APPLICATIONS OF HYBRID PROPULSION SYSTEM ON TRIMARAN TOURIST VESSELS WITH RELIABLE AND ENVIRONMENTAL FRIENDLY

Eddy Setyo Koenhardono[1]

[1]Department of Marine Engineering, Institut Teknologi Sepuluh Nopember
60111 Keputih, Surabaya, Indonesia
*Email: eddy-koen@its.ac.id
Phone: +6231594; Fax: +62000000

ABSTRACT

Indonesia is the largest archipelagic country in the world, as it has 13,487 islands spread from Sabang to Merauke. These islands have the potential of marine tourism is very large, but not yet optimally utilized. One of the problems is the limitation of reliable, safe, convenient and environmentally friendly transportation. This problem can be overcome by the presence of trimaran tourism vessel that uses hybrid propulsion system.
In this paper, the trimaran tourist vessel is planned to have a passenger capacity of 20 people, a cruising range of 25 km and has two official speeds, 3 knots and 10 knots. The hybrid propulsion system is a combination of electrical propulsion systems and mechanical propulsion systems. Electrical propulsion system operated at low speed, 3 knots. The hybrid propulsion system is operated at 10 knots to get to the marine tourism sites and return to the mainland. At a speed of 3 knots, the ship will tour the marine tourism sites to enjoy underwater scenery. In this condition, trimaran tourist vessels are driven by two DC electric motors that derive energy sources from energy stored in battery and from solar cells mounted across the roof of the trimaran vessel. So that in this condition does not occur air pollution and noise pollution that can be caused the operation of motor fuel.

Keywords: tourist vessels, trimaran vessel, hybrid propulsion system, solar panel.

INTRODUCTION

The existence of sea transportation is fast, safe, comfortable and environmentally friendly is a necessity for the development of marine tourism in Indonesia. This condition becomes the main consideration for developing trimaran tourist vessels with hybrid propulsion system to become a marine tourism ship. The trimaran tourist vessel with three slender hulls has several advantages over the monohull[M1] vessel, which is low resistance at high speed, good stability, small rolling motion, wider ship deck, high reliability and energy efficiency. This has an impact on the safety and security of marine tourism boats to be higher.
Indonesia's location in the tropics has a potential advantage of sunlight reaching 4.8 kWh / m2 day or equivalent to 112 thousand GWp. The maximum capacity of solar energy absorption on marine tourism vessels is influenced by the area of solar panels that can be installed. In the same displacement, the area of solar panel cells that can be mounted on a trimaran tourist vessel is much larger than the monohull type. The utilization of sunlight as a source of energy in trimaran tourism vessels, in addition to batteries and generators, will result in financial and environmental benefits.

TOURISM TRIMARAN VESSELS AND HYBRID SYSTEM

The development of marine tourism vessels should consider safety, comfort and environmentally friendly factors. The safety factor on the vessel has a correlation with the level of stability and operational continuity of the propulsion system and the electrical system. A marine tourism ship has a good level of comfort, if it has a low movement, low vibration and noise levels and adequate passenger mobility. In addition to creating low-emission green ship, marine tourism vessels should have a low wave wash. The three factors that become the main consideration for the development of marine tourism vessel can be realized by a trimaran tourist vessels that uses hybrid propulsion system.

Trimaran ship is a ship with three slender hulls, where the main hull is flanked by two demihulls. The use of a slender form of hull can reduce the occurrence of wave wash (Jamaluddin & Utama 2009; Jamaluddin et al 2010) and reduce the resistance at high speed (Main et al. 2008). Trimaran ships also have a very good seakeeping (Sulisetyono 2012), so it has a higher level of comfort. Furthermore Indiyono (2010), declared trimaran ship has a wider deck, so that passengers more freely move and propulsion system placement becomes more flexible.

