteristics of fluid patterns and forces on two bare cylinders in various arrangements. For side-by-side arrangements, they found that there are three main flow patterns; single-body regime (approximately $1 < T/D < 1.1\text{-}1.2$), asymmetric regime/biased gap flow pattern ($1.1\text{-}1.2 < T/D < 2\text{-}2.2$), and symmetric regime / coupled flow pattern ($T/D > 2\text{-}2.5$). T is a distance between the cylinders [4,5].

Verma and Govardan [6] simulated two bare cylinders on side-by-side arrangement with distance between cylinders (T) variations of 1.5D, 2.0D, 3.0D, and 4.0D at low Re of 200. The result showed when the distance (T) increased, the fluid forces decreased. But at T = 2.0D, fluid

forces acting on the cylinders are increased. They called it as “flopping phenomenon”. Then Pang et al. [7] have numerically investigated two bare cylinders on side-by-side arrangement at high Re of 6 × 104. The variation of distance to diameter ratio (T/D) is in the range of 1.1 up to 7. The result show that drag coefficient (CD) are so high in single body regime (T/D < 1.1-1.2), then the CD decreased when the T/D increased. But when the T/D is in the range of 1.5-2.0 the CD is increased.

The present paper discusses effects of the interference of two cylinders on side-by-side arrangement to drag forces on uniform wind flow where the cylinders are wrapped around by triple helical rods with gap.

Experimental Method

Some of model ratios used in this experiment were adopted from Sugiwanto et al. [2] and Arianti et al. [3]. The model cylinders are made of aluminum tube and had length (L) of 48 cm with diameter (D) of 5.08 cm. The rods are made of stainless steel with ratio of gap and the rods diameter (d) to the cylinder diameter is 0.0625 or 0.3 cm. The rods are wrapped around to the cylinder for one pitch (See Fig. 1).

Figure 1. The model cylinder covered by triple helical rods with gap and the nomenclature.

The experiments were conducted at Low Speed Wind Tunnel (LSWT) Laboratory of BBTA3-BPPT, South Tangerang. The tunnel has a test section of 0.5m × 0.5m × 1.25m in size with maximum capacity of flow speed of 45 m/s. The two cylinders were horizontally installed and perpendicular to the flow direction. Load cells are installed at the all ends of the model cylinders which are supported by special frame as roll supports. Drag and lift forces were measured on both cylinders, upper and lower cylinders at Re = 3.9 × 104 with distance between cylinder variation of 1.75D, 2.0D and 2.5D.

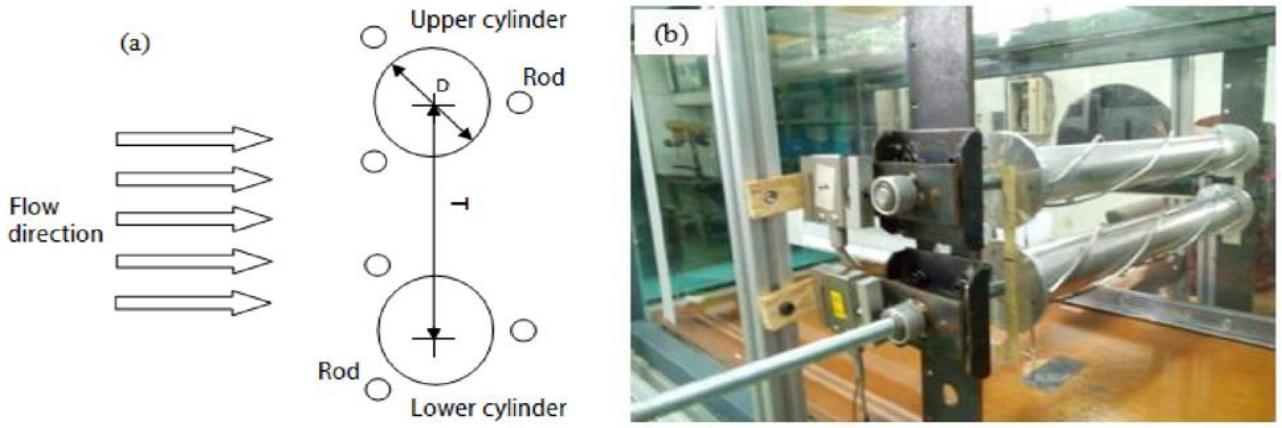

Figure 2. (a) Two dimensional illustration of the experiment; (b) Installation of the model in test section of the wind tunnel with load cells installed for drag measurement.

Results and Discussions

To assure the accuracy of the test, firstly the CD for a bare cylinder was measured. The result of the measurement was compared to relevant research [8] as a validation step. The validation showed a good result at the tested range of Re from 3.65 × 104 up to 5.3 × 104 as depicted in Fig. 3. So that, the test facilities were in good condition and the experiment setting could be accepted.

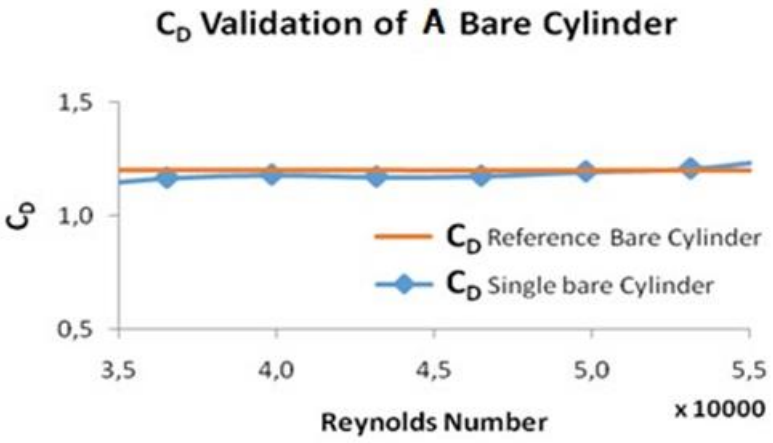

Figure 3. An experiment validation step for a single bare cylinder.

Figure 4(a) and (b) show the result of measurement of CD for both cylinders in a side-by-side arrangement at three variations of distance between the cylinders compared to CD of the single cylinder case (without and with helical rods). Fig. 4(a) shows CD of the upper cylinder, while Fig. 4(b) shows CD of the lower cylinder.

