Flat Top Barge 300feet Design Using Portable Dynamic Positioning System

Agoes Santoso[1], Juniarko Prananda[2], Amiadji[3], Edi Jadmiko[4], Izzu Alfaris Murtadha[5]

***Abstract*— portable dynamic positioning system has not commonly applied to the vessel, especially on barge. Besides for dynamic positioning function, the system can be used as vessel's main propulsion. By using this system, the vessel able to not using anchors because the functions can be performed by the Portable Dynamic System. This research designed the vessels with main dimensions LWL 90.1 meters, 25 meters wide, 5.5 meters high and 4.2 meters draft. To generate the vessel with a maximum speed of 8 knots, it takes four thruster supplied with power 225 kW each, so that the total generated power is 1100 kW. This study analyzes three conditions of the vessel stability, there are the condition of full payload, empty payload, and maximum payload. The first is full payload conditions resulting payload in the amount of 5650 ton with a draft on the LCF at 4,181 meters. The second is the large empty payload condition *displacement* is 2809 ton and water draft on the LCF at 1,591. And the last is maximum payload conditions, resulting payload in the amount of 7450 ton with a draft on the LCF at 4,994 meters**.

Keywords— flat top barge 300feet, portable dynamic positioning system, thruster, ship stability

I. INTRODUCTION

Dynamic positioning is a function to take control of motion system from vessel through propulsion systems to maintain vessel position in order to keep its position from another force which is work outside the vessel [7]. In general, dynamic positioning means a system to control vessel propulsion in order to keep vessel position stable. In some work fields of offshore vessel, dynamic positioning concept usually is used to support some work [7]. The example of work which is need the stability of vessel that keep its position quiescent is installation of subsea installations, such as pipelines. Until now, to keep vessel position quiescent in the middle of the roll waves of the sea, the vessels using anchor to hold force that work [8]. But the usage of anchor have some disadvantages, such as destroy biota of the seabed and installations that placed on seabed. To anticipate those disadvantages, so Portable Dynamic Positioning System is used as alternative [8]. Beside as a dynamic positioning functions, this system can be used as vessel main propulsion. Therefore, not only offshore vessel which is possible to use this system, conventional vessels like cargo vessel and barge also possible to use Portable Dynamic Positioning System.

Portable Dynamic Positioning System (PDPS) is a unique propulsion system which is utilize azimuth propeller as a propulsion device[7]. Its purpose is maintain the vessel position in order to stay stable although experiencing thrust force from the surrounding system [7]. This system consist of some hydraulic outboard thruster dengan HPU (Hydraulic Power Unit) for each thruster. it makes this propulsion system very simple but not reducing the performance as a prime propulsion system to maintain vessel position in order to remain in place[8].

Agoes Santoso is with Departement of Marine Engineering, Institut Teknologi Sepuluh Nopember, Surabaya 60111, Indonesia. Email: agoes@its.ac.id

Juniarko Prananda is with Departement of Marine Engineering, Institut Teknologi Sepuluh Nopember, Surabaya 60111, Indonesia. Email: juniarko.prananda@gmail.com

Amiadji is with Departement of Marine Engineering, Institut Teknologi Sepuluh Nopember, Surabaya 60111, Indonesia. Email: amiadji@yahoo.com

Edi Jadmiko is with Departement of Marine Engineering, Institut Teknologi Sepuluh Nopember, Surabaya 60111, Indonesia. Email: gusjadmiko@gmail.com

Izzu Alfaris M is with Departement of Marine Engineering Institut Teknologi Sepuluh Nopember, Surabaya 60111, Indonesia. Email: -

II. METHOD

In this researh, the early design process of vessel including 2D and 3D design . This design will be used to do software simulation. Software simulation devide into three, the first is Hull Speed analysis for the specs selection and power requirements of *Portable Dynamic Positioning System*, the second is Hydromax analysis for find out vessel stability on some load condition, and the third is Thruster position analysis on some vessel load condition[6]. Vessel load condition devide into three, the first is full load, the second is empty load, and the third is maximum load. Since Software analysis complete, the next step is designing the General Arrangement. This General Arrangement picture show a top view and side view of the vessel, including picture from each of the existing deck, such as main deck and navigation deck, the last is picture of placing tank plan.

