OPTIMIZATION OF BUOYWEATHER MODELS USE OF PSO METHOD: High Reliability in Java Sea as Maritim Weather Station

Syamsul Arifin[1*], Aulia Siti Aisjah[2], and Nuri Sabrina[3]
[1,2,3] Department of Engineering Physics
Faculty of Industrial Technology, Institute of Technology Sepuluh Nopember,
60111 Keputih, Surabaya, Indonesia
[*]Email: syamp3ai@its.ac.id
60111 Keputih, Surabaya, Indonesia

ABSTRACT

The design of a buoy with a performance that can meet dynamics positioning criteria when it is operated on the high seas, is one of the requirements of the floating objects. The design optimization method in the floating structure dimension use of particle swarm optimization (PSO) methods. It was proposed in this study, variable model of buoy design is the diameter and height of cylinder. Design optimization aims to meet the stability criteria of dynamic movement in sea state 6. In optimization process was used function criteria is to minimize the heave motion response (Response of Amplitude Operator - RAO) and by maximizing the mass of buoy. The optimization model is tested in various wave height and wave direction, i.e. in the direction of wave 0^o and in the direction of heave motion. The value of load tolerances as a substitute for the weight of the entire of device, equipmnet, instrument and installed sensor, is carried out under three conditions of loading. The loading conditions are in unloaded (0%), 50% and 100% loading of total mass of buoy. The model was tested by numerical simulation, and showed optimization results in a maximum heave motion response of 3.942 m / m. This condition when the dimension of outer diameter of (D1) of 1.27 m, inner diameter (D2) of 0.91 m, lower cylinder of height (L1) of 0.25 m, and the upper cylinder of height (L2) of 0.2 m. In the condition of buoy model in optimal state, the spectrum response as quality performances of motion shows the peak condition of 7.44 m^2 / (rad / s).

Keywords: *buoy weather, heave, Java Sea, particle swarm optimization (PSO), reliability, RAO, spectrum response,*

INTRODUCTION

Indonesia is a country with 2/3 of its part is ocean, and main source of livelihood for coastal community is as fishermen. The fishing life is very dependent on sea weather conditions. Accurate information of the sea conditions will help the fishermen in determining the schedule of fish searching. Marine weather information can be obtained from an official board of BMKG (Badan Meteorology, Klimatologi dan Geofisika), as a board of meteorology, climatology information through its website. It is rarely done by the fishermen to access the information, due to the educational background factors.

A study aimed of obtaining a model a floating weather station at sea, and installed several weather sensors of measuring devices as well as a wireless transmission system. Previous research results from the researcher is a prototype of a marine weather station, which has been tested in a significant wave height of 0.5 m, or in sea state 2 (Fossen, 2011). This prototype has properties that are capable of measuring sea weather that is: wind speed, wind direction, humidity, rainfall, air temperature, air pressure and speed of sea currents. All weather variables can be transmitted on a wireles basis through the existing monitor system on land. The monitoring systems is receive weather data information on the time, and also consists of features a software that is able to predict maritime weather in the later (Arifin, Syamsul; Aisjah, Aulia Siti; Nugroho, 2016).

Some prototype of floating buoy used by weather stations in abroad, among others, have a cylindrical shape, with equipment, instrument, sensors and power-supplied solar panels placed on the cylinder. Buoy weather in designs as resembling plates face down on the two top and bottom of its side, is used in deep waters. Another buoy in sphere had tendency to rotate aorund (Pedersen, Torstein; Siegel, 2008).

There has been a study of the sattic and dynamic stability of the two shapes of weather buoys. The first bouy shape is like a bowl, and the second shape was stacked cylinders in diameter of different size. The first buoy is named buoy type I and the second is buoy type II. The buoy weather type II can be used to measure maritime weather, with static and dynamic stability at sea level of 0.5 meters. The equipments installed in the buoy are: (i) wave height sensor, ocean currents, and other meteorological parameters, (ii) Data presented in real time, and there is data processing on board for all measured data, (iii) Communication in two directions between buoys and control data transfers, (iv) Available moorings to maintain reliability and safety of buoys (Arifin, Syamsul; Nugroho, Gunawan; Nugroho, 2014).

This study proposed was optimizes the geometry of a buoy, which will be used for a buoyant weather to be placed in waters with wave height > 2 meters. The optimization is performed by numerical methods using the Particle Swarm Optimization (PSO) for the RAO values of a floating object that is stable in sea state 6. The main requirement of a floating object in the sea is to have a positive stability. This stability condition is determined by the center of weight (G)/gravity, buoyancy (B), and meta center (M). If G is below of the metacenter point (M), it can be said that the floating object has a positive metacenter with positive enforcing arm (GZ), and could restore a floating object to its original position (Ueng, 2013).