Overall, the CD of both cylinders are larger than that of the single cylinder case, either bare or with helical rods cylinder. The largest value occurs at a ratio of the distance (T/D) of 2.0. This result shows that on all three tested ratio of distance to diameter variations there is still strong interference between the cylinders due to the air flow at this Re (= 3.9 × 104). But at T/D of 2.50 the CD is decreased. On the range of 2.0 ~ 2.50 we can observe that interference of two cylinders is slowly weakened as indicated by decreasing the CD and could be predicted then tend to behave like as a single cylinder.

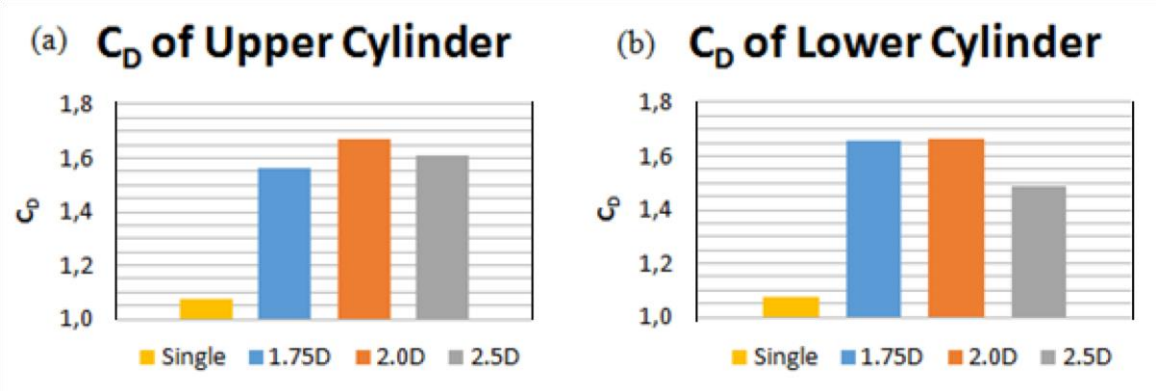

Figure 4. Comparison of C_D for various the distance to diameter ratios: (a) Upper cylinder; (b) Lower cylinder.

Figure 5 shows comparisons between result of CD for cylinders with triple helical rods with gap and some previous works on drag coefficient of bare cylinders in side-by-side arrangement. Alam et al. [9] and Pang et al. [7] investigated experimentally and numerically CD of bare

cylinders both at Re = 5.5 × 104 with ratio T/D = 1.1 ~ 7. It can be seen, CD from the distance to diameter ratio of 1.75 are still higher than CD of the single cylinder. Then when the ratio increased until in a range of 2.0 ~ 2.2, the drag coefficients are also increased. But after that, CD decreased along with increment of the distance to diameter ratio.

So, we know that the trend of CD in the present work has a similar behavior like the study of Alam et al. [9] and Pang et al. [7]. But CD of the cylinders with helical rods with gap is larger than CD of the bare cylinder in various distance to diameter ratio. It could be caused by the rods on the cylinders that in turn distract the flow around the cylinder and also shortened the distance to diameter ratio, so the interference become stronger than the bare one.

Table 1. C_D of the single cylinder on each works.

C_D of bare cylinder on each works		
Present	Pang et al. (2016)	Alam et al. (2003)
1.180 (single bare)	1.206	1.16
1.072 (single helic)		

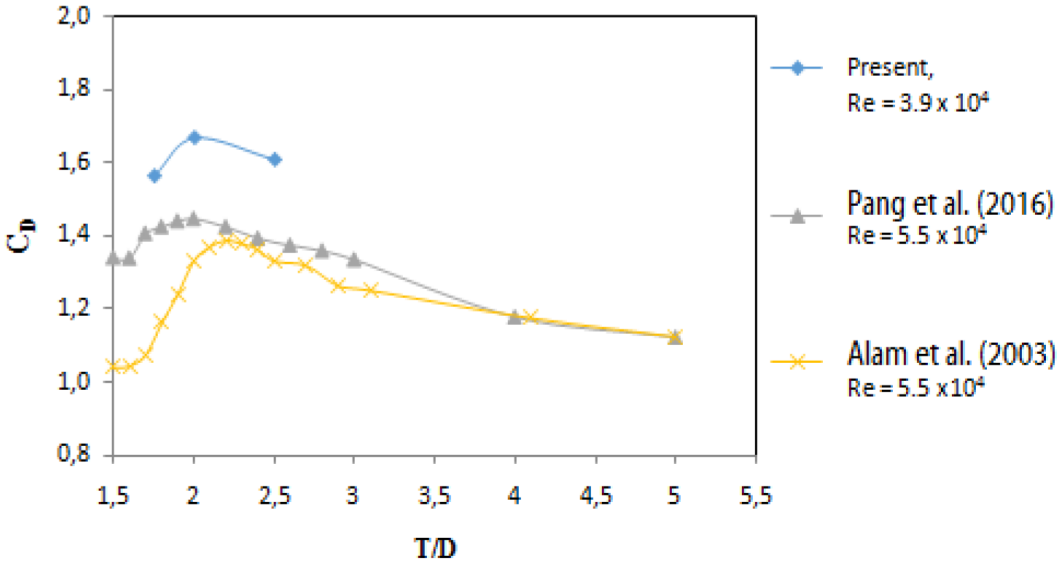

Figure 5. Comparison between C_D for cylinders with helical rods with gap and C_D for bare cylinders from previous works as function of distance to diameter ratio in side-by-side arrangement.

Conclusions

The result of the experiment showed a good agreement compared to some relevant previous works with similar trend of the CD as a function of the distance to diameter ratio between the cylinders. At Re = 3.9 × 104 the results showed that due to strong interference of the two cylinders, larger drag coefficient (CD) occurred in both cylinders for all distance variations tested. For the distance of 2.0D, the CD increased larger than other distances. The CD on the lower and upper cylinders increased by 55.8 % and 55.5 % respectively than the case of a single cylinder. So it can be predicted that when the distance to diameter ratio is increased then there is no interference between two cylinders and both cylinders will behave like single helical rods cylinder.

Acknowledgements

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Implementing Fiberglass Reinforced Plastic (FRP) Catamaran Fishing Vessel: A Road Map toward Advanced Integrated Fishing Vessel Operation

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Keywords: Catamaran, fishing vessel, laganbar.