The existence of three hulls make the planning of hybrid propulsion system on marine tourism ships become more freely. Hybrid propulsion system is a combination of mechanical propulsion system in main hull and electric propulsion system in the aftermath of hull. When trimaran tourist vessels operate at maximum speed, mechanical propulsion systems have higher efficiency than other propulsion systems. But at low speed, the efficiency of the mechanical propulsion system goes down. This weakness can be corrected by an electric propulsion system. Electrical propulsion systems have advantages in terms of low noise and low vibration, high redundant, low emissions, and low operating capacity. Therefore, the use of a hybrid propulsion system on a trimaran marine tourism vessel will increase the level of safety, comfort and friendliness compared to conventional propulsion systems. The operational mode of hybrid propulsion system on trimaran tourist vessels are:

- Mechanical mode, the vessel is driven by a diesel motor that drives the main propeller in the mainhull while the power requirements are obtained from batterey and solar cells.
- Electrical mode, the ship is driven by both direct current electric motors, while the diesel motor is on the off position. Both electric motors and electrical loads obtain electrical power from batterey and solar cells.
- Generator mode, the ship is driven by a diesel motor that also generates electricity through a dynamo connected through a chain or belt. The direct current electric power generated by the dynamo is used to meet all the electrical needs in the vessel and charging batterey.
- Hybrid mode, the ship is driven by propellers driven by a diesel motor and both propellers are driven by an electric motor. The need for electrical power, both for electrical equipment on board and both DC electric motors, supplied from battery and solar cells.

In addition, the electrical system used in trimaran tourist vessel is a hybrid system concept as well. Electrical systems are supplied from three sources of power generation, diesel-driven DC generators, battery in charge of PLN and solar panel cells. Three sources of power plants serve to meet the needs of electric power in the ship, namely

propulsion, pumps, compressors, navigation and communication equipment and so on. Figure 1 shows the energy flow diagram on a planned trimaran tourist vessel.
The existence of three hulls make the planning of hybrid propulsion system on marine tourism ships become more freely. Hybrid propulsion system is a combination of mechanical propulsion system in main hull and electric propulsion system in the aftermath of hull. When marine tourism boats operate at maximum speed, mechanical propulsion systems have higher efficiency than other propulsion systems. But at low speed, the efficiency of the mechanical propulsion system goes down. This weakness can be corrected by an electric propulsion system. Electrical propulsion systems have advantages in terms of low noise and low vibration, high redundant, low emissions, and low operating capacity. Therefore, the use of a hybrid propulsion system on a trimaran tourism vessel will increase the level of safety, comfort and friendliness compared to conventional propulsion systems. The operational mode of hybrid propulsion system on trimaran tourist vessel are:

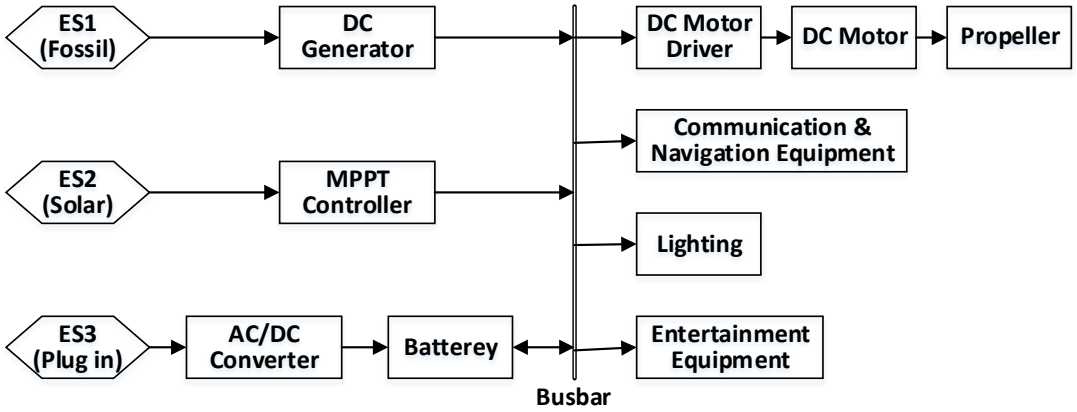


Figure 1. Diagram of energy generation system on tourism trimaran vessels

METHODOLOGY

Figure 2 is a plot of hybrid system design methodology on a trimaran tourist vessels. The methodology begins with the planning of a trimaran tourist vessel, with reference to the demihulls and mainhull displacement ratios of 1: 3. Then followed by ship resistance analysis and electric load requirements. The results of the ship resistance calculation are used to determine the magnitude of the thrust of the ship in accordance with the planned operating speed profile. The trimaran tourist vessel is planned to have two operating speeds, 3 knots and 10 knots. A mechanical propulsion system is used when the operating speed is 15 knots. If the vessel speed is 3 knots or less, then the electrical propulsion system operates.

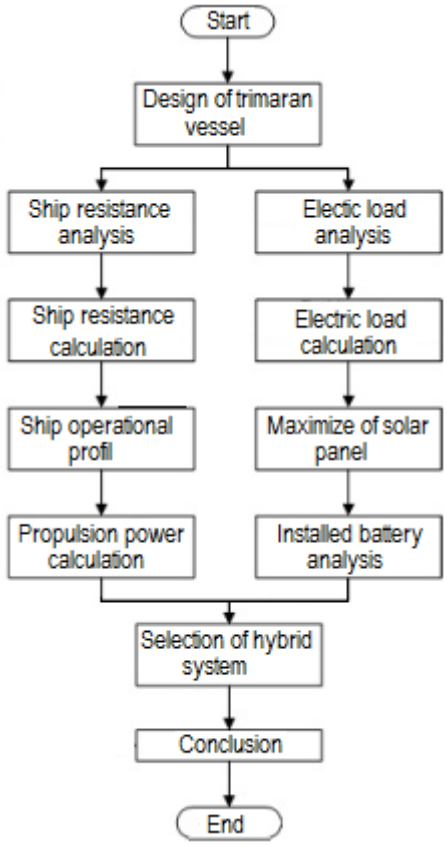


Figure 2. The diagram of research methodology

The need for propulsion power at speeds between 3 knots and 15 knots can be achieved by operating a diesel engine that drives propellers and DC generators. The electrical power of the DC generator is used to supply the electrical load on the ship, charging the battery and operating the DC motor.

RESULTS AND DISCUSSION

General Arrangement

This trimaran tourism vessel is designed with a capacity of 18 passengers and 2 crew. The mainhull displacement is 3 times the total displacement of demihull. The general arrangement are shown in Figure 2 and the dimensions in Table 1.

Table 1. Dimension of the trimaran tourist vessel

	Mainhull	Demihull	Distance of CL
Length pp (Lpp) m	11,31	7,703	1,8
Breadth (B) m	0,963	0,640	
Height (H) m	1,467	1,209	
Draught (T) m	0,782	0,524	