EXPERIMENTAL SET UP

The buoyweather type II with diameter and thickness of floating rides in fix value. The figure of the bouy is shown in Figure 1 below, and the specification is shown in Table 1. This buoy is analyzed of its static stability condition. The static stability is achieved of simulation numerically with hydromax software. The criteria of stability that is suitable with IMO (International Maritime Organization) stability criteria is shown in Table 2 below.

Table 1. Specification of bouy weather type II

Buoy Parameters	Value
Diameter silindre1 (D1)	1,6 m
Diamater silindre 2 (D2)	0,4 m
Height silindre 1 (L1)	0,25 m
Height silindre 2 (L2)	0,5 m
The density	860 kg/m^3
Modulus Young (E)	3.5 Gpa
Tensile Strength (Yield)	100 Mpa
Density of sea water	1.025 kg/m^3

Table 2. IMO (International Maritime Organization) Stability Standards for floating objects (IMO, 2002)

Code IMO	Criteria	Unit
A.749(18) Ch-3 Design criteria applicable to all ship section	GZ ≥ 2 m	m
A.749(18) Ch-3 Design criteria applicable to all ship section	Maximum of angle GZ ≥ 25°	deg
A.749(18) Ch-3 Design criteria applicable to all ship section	GMt ≥ 1,5 m	m

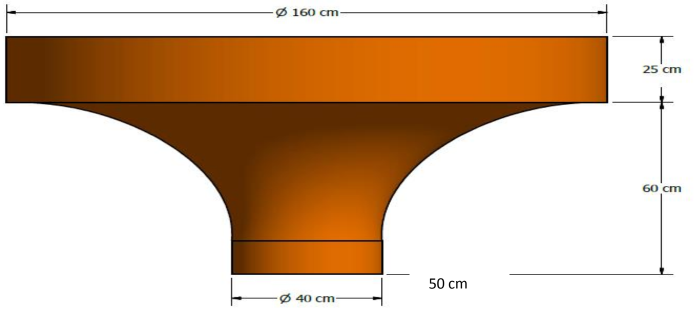

Figure 1 *Buoyweather Type* II

A. Modelling of The New Buoyweather

Buoy weather type II has been tested in Kenjeran waters, East Java, and shows dynamic stability in maximum of 0.5 m of significant wave height. It is proposed to develop a new type, which is stable at higher wave heights. This new model will be implemented at wave height in Indonesian waters more than 2 meters. Buoyweather modeling is performed in addition to its motion as well as buoy stability. The motion modeling is done numerically using the floating structure equations (Fossen, 1994). The static stability parameters of buoyweather buoyancy, ie: floating point, emphasis, displacement, height laden, and enforcement arm for each angle of inclination. The static and dynamics perfomances will be analized in corelated to RAO graphics. The bouy stability parameters vary performances for each different dimension. Dynamic stability parameters of floating structure coefficients include wave motion excitation force, bouy mass, the weight of installed instrument mass, hydrostatic stiffness, and the respective damping coefficient of motion.

B. Optimization Process

The buoyweather dimension optimization process is shown by block process diagram in Figure 2 below.

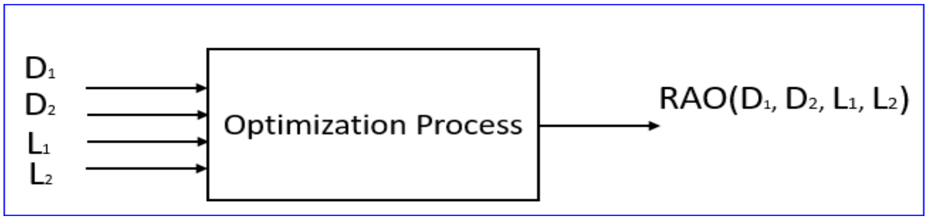

Figure 2. Optimization process of the new model buoy RAO's

There are 4 input variables used in the optimization of the bouy dimensions, namely:

1. Outer diameter of cylinder 1 (D1)
2. Inner diameter of cylinder 2 (D2)
3. The bottom height of cylinder 1 (L1)
4. The upper height cylinder (L2)

The optimization result is Response of Amplitude Operators (RAO) as a function of the dimension of diameter and the height of cylinder. The optimization process uses the PSO algorithm with the first step is determining the objective function, determining the constraint variable, and the design variable. The optimization result is modeling in the form of floating vehicle structure response (RAO) which is used as an objective function in the optimization process. The optimization process uses the reference that the condition / value of the objective function is the best, in this case is the maximum value. The objective function used in this study is expressed in equation (1)

$$RAO = \frac{\zeta_{za}}{\zeta_a} = e^{-0,1L_2}\sqrt{\frac{\{31541,3f_1\}^2+\{170620,53f_2f_1\}^2}{\{31541,3f_1-135,236f_2\}^2+\{170620,53f_2f_1\}^2}} \tag{1}$$

where,

$f_1 = 0,25{D_2}^2 + D_2L_2$

$f_2 = {D_1}^2L_1 + {D_2}^2L_2$

Before optimization process, the algorithm PSO is through a pre-design process. In the pre-design of buoy dimension was limitations the parameters are described in below.