III. RESULTS AND DISCUSSION

A. Flat Top Barge Design

Vessel design process using *Maxsurf* software which is resulting 2D and 3D picture. The main principle of vessel which is designed as follow: Vessel length (LWL) 91 meters, vessel width (B) 25 meters, vessel height (H) 5.5 meters, vessel draft (T) 4.2 meters. 3D design will show hull form and building of vessel. This 3D process is influenced by previous 2D design. 2D and 3D design will be used to perform software simulations.

B. Software Top Barge Analysis

The analysis conducted uses Maxsurf Pro, Hull Speed, dan Hydromax. Every single analysis process give different output.

1) Maxsurf Pro Analysis

Analysis methods using Maxurf Pro aims is to get vessel coefficient value and the displacement, also the extent of the area which is submerged water. The first step is determine zero point or station 0 vessel. For this Flat Top Barge, there is no rudder used so the 0 value is in the midhsip.

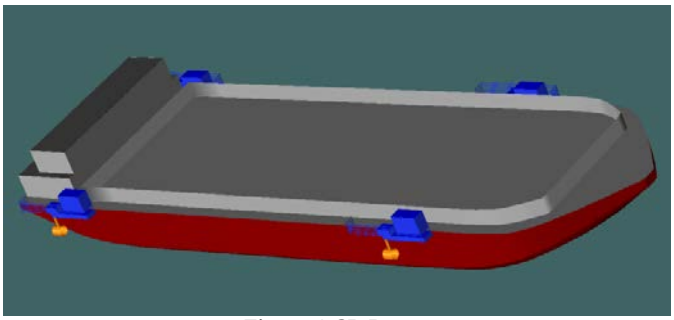

Figure. 1. 3D Design

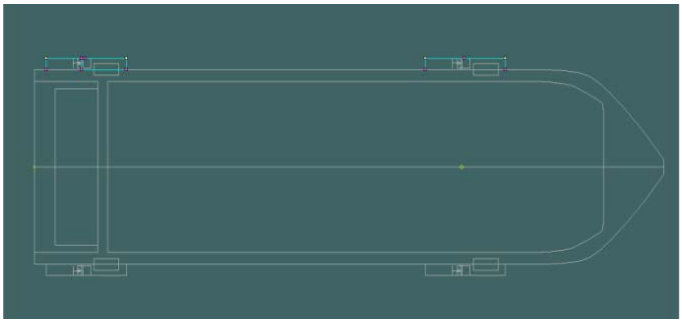

Figure. 2. 2D Design

System, so that vessel zero point is at the rear end or at AP (After Perpendicular). From plan of zero point vessel, will be obtained the length of AP to FP. From the picture above, length of AP to FP is 91.347 meter vessel draft. The next step is determine amount of station that is used, in this design, the station average is 20 with a distance of 4.6 meters inter-station. Beside for designing the average station, also planned the average of waterline and buttock line. Waterline average obtained by dividing the whole hull lengthwise and above. In this plan division of waterline only on the hull. Waterline in this vessel total is 11 pieces with each meter altitude 0:55 meter start from the lowest point to the top point on the hull. While design of buttock line aims is divide the vessel transversely from the bottom to the top hull. Design of buttock Line for this vessel is 6 lines.

Based on Hydrostatic Calculation is obtained vessel length 90.98 meters, vessel wide 25 meters, and vessel draft 4.2 m, hence generate midship coefficient 0.996, blocks coefficient 0844 and prismatic coefficient 0847. Also obtained displacement value in amount of 8277 ton.

2) Hull Speed Analysis

Early design of this Flat Top Barge use maximum velocity 8 knots. In the methods which is simulated using engine efficiency value of 45%. But in this Hull Speed analysis, power engine which obtained is (Effective Horse Power), so determining the power needed to choose the engine, should be changed to BHP (Brake Horse Power) in accordance with its efficiency Value which is given by Holtrop methods when running is a follows:

Vs : 8 knot
Rt : 82.48 kN
BHP scr : 754.32 kW

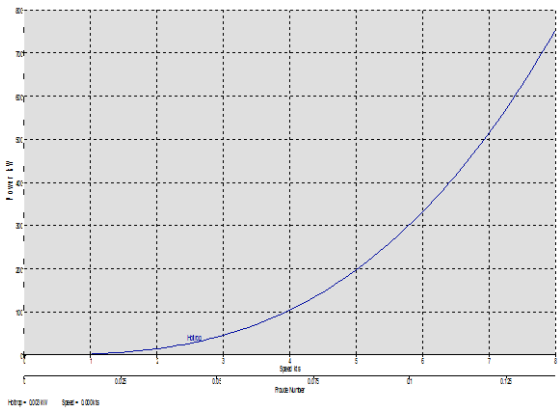

Figure. 3. Power and Speed Comparison

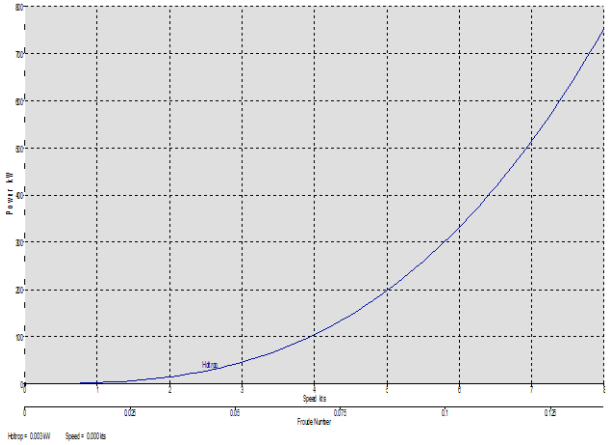

Figure. 4. Resistance and Speed Comparison

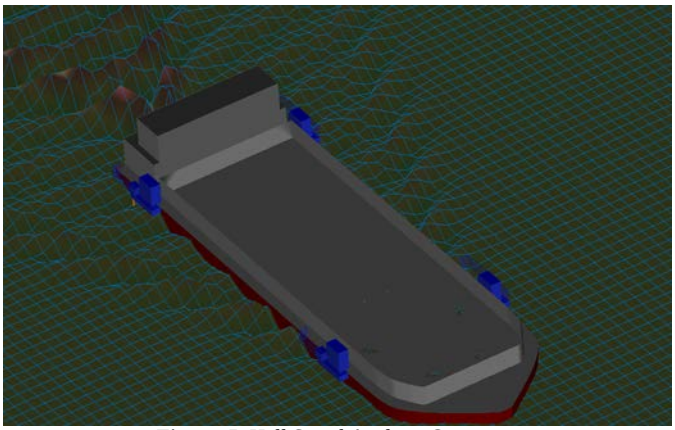

Figure. 5. Hull Speed Analysis Output

In achieving power 754.32 kW, the engine is in 85% of from MCR BHP, hence the value of BHP MCR as follows:

BHP = EHP/75%
= 754.32/0.75
= 887 kW

According to Figure 1 and Figure 2, can be concluded that between Power and Speed directly proportional, thus the higher speed, also greater power is required. So that in the relationship between speed and custody, the greater speed will generate greater custody.

3) Hydromax Analysis

To see the condition of the vessel's stability, will be conducted on three conditions. The first condition is when the condition of the load is full and ballast is empty. The second condition is when the load is 50% and ballast 100%. The last is maximum load. To perform running hydromax, it takes some inputs that must be calculated first. The steps are as follows:

a) Calculate LWT and Payload

$LWT_{(total)}$ = LWT + (2% LWT)
= 2005 ton
DWT = *displacement* – LWT
= 8277ton – 2005 ton
= 6272 ton
Payload = DWT – Wtotal
= 6272 – Wtotal
= 5427

b) Calculate Requirement Tank and Pump
Requirement of tank devided into *Ballast, Fuel Oil,* dan *Fresh Water* .

i. *Ballast*
$W_{ballast}$ = 10% x ▲ ton
= 827,7 ton
$V(W_{ballast}) = W_{ballast}/\rho$ sea water
= 807.5 m^3
Specification of used pump :
Type = SILI 125 CLH 12
Capacity = 160 m^3/h
Head = 50 m
Power = 22 kW

ii. *Fuel Oil*
MDO Mass = 887 x 196 x 8 2 x 10^{-6}
= 4.23 ton
Volume MDO = MDO mass/Density
= 4.23/0.85
= 4.975 m
Spesification of pump that will be used:
Merk = IRON PUMP
Type = ON-V 7
Capacity = 14 m^3
Head = 20 m
Rpm = 850 RPM
Power = 0.7 HP

iii. *Fresh Water*
Total fresh water requirement are as follows:
Wfw = Wfwd+ Wfws+ Wfwc+ Wfwj+ Wfae
= 0.5 + 5 + 0.14 + 0.65 + 0.13
= 6.5 ton

After calculating the required parameters the hydromax can be performed.