Abstract. Fishing vessel restructure program in Indonesia requires technology to convert undecked motor vessel type into decked motor vessel type. Catamaran vessel is one of the covert method and most advance technology in ship building. The purpose of this applied research implements catamaran vessel technology for fishing vessel. Furthermore, the technology aims to prepare alternative vessel on integrated fishing vessel operation system. Principal dimension of 5 GT catamaran vessel are Loa = 12.00 meters B =3.50 meters and H = 1.00 meters with S/L=0.22 and engine power = 2 x 30 hp. The materials are Fiberglass Reinforced Plastic (FRP) referred to Non-Metallic Indonesia Classification Bureau 2006 Rules. The Vessel Construction referred to Fiberglass Reinforced Plastic Indonesia Classification Bureau 1996 Rules. The results of sea trial speed 9~12 knots following seas and 7~8 knots head seas. Turning cycle test 17-50 seconds with 50% and 80 % of engine Revolution per Minutes. The vessel stability criteria complied to IMO MSC.36(633) HSC code annex 7 multihulls intact: maximum angle GZ = 24,5°; maximum area 0° ~ 30° = 16,23 m°; area GZ and HA = 6,64 m°. Catamaran vessel design operational capability up to 60 nautical miles with moderate and fresh breeze (Beaufort scale 4 and 5; wave height 1-2 meters).

Introduction

Fishing vessel fleet has various types, based on Indonesia's fisheries statistical category and boat/vessel size for each fishing gear are distinguished by categories, undecked motor vessel, decked motor vessels and undecked vessel without motor. Outboard engine - undecked motor vessel the fleet number approximated ± 8000 units in the southern coast of Java, Bali and Nusa Tenggara [1] Indian Ocean inshore.

Fishing vessel restructure program in Indonesia requires technology to convert undecked motor vessel type into decked motor vessel type. Catamaran vessel is one of the convert method and most advance technology in ship building. The purpose of this applied research implements catamaran vessel technology for fishing vessel. Furthermore, the technology aims to prepare alternative vessel on integrated fishing vessel operation system.

Method

Comparative studies to develop this applied research on catamarans includes construction, material and stability from existing outboard engine - undecked vessel (“trimaran”) in Fig. 1. Regarding the catamaran hull design -how it works and hydrodynamic forces generated-conduct simulation with MAXSURF and ABAQUS software.

The software used to determine the hull shape and size of the optimum catamaran and based on existing undecked vessels. Iteration process aim to have a minimum hull resistance with

proper fishing hold capacity. Hull data measurement results obtained from undecked vessels are further processed calculation using the software to make the catamaran design drawings.

Construction calculation with ABAQUS analysis using Finite Element Method (FEM) as a numerical technique method for finding approximate solutions to boundary value problems for partial differential equations (PDEs). Production of catamaran vessel from molding process to sea trial conducted at the shipyard and open water. All data collected in the field processed by combining the simulation results with sea trial data.

Results and Discussion

The existing design without any standard lamination and construction on monohull round bilge type (trimaran) be used as hull base on catamaran engineering. The undecked vessel installed one outboard engine as it primary mover with a set of outriggers on both side in Fig. 1.

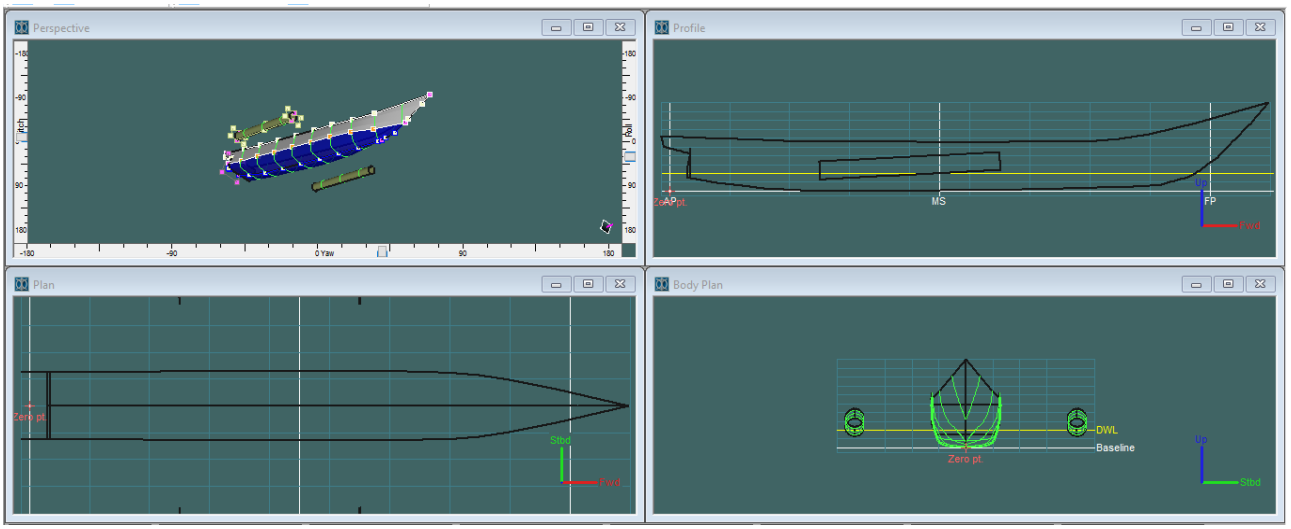

Figure. 1. Undecked fishing vessel.

The manufacture of undecked motor vessel with the size L x B_{hull} x D = 10.00 x 1.20 x 0.80 m used are as follows:

1. Keel/Stem
   7 layers Chopped Strand Mat 300 gr/m^{2}and Woven Roving 800 gr/m^2 with 5.56 mm thickness and 3400 gr/m^2.
2. Shell/Hull Side
   5 layers Chopped Strand Mat 300 gr/m^2 and Woven Roving 800 gr/m^2 with 3.53 mm thickness and 1700 gr/m^2.
3. Frame/Wrang/Girder-Sandwich System (Wood core)
   3 layers Chopped Strand Mat 300 gr/m^2 and Woven Roving 600 gr/m^2 of 50 x 70 mm with 3.21 mm thickness and 1500 gr/m^2

Hull shape and separation of demihull determines value of hull resistance, for the round bilge type of hull considers maximize volume of fish hold with higher value of hull resistance. Meanwhile hard chine type decreases hull resistance value and reduces volume of fish hold. The combination of both types emerges basic demi hull design for catamaran. Recent research shows vessel of monohull with hard chine ran faster than round bilge for the same main engine (horse) power at higher Froude number (over 0.3). The catamaran most probably offers total resistance (engine power) lower than or equal to those monohull [2]. Separation of demihull S/L ratio, where S is horizontal distance of center line of demi hull and L is Length of water line. S/L value considers interference on fluid below the bridge deck, effect of separation of

demihull transversely to component constraints catamaran hull is significant even though not on every variation of speed [3].