a. Initial design

- Cylinder Diameter 2 is ¼ times cylinder diameter 1 or $D_2 = (1/4)\ D_1$
- The cylinder height 2 is 2 times the height of the cylinder 2,
- The structure mass is the minimum

b. The boundary conditions are based on Archimedes laws

- GM> KG

c. Limits on stability based on IMO (International Maritime Organization) standard. IMO requirements are shown in table 3.

Table 1. The stability as IMO standards

IMO Stability	Criteria
Area of area under GZ curve for angle 0-30^o	> 0,055 m.rad
Area of area under GZ curve for angle 30^o-40^o	> 0,09 m.rad
Area of area under GZ curve for angle 0-40^o	> 0,03 m.rad
GZ	> 0,2 m
The height of GMt	> 0,15 m

C. Optimization of Buoy Dimension using PSO

There are several parameters used in the optimization process of dimension the new bouyweather. These parameters are population number, range of each particle (dimension variable) to be generated in each population, value of c1 & c2, value of r1 & r2, number of iteration, and weight ranges of inertia in each iteration. The value determinination of c1 and c2 are same with damping coefficient of the buoy when oscillating due to the wave load. The value of c1 and c2 are expressed by 10% of the buoy critical damping and a value of added mass in three criteria, i.e: 0%, 50%, and 100% of mass. The c1 and c2 parameters are often said a user supplied coefficients in the velocity of particle movement in achieving optimal solution. The parameter in the optimization process is the magnitude of the RAO criteria function which is always changed for various solution conditions (Blondin, 2009).

The number of populations in PSO methods is generated by 30 populations with each population have 4 particles and 35 iterations. 4 particles are dimension variables of the new buoy. The determination of these value will be increased until achieving in a good particle positions. The span of particle as the value of dimension buoy variables used referring to dimension of buoyweather type II (Aisjah & Arifin, 2012). The value of c1 & c2 parameters are randomly between 0 and 1.

D. The Testing of Optimize Dimension

In the optimization test stage, conducted by evaluating the optimization parameters of new buoy weather. The evaluation is based on IMO stability criteria. Table 2 shows the results of the design criteria. The values in Table 2 indicate that some criteria of the old buoyweather design were not suitable to IMO stability criteria. The large of GZ at an angle of 30^o is smaller than the standard IMO stability requirement (0.13 m < 0.2 m). The evaluation data is used as a reference for optimizing geometry and dimension of buoyweather to meet IMO stability criteria and of wave in sea state 6.

Table 2. The evaluation results of buoyweather according to IMO Criteria

Criteria	IMO Standard	Buoy Data	Remark
Value of GMt (m) >	0.15	0.26	suitable
Criteria of 0-30 (m.deg) >	0.055	0.3822	suitable
Criteria of 0-40 (m.deg) >	0.09	0.62328	suitable
Criteria of -40 (m.deg) >	0.03	0.24108	suitable
The maximum of GZ in 30 or more (m) >	0.2	0.13	not suitable
Angle of maximum GZ (deg) >	25	50	suitable

The values in Table 2 indicate that one criteria of the old buoyweather design do not meet IMO ie the value of GZ at an angle of 30^o is smaller than the standard stability requirement of IMO (0.13 m <0.2 m). The evaluation data is used as a reference for optimizing buoyweather type II design to meet IMO stability criteria of sea state 6.

RESULT AND ANALYSIS

A. The Static Stability of Buoyweather Type II

The new buoy modeling is based on the shape and size already present in the buoy type II. There was added mass in buoy of 0%, 50%, and 100% of mass will change static stability performances. The static criterion can be used to determine dynamic stability criteria. The static stability criterion states the stability of the buoyweather in buoyancy design due to in un load (of

0% load) from the environmental. Stability can be obtained from the height of metasentrum. The following table 3 is static staility criteria of buoy modeling in 3 weight conditions.