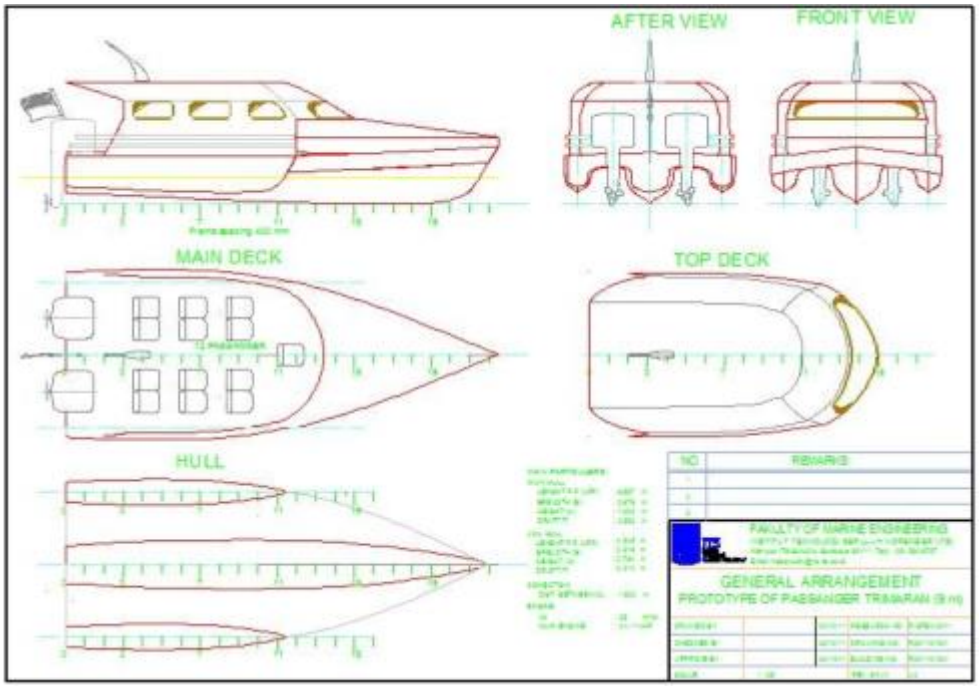
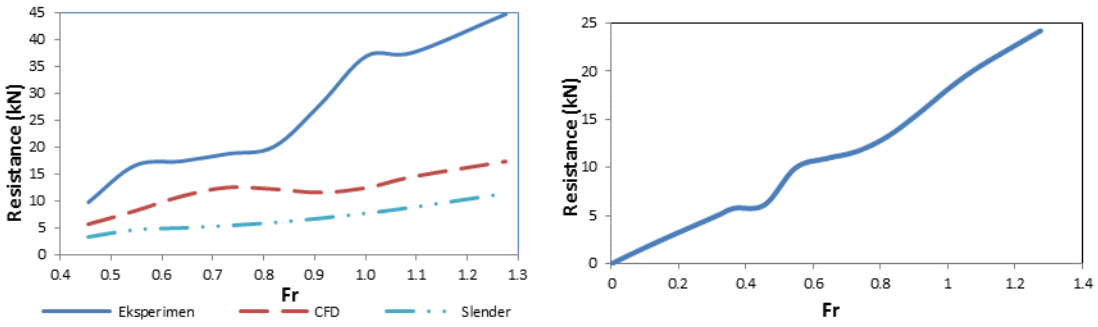


Figure 2. General arrangement of the trimaran tourist vessel

Resistance and Power

The analysis of trimaran tourist vessel resistance is done by using three methods, namely experiment, computational fluid dynamic (CFD), and slender body calculation method. The results of the analysis of these methods can be seen in Figure 3a. Since the results of the three methods are not convergent, the average resistance value of the trimaran tourist vessel is used, as shown in Figure 3b.



a. Result of resistance with three methods b. The average result of resistance

Figure 3. The resistance analysis of tourist trimaran vessel

The calculation of the need for propulsion power trimaran tourist vessel distinguished between mechanical systems and electrical systems. Based on the power-speed graph on Figure 4, it can be obtained the need for propulsion power:

- At a speed of 3 knots, the ship uses an electric propulsion system or electrical transmission, where it takes propulsion of 6.35kW. Therefore, two DC motors with 4 HP power are used.

- At a speed of 10 knots by mechanical propulsion or mechanical transmission system, the propulsion power requirement is 53.56 kW, so the 75 HP diesel engine is selected.

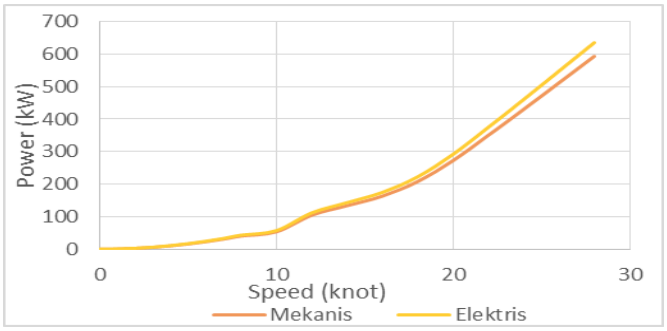


Figure 4. Speed power calculation of trimaran tourist vessel

Calculation of solar cell capacity

Solar cells can serve as a source of DC motor drive energy and battery charging. The characteristics of solar cell output power are affected by solar radiation and surface temperature of solar cells, an algorithm is needed to find the maximum power point (MPPT) and maintain at that point of work. By using the MPPT algorithm, the system can deliver maximum power from solar cells to the load.