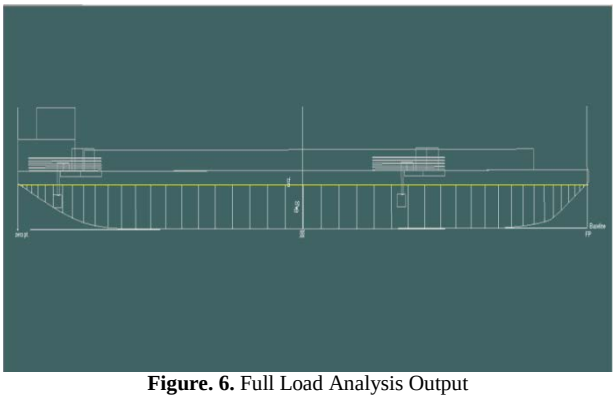

Figure. 6. Full Load Analysis Output

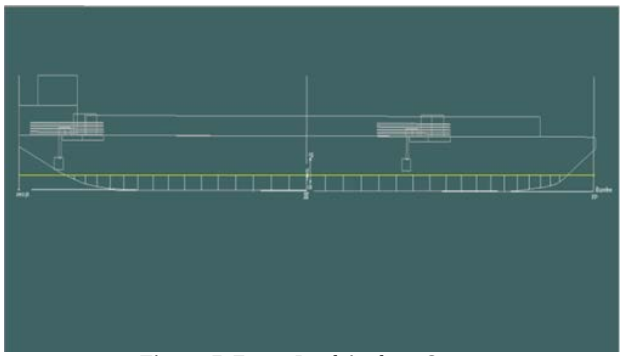

Figure. 7. Empty Load Analysis Output

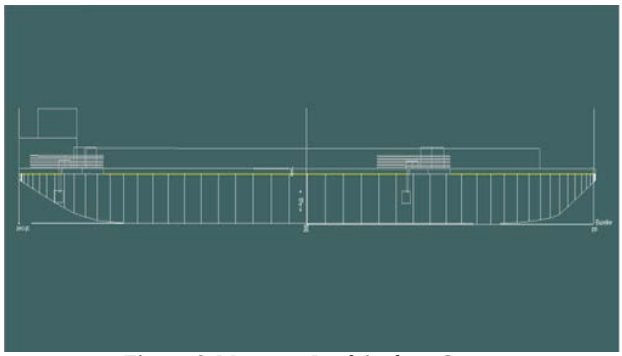

Figure. 8. Maximum Load Analysis Output

a) Condition 1

First condition simulation when the load is full and ballast is empty, FO and FW full. For hydromax simulation on first condition, the results is: in the middle draft vessels has a value of 4,177 meter. While displacement value which is resulted in those draft height is 8236 ton. Whereas, slope of the vessel value is 0, which means that vessel is straight and is not sloped to *starboard* or *portside*. For vessel draft in this condition has value 4.104 meter at the bow and 4.250 at stern. For Cb and Cp at condition of draft water in the middle vassel is 0.841 for Cb, and 0.838 for Cp. Then for LCB point from midship, the value is -0.988 meter, it means this point are behind the midpoint of vessel as well as the value of LCF -2256 meters, which means floating point behind the midpoint of vessel.