Table 3. The result of new model buoyweather based on dimension and shape of type II Numerical Methods

Criteria	**The value**		
	Buoy (I)	**Buoy + 50% load (II)**	**Buoy+100% load (III)**
mI	432.064	432.064	432.064
Added mass	0	243.036	486.072
mII	54.008	54.008	54.008
mtotal	486.072	729.108	972.144
FG	4763.506	7145.258	9527.011
V_I	0.502	0.502	0.502
V_{II}	0.063	0.063	0.063
KG	0.583	0.583	0.583
h_1 sumerged	0.205	0.323	0.441
h_2 sumerged	0.500	0.500	0.500
V_1 sumerged	0.411	0.649	0.886
V_2 sumerged	0.063	0.063	0.063
KB	0.556	0.625	0.689
I sumerged	0.322	0.322	0.322
BM	0.678	0.452	0.339
GM	0.650	0.494	0.445
Aw	3.666	4.259	4.852
Aw_I	2.010	2.010	2.010
Load	0.705	0.823	0.941

The result of modeling of stastic stability criteria of bouy is shown in Table 3. The metacenter of buoy (GM) when in unload is 0.650 and the weight (KG) is 0.583. The value of KG < GM. This value indicate that buoy have a positive stability. In the condition when buoy is added load of 50% load, the metacentrum (GM) is 0.494 and the weight (KG) is 0.583, and it is showed that the metacentrum (GM) of the bouy is less than the weight (KG). This condition is said that buoy has a negative stability (BMT Fluid Mechanics, 2006). The buoy condition at 100% of metacentrum (GM) load from is 0.445 and weight (KG) of buoy is 0.583. It can be seen that buoys in 100% load state also have a negative stability (BMT Fluid Mechanics, 2006). Numerical modeling using done already fulfilled then validated with result of running buoy design using Hydromax at state I that is empty state. All buoyweather parameters are tested using the software, showing valid results.

B. Respon of Amplitude Operator (RAO) of Buoyweather Model

RAO of buoy models result of numerical optimization in two motions in heave and roll motion and in 3 variations of loading. The load of buoy in unload (0% load), 50% load and 100% load. The sudden change of the forced state of the ship, which put the ship in a floating structure in dangerous situation (Guo, Sun, Cao, & Huang, 2017). The equation of RAO in the 2 motions are showed in below equation 2 and 3. An empty or 0% load is a bouy conditions without an instrument mounted, and without component of power for the supply of electricity to the sensor and system. The value of structure motion responses (RAO) in disturbances of wave in phase angle 0^o (following seas) reaches a maximum at frequency of 7.526 rad / s or period of 0.557 s. The magnitude of this maximum of RAO is 3.090 m / m. An additional 50% load in buoy is the added mass that consists of the load of all components, sensors, power supplies, transmission systems, etc. The maximum value of RAO that indicated of motion response the buoy in the wave of phase angle is 0^o as following seas, occur on frequency of 7.526 rad / s or in the 0.557 s wave period. The maximum RAO values of 50% load is 4.127 m / m. The buoyweather response with 100% loading with maximum RAO value when exposed to wave with wave phase angle 0^o (in following seas) is 4.350 m / m. RAO reaches maximum at wave frequencies of 7,008 rad / s or in the period of 0.716 s. While the natural frequency of heave direction movement for buoyweather is 8,704 rad / s.

$$RAO\ heave = \frac{\zeta_{za}}{\zeta_a} = e^{-KT}\sqrt{\frac{\{c\text{-}a\omega^2\}^2+\{b\omega\}^2}{\{c\text{-}(m+a)\omega^2\}^2+\{b\omega\}^2}} \qquad \dots (2)$$

$$RAO\ roll = \frac{\zeta_{\phi a}}{\zeta_a} = e^{-KT}\sqrt{\frac{\{c\text{-}a\omega^2\}^2+\{b\omega\}^2}{\{c\text{-}(I+a)\,\omega^2\}^2+\{b\omega\}^2}} \qquad \dots (3)$$

The motion of three shape model are shown in different pattern of RAO graphics. Model in unloaded equipment shows the least RAO, and the largest RAO when the load is 100%. The RAO indicates that is increasing the value when decreasing the load. The RAO values of buoyweather in unloaded condition at peak frequency of sea state 6 is 0,934 m / m. When the loading is 50%, the RAO value is 0.927 m / m, and when the loading is 100% the maximum RAO value is 0.915 m / m. Slowing decerease of RAO when sea at state from 5 to 1.