Body plan of catamaran in Fig. 2 have been analyzed and resulting hydrostatic information of the vessel's characteristic. The result was S/L = 2.40/10.88 = 0.22 and with equilibrium condition from specific component at full condition load. Designed velocity for full load Vs (service speed) = 10 knots with catamaran's Froude Number value 0.498.

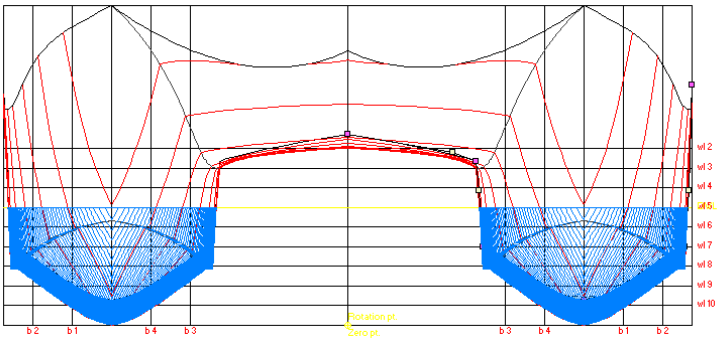

Figure 2. Catamaran 3-D body plan view MAXSURF.

The calculation of the construction of fiberglass boats can referred to the FRP vessel regulations Indonesia Classification Bureau 1996 [4]. Mechanical Properties of FRP for ships [5]:

- Tensile strength 85 N/mm^2
- Young's modulus 6350 N/mm^2
- Flexural strength 152 N/mm^2
- Shear modulus of 2750 N/mm^2

The manufacture of 5 GT catamaran fishing vessel in Fig. 3 calculates hull construction with the size L x B_{hull} x D = 12.00 x 1.20 x 1.00 m used are as follows:

1. Keel/Stem
   11 layers combination of Chopped Strand Mat 300 gr/m^2 and Woven Roving 800 gr/m^2 with 10.3 mm thickness and 5300 gr/m^2.
   Width = distance girth hull chine left to right = 2300 mm
   Keel width = 400 mm.
2. Shell/Hull Side
   7 layers Chopped Strand Mat 300 gr/m^2 and Woven Roving 800 gr/m^2 with 6.3 mm thickness and 3100 gr/m^2.
3. Frame/Wrang/Girder-Sandwich System (Polyurethane core)
   7 layers Chopped Strand Mat 300 gr/m^2 and Woven Roving 600 gr/m^2 of 50 x 70 mm with 5.67 mm thickness and 2700 gr/m^2

ABAQUS Finite Element Method simulates concentrated force 5 tonnes load on keel on both hull caused maximum pressure 73.96 N / mm^2 on upper bridge deck in Fig. 3 [6]. The pressure is bellow tensile strength of FRP material with 85 N / mm^2 value.

Analysis of the vessel's speed requirement using MAXSURF-hullspeed 13:01 slender body method and the efficiency of the engine uses 80% for safety factor in Fig. 5. However, use of the method slender body has the following requirements: 4 or 5 < $(L/V)^{1/3}$ < without limitation. The lower speed limit = 0.0 with high speed limit = FnL = 1.0 (depending on the value of slenderness ratio) [7]. The graphic shows high inclination between 7.5 knots and 15 knots in speed and correlate with demands adequate power increased rapidly.

The vessel stability criteria complied to International Maritime Organization (IMO) Maritime Safety Committee (MSC).36(633) High Speed Craft (HSC) code annex 7 multihulls intact: maximum angle GZ = 24,5° > 10°; maximum area 0° ~ 30° = 16,23 m° > 3.851 m°; area

GZ and HA = 6,64 m° > 1,604 m° with full load condition analyzed - intact stability in Fig. 6. The graphic shows intact stability of the vessel adequate to counter static heel degree up to 90°.

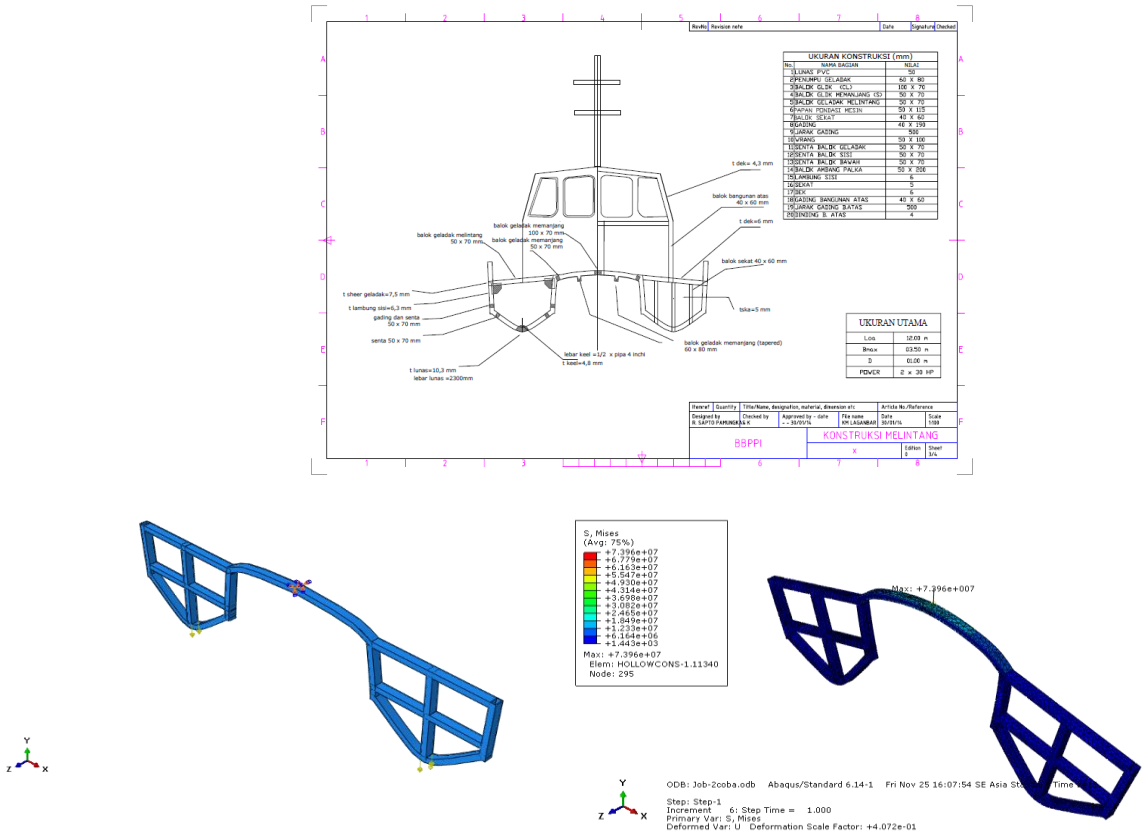

Figure. 3. Midship section.