The results of testing of solar cells with parameter data in Table 2 at 10.00 WIB and 15.30 WIB are shown in Figure 5. Based on the results of testing of MPPT and without MPPT algorithm, it shows that the application of MPPT algorithm can optimize the power (maximum power) produced by solar cell according to magnitude insolation of the sun that changes with time, as shown in Figure 6.

Based on the experimental results, the power that can be generated by solar cells is 80 watts / m2. If the surface area of the trimaran roof 40 m2, then the power that can be produced is 3200 watts**.**

Table 2. Solar cell parameters

Maximum Power (PM)	50 W
Open Circuit Voltage	21,6 V
Short Circuit Current (Isc)	3,04 A
Maksimum Power Voltage (Vmp)	17.6 V
Maksimum Power Current (Imp)	2,84 A

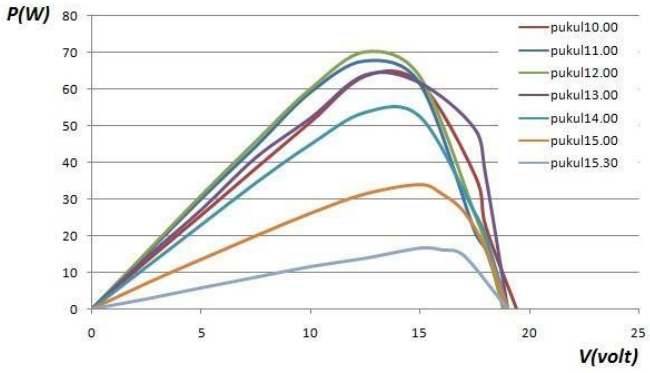


Figure 5. Testing of solar panel

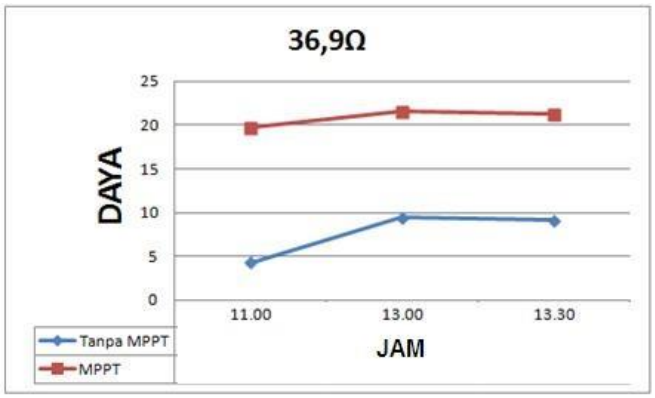


Figure 6. Testing of MPPT with 36,9 Ohm

Arrangement of hybrid system

Based on the results of solar cell analysis above, the power generated solar cell is only 3.2 kW, while the power requirement for the motor reaches 6.35 kW. This condition makes the hybrid system between solar cells and batteries as a source of energy for electric motors is not possible, because the needs of large batteries, thus impacting the high battery weight. Therefore, the hybridisation uses dynamo and solar cells. The electric power supplied from the dynamo is 3.5 kW and 3.2 kW solar cell to drive the electric motor.

CONCLUSION

The components of the hybrid propulsion system on a trimaran ship consist of:

- The main engine is a diesel motor with 75 HP power, this motor is in the mainhull. This diesel motor can drive propellers and dynamo to produce electrical power.
- Two direct current motors that have power of 4 HP each, placement on demihull
- The required dynamo capacity is 10 kVA
- Solar panels with capacity of 3.2 kW or 40 m2 area

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