The spectrum equation of JONSWAP, is shown in Equation of (3), where $A = \exp\left\{-\left(\frac{\frac{\omega_c}{\omega_p}-1}{\sigma\sqrt{2}}\right)^2\right\}$,

$\omega_p = \frac{2\pi}{T_p}$

σ is shape parameters, in two values: σ = 0,07 jika $\omega_c < \omega_p$, and σ = 0,09 jika $\omega_c > \omega_p$

The frequency at sea state 6 is 0.458 rad / s or in the peak period of 13.8 s is at peak spektrum.

$$S_\zeta(\omega) = \frac{320 {H_{1/3}}^2}{T_p}\,\omega_c^{-5} exp\left\{\frac{-1950}{{T_p}^4}\,\omega_c^{-4}\right\}\gamma^A \qquad \dots (4)$$

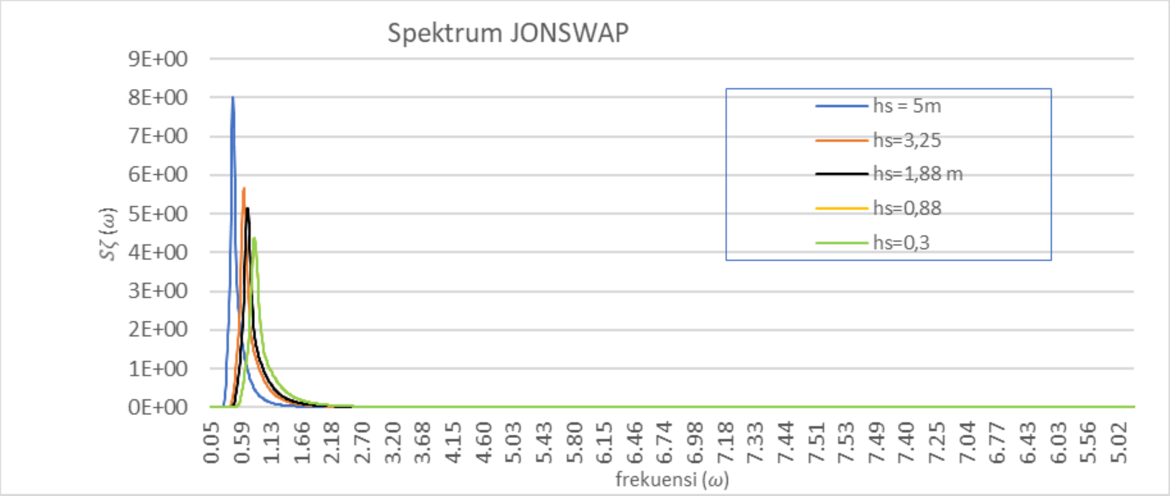

Figure 3. JONSWAP spectrum

Figure 3 shows the spectrum response of buoyweather, by means of quadratic RAO multiplication with wave spectrum for each RAO with variations of loading and significant wave height variations, ie for sea state 2 to sea state 6. The buoyweather response curve of the heave motion spectrum is shown in Figure 4 below.

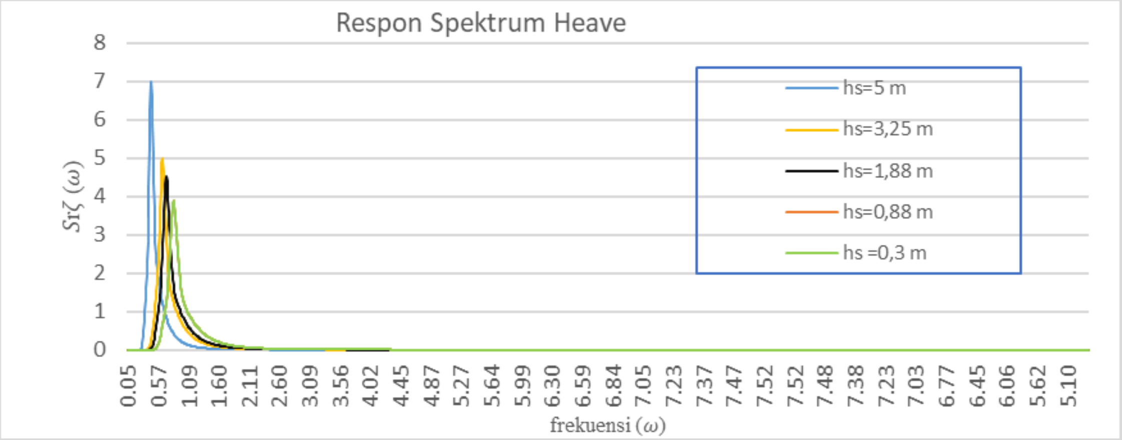

Figure 4. Spectrum Response Curve for Buoy in no Load

Graphs of Figures 3 to 4 show the peak value of the response spectra for each of the significant wave heights for 3 floating vehicle states. When the 5 meters in significant wave height, the spectral peak value of 6.99 m, and the peak value decreases as significant wave height decreases. Based on the three graphs in Figure 3 and 4, it can obtain stochastic parameters of heavy buoyweather movement. Stochastic parameters are obtained by calculating the area of expanse and spectral moment for heave motion. Table 5 below is the magnitude of stochastic parameters of heave motion when the load is empty.