Figure 4. Catamaran 3-D view -MAXSURF (left) and sea trial of laganbar (right).

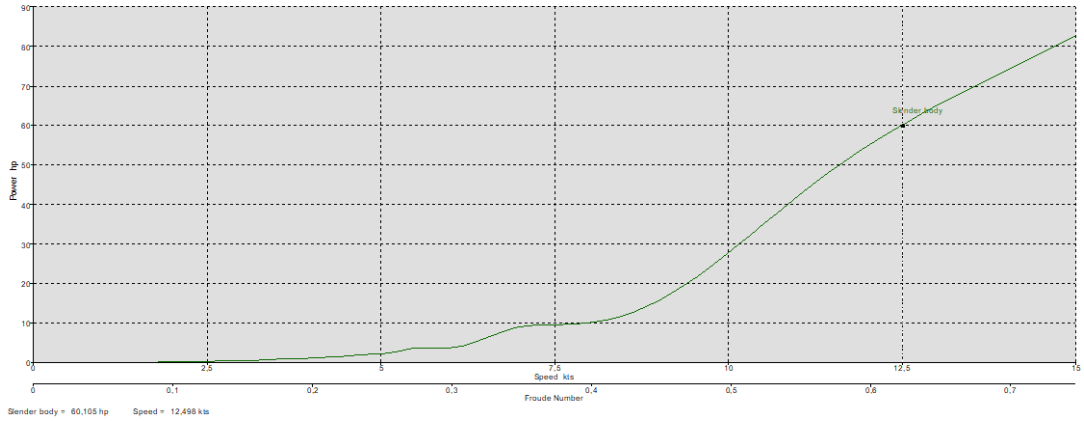

Figure 5. Speed- horse power (HP) with slender body method.

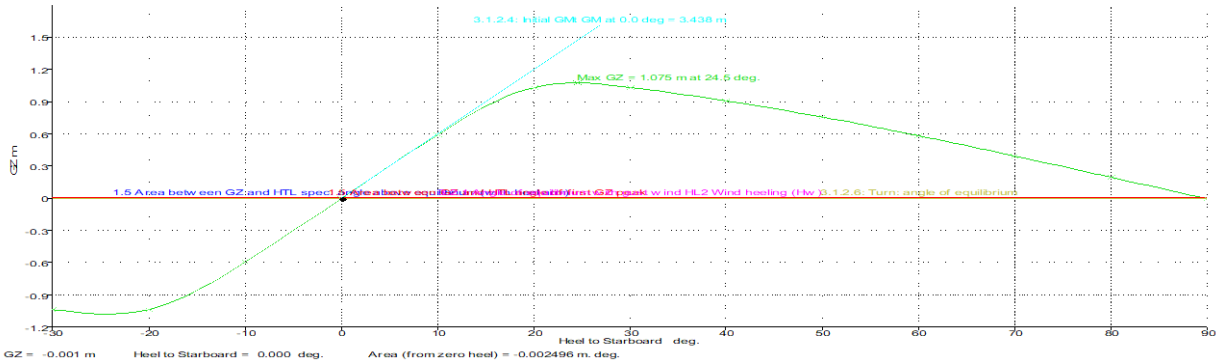

Figure 6. Full load condition intact stability.

Table 1. Comparative studies parameter.

		Mono Hull Round Bilge (Trimaran)	Demi Hull Hard Chine (Catamaran)
Principal Dimension	Length Overall	10 Meter	12 Meter
	B_{hull} ($B_{max.}$)	1.2 Meter (3.5Meter)	1.2 Meter (3.4 Meter)
	H	0.8 Meter	1 Meter
Layers	Keel (Weight)	7 layers (2800 gr/m^2)	11 layers (5300 gr/m^2)
	Hull	4 layers (1700 gr/m^2)	7 layers (3100gr/m^2)
	Frame	4 layers (1500 gr/m^2)	5 layers (2700gr/m^2)
Construction	Frame Spacing	0.6 Meter	0.5 Meter
	Frame	30x60 mm	50x70 mm
	Girder	30x50 mm	50x70 mm
	Engine power Speed	15 HP 7~11 knot	2 x 30 HP 7~12 knot
Stability	Area 0 to 30	11.34 m°	16,23 m°

		Mono Hull Round Bilge (Trimaran)	Demi Hull Hard Chine (Catamaran)
IMO MSC.36(633) HSC code annex 7 multihulls intact			
	Angle of max. GZ	22.7°	24,5°
	Area between GZ and HTL		
	Hpc + Hw	5.26m°	6,64 m°

Comparative studies parameter shows catamaran design perform better for construction, velocity and stability (Table 1). Construction catamaran marginal value estimated 50% higher towards undecked motor vessel. Velocity and stability marginal value approximated 2%-15% above undecked motor vessel. The technology of catamaran vessel fleet has potential role to support fishing vessel restructure and fisheries industrialization program. Catch production of the fleet with high quality fish by applying Good Handling Practices are achievable in order to supply fish carrier vessel, furthermore export quality needs for fish production facility.

5 GT catamaran vessel is an alternative technology integrated operation with fish carrier vessel. The fish carrier vessel will transport fish from catamaran vessel to near inshore nor land fish production facility. The facility fulfils for export requirement and regulation to be consignment with air transportation and eventually delivers to consumer at fish market in Fig. 7.