b) Condition 2

Second condition simulation when the load is empty, ballast is full, FO 50% and FW full. For hydromax simulation in the second condition, the result is: in the middle draft vessel has a value of 1.591 meter. While displacement value which is resulted in draft height is 2809 ton. Whereas, slope of the vessel value is 0, it means that vessel is straight and is not sloped to *starboard* or *portside.* For vessel draft in this condition has value 1.484 meter at the bow and 1.697 at stern. For Cb and Cp at condition of draft water in the middle vassel is 0.828 for Cb, and 0.857 for Cp. Then for LCB point from midvessel, the value is -0.648 meter, it means this point are behind the midpoint of vessel as well as the value of LCF 0.141 meter, which means floating point in front of the midpoint of vessel.

c) Condition 3

Third condition simulation when the load is maximum, ballast is empty, FO and FW is full. For this hydromax simulation in the third condition, the result is: in the middle draft vessel has a value of 4.995 meter. While displacement value which is resulted in draft heigh is 10036 ton. Whereas, slope of the vessel value is 0, it means that vessel is straight and is not sloped to *starboard* or *portside.* For vessel draft in this condition has value 5.020 meter at the bow and 4.994 at stern. For Cb and Cp at condition of draft water in the middle vassel is 0.853 for Cb, and 0.858 for Cp. Then for LCB point from midvessel, the value is -0.933 meter, it means this point are behind the midpoint of vessel as well as the

value of LCF -2.337 meter, which means floating point behind the mid point of vessel.

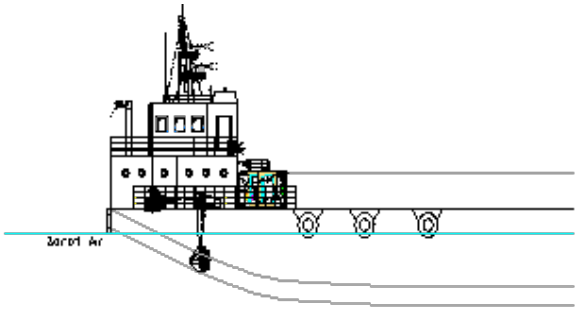

Figure. 9. Draft at Condition 1

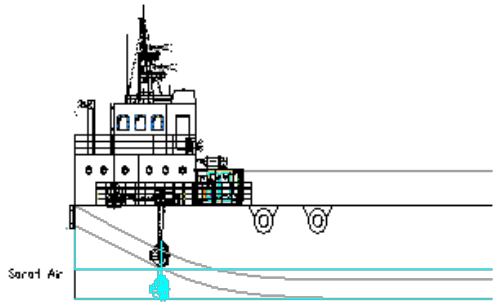

Figure. 10. Draft at Condition 2

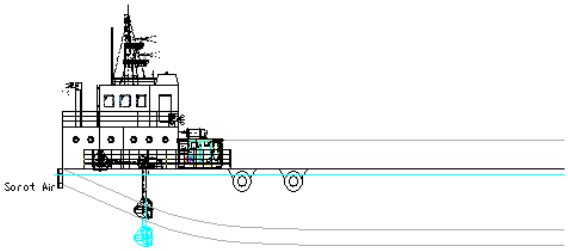

Figure. 11. Draft at Condition 3

4) *Thruster Analysis*

This analysis is conducted to three vessel operational condition which is discussed earlier, there are full load condition, empty load, and maximum load.

a) Condition 1

Analysis is conducted based on draft water value which is generated at Hydromax simulation. According to spesification of Portable Dynamic Positioning System, known that the normal length of shaft until thruster is 3.72 meters. While the length of shaft is 2.3 meter. Length of stem is 2.3 meter. Length of stem suitable to specs description, can be extended up to 5.5 meters. In the picture above using standard stem and the result is thruster fully submerged into water so it does not need to add the length of the stem

b) Condition 2

Analysis is conducted based on water value which is generated at Hydromax simulation. By the time usage of a standard stem, the water surface is lower than thruster does not fully submerged. Thus the stem is extended to a maximum of 5.5 meters. After the stem is at maximum length can be seen from the picture above that the thruster had been submerged completely.

c) Condition 3

Analysis is conducted based on draft water value which is generated at Hydromax simulation. At third condition of water draft, simply use the standard stem and does not need to extend stem. The position of height draft which reaching 5 meters is caused by maximum load, so enough to use standard stem for thruster in completely submerged condition.