Table 5. The stochastic parameters of Buoy Weather in Unload Condition

Stochastics Parameters	**Significant Wave Height**				
	Sea State 6 (5 m)	**Sea State 5 (3,25 m)**	**Sea State 4 (1,88 m)**	**Sea State 3 (0,88 m)**	**Sea State 2 (0,33 m)**
mr0	1,223	1,241	1,250	1,269	1,269
mr1	0,690	1,016	1,137	1,380	1,380
mr2	0,490	1,098	1,388	2,065	2,065
mr4	2,511	10,003	14,650	27,399	27,399
To	11,126	7,674	6,903	5,775	5,775
Tp	2,773	2,081	1,933	1,724	1,724
Tz	9,924	6,678	5,961	4,924	4,924
e	0,960	0,950	0,946	0,937	0,937
w0	0,564	0,818	0,910	1,087	1,087
wp	2,264	3,018	3,249	3,643	3,643
wz	0,633	0,940	1,054	1,275	1,275
Hs	3,129	3,153	3,164	3,189	3,189
Hav	2,765	2,786	2,795	2,817	2,817
H1/10	5,618	5,660	5,680	5,724	5,724

A. Optimize of Buoyweather Type II using PSO

After the modeling and calculation of motion response and spectrum response on the model or design of the old buoyweather, then optimized the design of dimension buoyweather to get the proper floating stucture. The performance dimension design that has suitability criteria on sea state 6. Here is the optimization result of dimension buoyweather buoyancy buoy type II:

Table 6 Results Optimization Dimension Forum Buoyweather Buoyweather Type II in Empty State

Criteria	Buoy		Δ
	Design	optimasi	
D1	1,60	1,27	0,33
D2	0,40	0,91	-0,51
L1	0,25	0,25	0,00
L2	0,50	0,20	0,30
mI	432,06	273,31	158,75
M added	0,00	0,00	0,00
mII	54,01	111,63	-57,62
mtotal	486,07	384,94	101,13
FG	4763,51	3772,39	991,12
VI	0,50	0,32	0,18
VII	0,06	0,13	-0,07
KG	0,58	0,26	0,32
h1 submerged	0,20	0,19	0,01

Criteria	Buoy		Δ
h2 submerged	0,50	0,20	0,30
V1 submerged	0,41	0,25	0,16
v2 submerged	0,06	0,13	-0,07
KB	0,56	0,23	0,33
I submerged	0,32	0,13	0,19
BM	0,68	0,34	0,34
GM	0,65	0,31	0,34
Aw	3,67	2,61	1,06
Awl	2,01	1,26	0,75
Load	0,70	0,39	0,31
c	36826,39	26200,01	10626,38
b	846,17	635,15	211,02
k	0,10	0,10	0,00
wc	7,53	7,53	0

Design variables or particle values are obtained from optimization process using particle swarm optimization (PSO) by determining the particle minimum values and generation values. These values required to obtain the optimum solution using PSO. After obtaining the minimum particle value and the generation value of the PSO algorithm is run 30 times considering the design parameters that have been made and the values are close together.

B. Model Response of Optimize Buoyweather

Design of buoyweather dimensions that have been obtained from the optimization results using PSO, and it was analyzed the nature of its dynamics using RAO parameters. The RAO of the optimized model is shown in Figs 8 through 10.

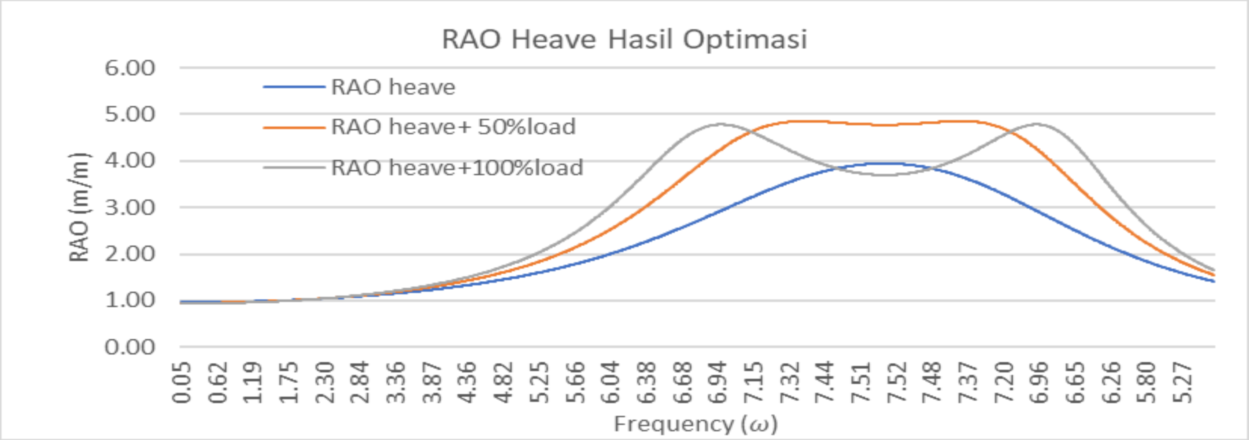

Figure 5. RAO of Optimize Buoyweather

Figure 5 in above shows that RAO for three loading conditions, ie: (1) unload (0%), (2) 50% load, and (3) 100% load. The unload condition, the model of the buoyweather when it exposed to waves in the direction of wave 0^{o} (following seas), shows the maximum RAO in frequency of