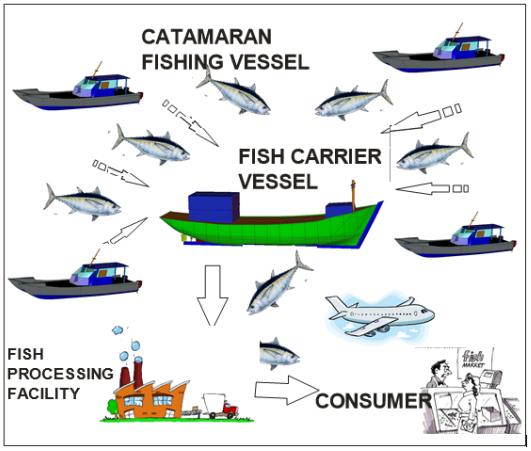

Figure 7. Integrated fishing vessel operation system.

Conclusions

Principal dimension of 5 GT catamaran fishing vessel are Loa = 12.00 meters B =3.50 meters and H = 1.00 meters with S/L=0.22 and engine power = 2 x 30 hp.

The materials are Fiberglass Reinforced Plastic (FRP) referred to Non-Metallic, Indonesia Classification Bureau 2006 Rules. The Vessel Construction referred to Fiberglass Reinforced Plastic, Indonesia Classification Bureau 1996 Rules.

The results of sea trial speed 9~12 knots following seas and 7~8 knots head seas. Turning cycle test 17-50 seconds with 50% and 80 % of engine Revolution per Minutes.

The vessel stability criteria complied to IMO MSC.36(633) HSC code annex 7 multihulls intact: maximum angle GZ = 24,5°; maximum area 0° ~ 30° = 16,23 m°; area GZ and HA = 6,64 m°.

Catamaran fishing vessel design operational capability up to 60 nautical miles with moderate and fresh breeze (Beaufort scale 4 and 5; wave height 1-2 meters).

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A Study of the Assist Tug Requirement for LNG Carrier

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Keywords: Harbor tug, LNG carrier, Arun terminal, Bollard Pull.

Abstract. Harbor tug boat is auxiliary craft for navigation and maneuvering of vessels and other floating. There are many types of harbor tug boat, for example azimuth stern drive (ASD), voith schneider tractor tug (VST), and rotor tug. The purpose of the research study is to get main dimension and type of tugboat for escorting LNG carrier in Arun Terminal. In this study, it uses force estimation method to calculating resistance of ship. All of harbor tug type can be implemented in Arun Terminal. The minimum of main engine power (BHP) 2 x 2000 Hp with the minimum bollard pull 50 ton.

Introduction

Harbor tug boat is auxiliary craft for navigation and maneuvering of vessels and other floating bodies and it is used to assist the vessel in going alongside and sheering away maneuvers and on certain occasions when staying, to aid the vessel in turning about in a small area, to escort vessels with hazardous cargoes in high risk areas as a precaution for a loss steering, and to tow, push or aid a vessel which has lost its means of propulsion or steering. There are many types of harbor tug boat, for example azimuth stern drive (ASD), voith schneider tractor tug (VST), and rotor tug.

The ASD has the following characteristics: low relative draught, good steering characteristics, except when going astern at higher speeds, towing point is just forward or just aft of amidships, underwater hull form improves the dynamic stability of the tug, bollard pull going astern is reduced only by approximately 10%, maneuverable and able to pull effectively over the stern or bow, towing winches often fitted both fore and aft, risk of girting/girding when towing over the stern, and enhanced training of tug masters required when operating the forward winch [1,2,3].

The VST has following characteristics: full power available in all directions, quick response to engine movements, very maneuverable, especially in tight sea space, reduced risk of girting/girding, reduced maneuverability if towing from forward at higher speeds. reduced directional stability, particularly in open waters, reduced bollard pull per kilowatt output, relatively deeper in draught therefore increased risk of bottom damage from grounding, and increased training required for tug masters [1,2,3,5,6,7].

The Rotor Tug has following characteristics: a rotor tug featuring two single drum winches will simply turn about and re-establish a towline connection in under 6 minutes in the first case, a rotor tug continues operation at 66% performance in case of a propulsion (system) failure. Downtime due to engine maintenance can be zero, limited repositioning when changing vessel direction from/to berth means reaction time is decreased; increased number of operation conditions operable with fewer tugs, faster reaction times enable safer operation with fewer tugs, a rotor tug can work both ends. It always has the choice to work bow first, increasing the overall safety envelope and window of operation in adverse weather, a rotor tug can steer and brake at the same time, having pivot point in the middle of the tugs, enables a

comparatively large size vessel to operate similar to smaller terminal tugs, and the small turning radius and ability to transfer forces directly (no repositioning) increases the vessel's safety zone dramatically [1,2,3].

Fig. 1 Arun LNG terminal site

Fig. 1 shows location of Arun LNG in Lhokseumawe, Aceh [8]. The objective of this study is to get main dimension and type of tugboat for escorting LNG carrier. The LNG carrier has capacity of 145700 m^3 with the length 285.4 m, breadth 43.4 m, depth 26 m, draft (design) 11.5 m, draft (scantling) 12.5 m. The Arun LNG terminal with a capacity of 405 million standard cubic feet per day (MMSCFD), and is now operated PT Perta Arun Gas, a subsidiary of PT Pertamina Gas. It is the first LNG plant in the world and has the potential of LNG storage capacity of 12 million tons per year.

Table 1 Option of proposed harbour tugboat

Option	Ship Type	Power (HP)	Total Power	Bollard Pull	Wind Speed Maximum
1A	ASD 30-50 (3 pcs)	2 x 2000	4000	50	14
1B	ASD 34-65 (3pcs)	2 x 2500	5000	65	16
1C	ASD 32-78 (3pcs)	2 x 3386	6772	78	18
2	ART 32-80 (3 pcs)	3 x 2463	7387	80	20
3A	VWT 29-58 (3 pcs)	2 x 2760	5520	58	16
3B	VWT 32-70 (3 pcs)	2 x 3384	6768	70	18

The objective of this study is to get main dimension and type of tugboat for escorting LNG carrier in Arun Terminal. Table 1 shows option of proposed harbour tugboat that will be evaluated. In this study, it uses force estimation method to calculating resistance of ship. This study uses steering analysis, bollard pull analysis, and rule from ministry of transportation Republic of Indonesia "Nomor PM 93 Tahun 2014" [9].