C. Portable Dynamic Positioning System Specification

From rotation of work data and power on MCR condition, can be determine the thruster specification which will be used. Because of thruster amount that is used is four pieces, thus BHP MCR power which is obtained is the sum of the four thruster power. Specifications that have been selected are as follows:

Thruster	: THRUSTMASTER
Type	: OD300N
Power	: 225 kW

Bollard Pull	: 40 kN	Power	: 1600 kW
Stem	: 5.5 m	HPU Weight	: 5.125 ton
Thruster weight	: 2.8 ton	HPU Dimension	: 3454 x 1701 x 2971 mm
HPU Spec			
Engine	: Caterpillar 3561B		

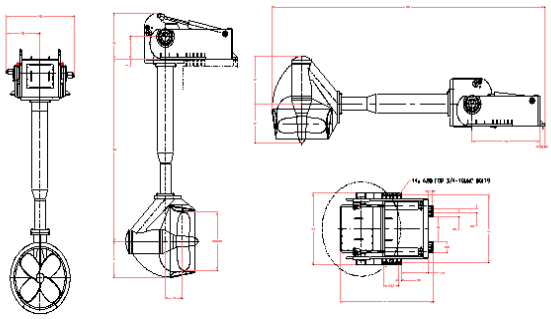

Figure. 12. Thruster Specification

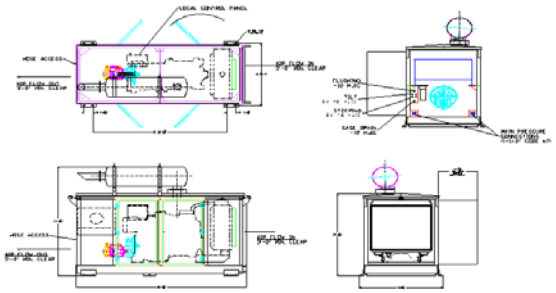

Figure. 13. HPU Specification

D. General Arrangement

Pictures of the general plan that has been designed include picture looks from side of vessel and looks from above of vessel. Besides that, there is picture of design from every deck which on the vessel. Then, there is also picture of tank position on double bottom construction.