7.526 rad / s or in the 0.557 s wave period. The value of RAO in this condition is 3.942 m / m. The buoy condition with 50% cause when the angle is exposed to the wave with the coming angle of wave 0^o (following seas), indicating the motion response (RAO) occurs at 7.39 rad / s wave frequency or in the wave period 0.850 s. The maximum RAO value is 4,852 m / m. When buoyweather type II condition in 100% load loading and exposed in wave with the arrival angle of wave 0^o (beam seas), shows the maximum RAO response occurs when the wave frequency is 6.965 rad / s or in the period of 0.902 s. The maximum RAO value when the load is 100% is 4.780 m / m. Natural frequency for weather buoy model optimization design results 8,250 rad / s. The response results for the new model (the result of the old model optimization) in the empty state indicates that the maximum RAO occurs at the same frequency. This also applies to buoyweather type II with 100% loading of optimization results, but for buoyweather type II loading 50% result of heave motion response curves experienced enlargement rather than the long buoyweather type II motion response curve so that the peak frequency also shifts smaller of the peak frequency of the old buoyweather type II. The comparison of long buoyweather type II motion response result of buoyweather motion optimization result is relatively bigger. While the RAO value obtained after optimizing the buoyweather type II in the empty state is 0.964 m / m at the peak frequency of sea state 6 that is 0.458 rad / s or in the peak period of 13.8 s according to the objective function used. For buoyweather with 50% loading RAO value of optimized result obtained is 0.951 m / m at sea state 6 peak frequency while for buoyweather type II with 100% loading RAO value of optimization result obtained is 0.937 m / m.

The condition of waters in sea state 6, requires a floating vehicle that has dynamic stability. Result of buoy weather optimization model As in buoyweather type II before being optimized compared to optimized. RAO value of optimization result is done by making projection of wave spectrum from waters where floating vehicle will be operated at sea state maximum 6.

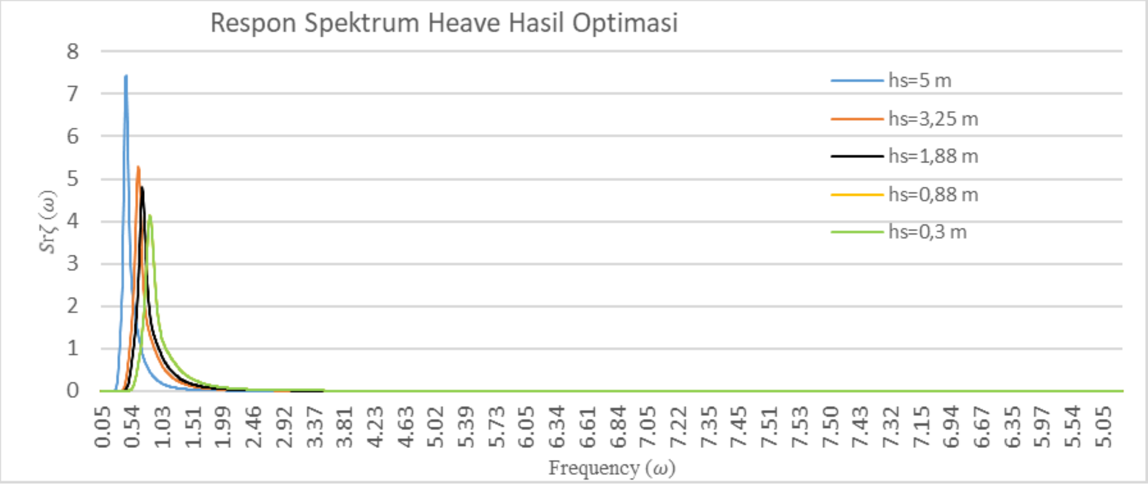

Figure 6. Spectrum Response of Buoyweather in Unloaded

CONSCLUSION

Based on the above description, the following temporary conclusions can be drawn:

1. Floating buoyweather type II buoyweather still has suitable with IMO criterias that has been set that is the moment of pengengak (GZ) = 0.13 m.
2. The design variables obtained from the optimization results using PSO when sea state 6 are D1 = 1.27m, D2 = 0.91m, L1 = 0.25m, L2 = 0.2m.