Method

Force Estimation. Ship resistance is the important component in ship operation. Increasing of ship resistance needs more BHP for Main Engine. Force estimation is done to calculate force below and above water. It is used to powering estimation of tugboat that will be used for escorting LNG carrier. A ship travelling in still air experiences air resistance on its above-water hull and superstructure. The level of air resistance will depend on the size and shape of the superstructure and on ship speed. The air drag of the above water hull and superstructure is generally a relatively small proportion of the total resistance. However, for a large vessel consuming large quantities of fuel, any reduction in air drag are probably worth pursuing. The air drag values shown are for the ship travelling in still air. The proportion will of course rise significantly in any form of head wind. The air drag on the superstructure and hull above the waterline may be treated as the drag on a bluff body. Typical values of C_D for bluff bodies for $Re > 10^3$ are given in Table 2 [4].

Table 2 Approximate values of drag coefficient for bluff bodies

NO	TYPE	CD
1	Square Plates	1.1
2	Two-dimesional plate	1.9
3	Square Box	0.9
4	Sphere	0.5
5	Ellipsoid, end on (Re 2x 10^5)	0.16

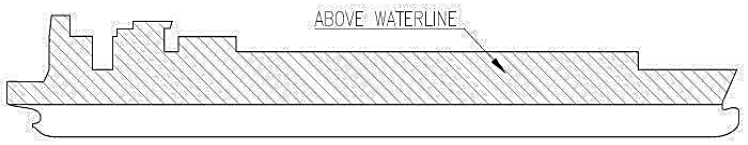

Fig. 2 Force above waterline

Fig. 2 shows force above waterline for longitudinal view. The value of force above water line has been influenced by velocity of the wind to ship (v), projected area, and the coefficient of drag. The air force equation can be written as [4],

$$R_A = \frac{1}{2} \rho_A C_D A_p V^2 \quad (1)$$

Where,

Ap = the projected area perpendicular to the relative velocity of the wind to the ship

V_A = the relative wind and, $\rho_A = 1.23$ kg/m^3 for air.

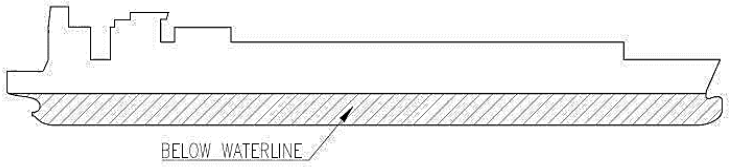

Fig. 3 Force below waterline

Fig. 3 shows force below waterline for longitudinal view. The value of force below water line has been influenced by speed of ship (v), wetted surface area, and hull form of ship. The force below waterline can be written as [4],

$$R_{BW} = \frac{1}{2} \rho V^2 A_{BW} [C_F(1+k)+C_A] \quad (2)$$

Where,

A_{BW} = the wetted surface area
V = the speed of ship
ρ = density of fluid, $\rho = 1025$ kg/m^3 for salt wate
C_F = coefficient of friction resistance
(1+k) = coefficient of ship body type
C_A = coefficient of model ship correlation allowance

Fig. 4 shows the scenario of ship position for escorting activity. It shows ship various angle for ship position. There are 0º, 30º, 45º, 60º, and 90º. The angle of ship position has effect for force below waterline and above waterline. It is related with choosing the capacity of bollard pull for Tugboat.

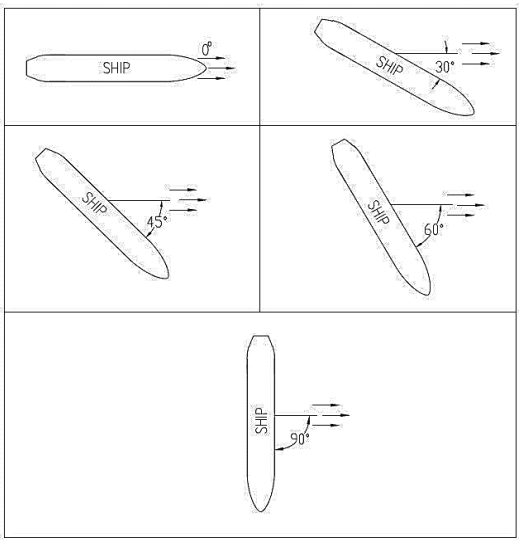

Fig. 4 The scenario of ship position

Steering Pull Analysis. IMO has issued rules for ships' maneuverability (IMO 751 – 10/10 zigzag maneuver criterion) [9]. To provide maneuverability corresponding to these rules, the escort tug requires a typical steering pull (TSP) as plotted in Fig. 5.

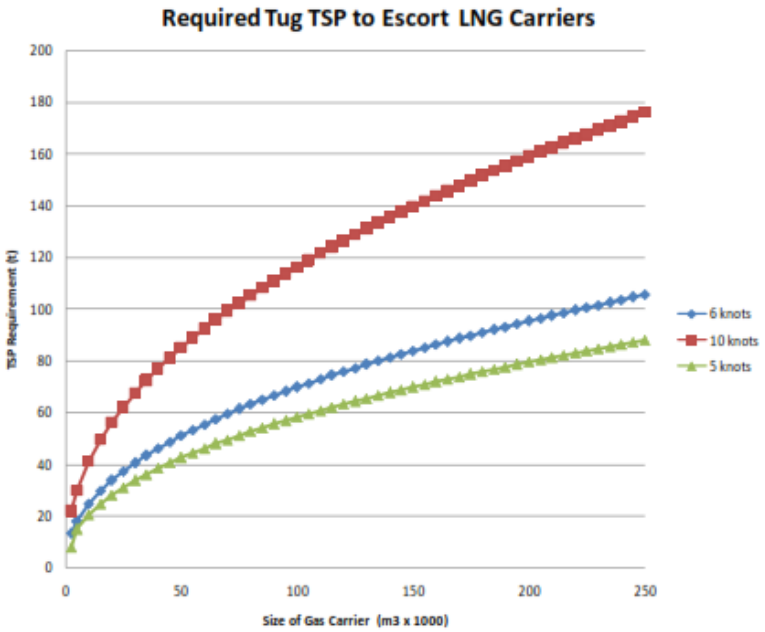

Fig. 5 Required Tug Tones Steering Pull to Escort LNG Carrier

Ministry of Transportation Republic of Indonesia "Nomor PM 93 Tahun 2014". Ministry of transportation gives a rule describing relationship between ship's length, engine power, bollard pull and required tug's number as shown in Table 3. It describes minimum requirement in function of ship's length [9].

Table 3 Rule of Ministry of Transportation Republic of Indonesia "Nomor PM 93 Tahun 2014"

No	Ship Length (m)	Req. Total Number of Tugs	Req. Power Engine (HP)	Req. Bollard Pull (Ton)
1	70≤L≤150	1	2000	24
2	150<L≤250	2	6000	65
3	>250	3	11000	125

Result

Based on Fig. 6, they show total force in several of angle and air velocity. They show that the increasing of total force depends on the air velocity and angle. The maximum of total force occurs when the angle of ship is 90^0. It is 266.96 ton. The minimum of total force occurs when the angle of ship is 0^0. It is 2.11 ton. The total force (6 – 28 ton) is between air velocities 8 – 18 knots for angle 0^0. The total force (29 – 67 ton) is between air velocities 8 – 18 knots for angle 30^0. The total force (40 – 95 ton) is between air velocities 8 – 18 knots for angle 45^0. The total force (50 – 117 ton) is between air velocities 8 – 18 knots for angle 60^0. The total force (58 – 134 ton) is between air velocities 8 – 18 knots for angle 90^0.

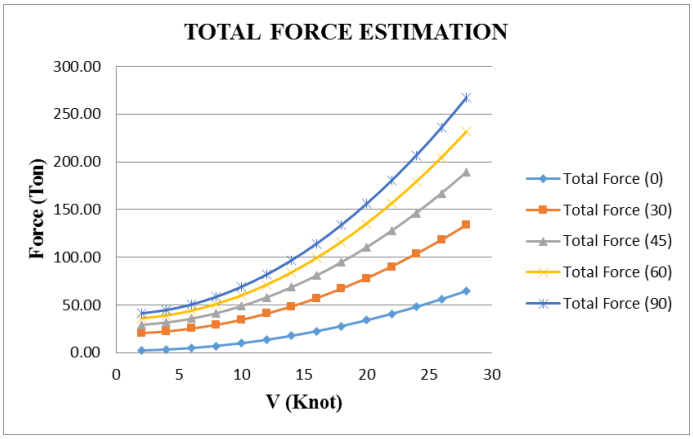

Fig. 6 Total Force in Various of Angle and Air Velocity (Entering to Arun Terminal)

As seen in Fig. 7, they show total force in several of angle and air velocity. They show that the increasing of total force depends on the air velocity and angle. The maximum of total force occurs when the angle of ship is 90^0. It is 286.53 ton. The minimum of total force occurs when the angle of ship is 0^0. It is 1.64 ton. The total force (7 – 34 ton) is between air velocities 8 – 18 knots for angle 0^0. The total force (24 – 68 ton) is between air velocities 8 – 18 knots for angle 300. The total force (34 – 96 ton) is between air velocities 8 – 18 knots for angle 45^0. The total force (42 – 117 ton) is between air velocities 8 – 18 knots for angle 60^0. The total force (49 – 135 ton) is between air velocities 8 – 18 knots for angle 90^0.

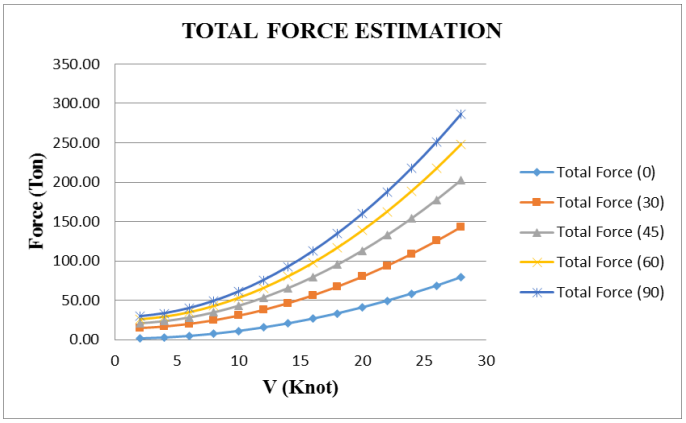

Fig. 7 Total Force in Various of Angle and Air Velocity (Out from Arun Terminal)

Referring to Fig. 5, a ship of 145,700 m3 should be assisted by escort tug(s) with various steering pull depending of its speed. For standard tug boat speed during birth and un-birthing process, tug boat's speed is given at 6 knots. Referring to Fig. 5, required tug tones steering pull is about 83 tones. Table 4 shows all of option has met with the requirement for steering pull analysis.

Table 4 Tones steering pull (TSP)

Option	Total Bollard Pull	Tones Steering Pull (TSP)		Ratio	Status
		Offered (t)	Req. (t)		
1A	100	160	83	1.92	OK
1B	130	208	83	2.50	OK
1C	156	250	83	3.01	OK
2	160	256	83	3.08	OK
3A	116	185	83	2.22	OK
3B	140	224	83	2.69	OK

Table 5 presents the result of total engine power, total bollard pull and number of tugs. Based on Table 3, all of option has met the requirement of minimum bollard pull, minimum engine power and number of tugs in function of ship length.

Table 5 Requirement of Average Number of Tugs, Engine Power, and Bollard Pull in Function of Ship Length

Option	Total Number of Tugs	Req. Total Number of Tugs	Status	Total Engine Power	Req. Engine Power (HP)	Status	Total Bollard Pull (Ton)	Req. Bollard Pull (Ton)	Status
1A	3	3	OK	12000	11000	OK	150	125	OK
1B	3	3	OK	15000	11000	OK	195	125	OK
1C	3	3	OK	20316	11000	OK	234	125	OK
2	3	3	OK	22161	11000	OK	240	125	OK
3A	3	3	OK	16560	11000	OK	174	125	OK
3B	3	3	OK	20304	11000	OK	210	125	OK

Summary

As described in the previous section, it can be concluded that all of option can be implemented in Arun Terminal from which the proposed tugboat has been satisfied all of requirement as Fig. 5 and Table 3 for IMO Criteria and Ministry of Transportation Republic of Indonesia, respectively. However, it is noted that each option has wind speed limitation for maximum 14 knot. Force below and above water line is 96.95 ton for 14 knot wind of speed. So the minimum number of harbor tug is 3 tugboat. All of harbor tug type can be implemented in Arun Terminal from which the proposed tugboat has been satisfied all of requirement. The minimum of main engine power (BHP) 2 x 2000 Hp with the minimum bollard pull 50 ton.

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