3. Perfomance of buoyweather buoyancy in new model is better than existing model, that is with maximum RAO value 3.942 m / m and minimum total mass equal to 384.94 kg have spectrum peak value equal to 7.44 m2 / (rad / s).

AKNOWLEDGEMENT

Thanks to:

1. Ministry of Research, Technology, and Higher Education (Kemenristekdikti) Indonesia, which has provided funding for the implementation of Penelitian Unggulan Perguruan Tinggi (PUPT) in 2017.
2. Indonesian Hydrodynamics Laboratory, BPPT-Indonesia.
3. Hydrodynamics Laboratory, Department of Shipping Engineering ITS.

REFRERENCES

Aisjah, A. S., & Arifin, S. (2012). Integrasi sistem buoyweather untuk membangun sistem informasi cuaca maritim sebagai upaya peningkatan keselamatan nelayan dan pengguna laut. In *Seminar SENTA 2012* (pp. 1–12). Surabaya.

Aulia S. Aisjah, Syamsul Arifin (2011). Maritime Weather Prediction Using Fuzzy Logic In Indonesia Waters”. *International Workshop and Annual Meeting Dev Sus 2011*. Zanzibar, Tanzania: University Daar Er Salaam.

Aulia Siti Aisjah, Syamsul Arifin (2012). Design a System Predictors and Information of Maritime Weather for the Fishermen's in East Java – Indonesia, Mexico. *Annual workshop Developing Sustainibility* (hal. 12-13). Mexico: Universidad Quintanaa Roo.

Aulia Siti Aisjah, Syamsul Arifin (2013). Maritime Weather Prediction using Fuzzy Logic in Java Sea for Shipping Feasibility. *IJAI*.

Arifin, Syamsul; Aisjah, Aulia Siti; Nugroho, W. (2016). *Integrasi Sistem Buoyweather Untuk Membangun Sistem Informasi Cuaca Maritim Di Subdaerah Wpp 712 – Laut Jawa Sebagai Upaya Peningkatan Keselamatan Nelayan Jawa Timur*.

Arifin, Syamsul; Nugroho, Gunawan; Nugroho, W. H. (2014). *Integrasi Sistem Buoyweather Untuk Membangun Sistem Informasi Cuaca Maritim Di Subdaerah Wpp 712 – Laut Jawa Sebagai Upaya Peningkatan Keselamatan Nelayan Jawa Timur*.

Babovi, S. S. (2010). Error Forecasting in a Wave Prediction Model Using Local Linear Model . Singapore: Tropical Marine Science Institute , Singapore.

Blondin, J. (2009). Particle Swarm Optimization : A Tutorial.

BMT Fluid Mechanics. (2006). *Review of issues associated with the stability of semi-submersibles Prepared by BMT Fluid Mechanics Limited for the Health and Safety Executive 2006*.

CAIRES, A. S. (2005). Climatology, Variability And Extrema Of Ocean Waves: The Web-Based Knmi/Era-40 Wave Atlas. *International Journal Of Climatology*, 963–977 .

CAIRES, S. a. (2005). A New Nonparametric Method to Correct Model Data: Application to Significant Wave Height from the ERA-40 Re-Analysis. *Americal Meteorogical Society*, 443 - 459.

Fossen, T. I. (1994). *Guidance and Control of Ocean Vehicles - Thor I. Fossen.pdf* (1st ed.). Trondheim: British Library.

Fossen, T. I. (2011). *Handbook Of Marine Craft Hydrodynamics And Marine Craft Hydrodynamics And*. Norway: John Wiley & Sons.

Guo, K., Sun, P., Cao, X., & Huang, X. (2017). A 3-D SPH model for simulating water flooding of a damaged floating structure *. *Journal of Hydrodynamics*, *29*(5), 831–844. http://doi.org/10.1016/S1001-6058(16)60795-3

G. N. Kariniotakis, I. M. (2006). Advanced Short-term Forecasting of Wind Generation - Anemos. (on power system performance issues associated with wind energy).

Gardner, M. a. (1998). Artificial Neural Network (Multilayer perceptron) – a Review of Application in

Atmospheric Sciences . *Atmospheric Environment*, 2627 – 2636.

Pedersen, Torstein; Siegel, E. (2008). Wave Measurements from Subsurface Buoys.

Ueng, S. (2013). PHYSICAL MODELS FOR SIMULATING SHIP STABILITY AND HYDROSTATIC MOTIONS. *Journal of Marine Science and Technology*, *21*(6), 674–685. http://doi.org/10.6119/JMST-012-1121-1