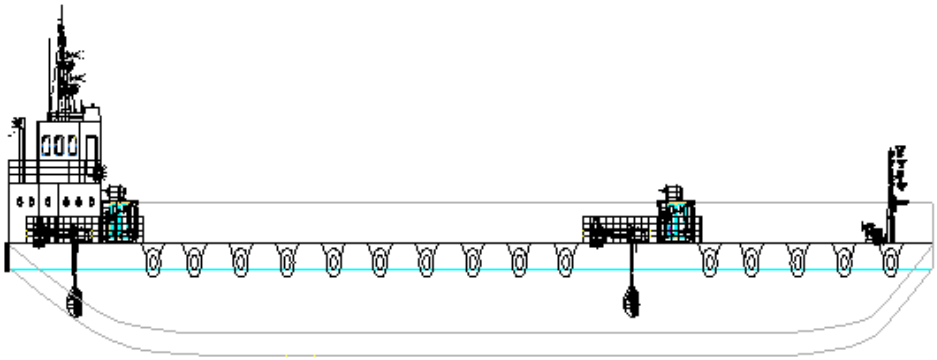

Figure. 14. General Arrangement Side View

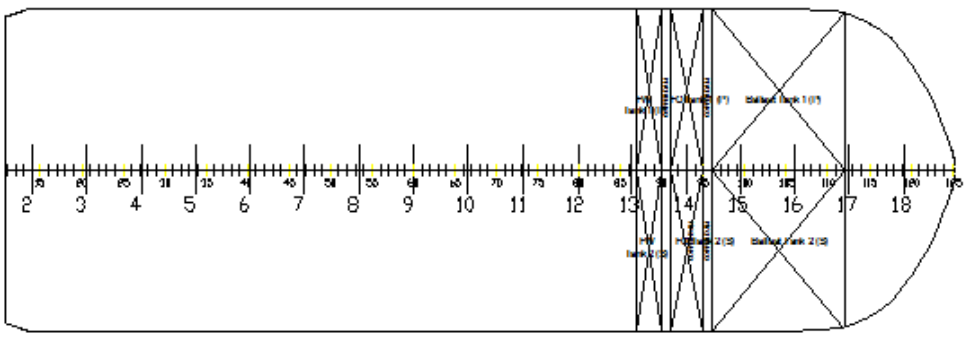

Figure. 15. General Arrangement Top View

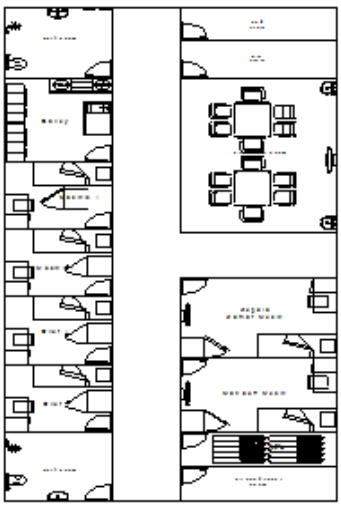

Figure. 16. Main Deck

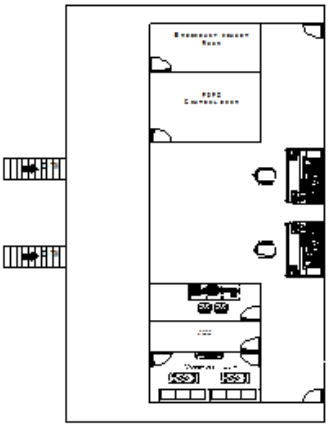

Figure. 17. Navigation Deck

IV. CONCLUSION

From the result of calculation and design which has purpose to get the vessel design Flat Top Barge 300 feet using Portable Dynamic Positioning System as propulsion system, it can be conclude as follow:

a. Flat Top Barge vessel which is designed has main dimension, there are Lwl 90.1 meter, width 25 meters, height of 5.5 meters, displacement 8277 tons.
b. Thruster total which is used for Portable Dynamic Positioning System is four pieces. Each thruster has power in amount of 225 kW. Thus, four pieces of thruster total has power in amount of 900kw. Total of HPU (Hydraulic Power Unit) also four pieces, each of HPU has engine caterpillar 3516B with 1600 kW power. To control the work of Portable Dynamic Positioning System, provided a control room located in the navigation deck.
c. In the early design using Maxsurf Pro, main principle of vessel is Lwl 90.1 meter, 25 meters wide, 5.5 meters high, draft bow and 4.2 meters stern, also 8277 tons displacement. After the analysis using Hydromax is conducted on the first condition which is full load, flat top barge vessel has *displacement* 8236 ton, draft on the bow 4.250 meter, draft of the sterm 4.1 meter. Those difference value can be caused by the deviation of calculation on LWT (Light Weight Tonne). While the analysis of Hydromax on second condition is empty load, obtained the value of displacement of 2809 tons, draft on the bow 1.484 meter, and draft on stern 1.679 meter, Then the analysis of last condition is maximum load, obtained the value of displacement 10036 ton, draft on the bow 4.97 meter, draft on the stern 5.02.

REFERENCES

[1] Adji,S.W, "*Diktat kuliah Pengenalan Sistem Propulsi Kapal"*, Teknik Sistem Perkapalan FTK-ITS, Surabaya, 2006.
[2] Wibawa,Ari., Trimulyono,Andi., Ubaidilah,Fazjeri. "*Perencanaan Kapal Tongkang Sebagai Penyeberangan Masyarakat Di Sungai Bengawan Solo, Desa Jimbung, Kabupaten Blora, Jawa Tengah*",Semarang,2012.
[3] Papalangi,Ferlyn., Mulyatno,Imam Pujo., Manik,Parlindungan. "*Studi Perancangan Tongkang Pengangkut Limbah Batubara Di*

PLTU Tanjung Jati B Jepara", Tugas Akhir S-1, Teknik Perkapalan UNDIP, Semarang,2015.

[4] Prayoga,Bagus Nandika. "*Desain Self Propelled Oil Barge (SPOG) Untuk Distribusi Crude Oil Di Kabupaten Sorong, Papua Barat*", Tugas Akhir S-1, Teknik Perkapalan, Surabaya,2015.

[5] Kemetrian Kelautan Dan Perikanan. "*Perencanaan Detail Engineering Design (DED) Kapal Riset 60 Meter"*. Jakarta: PT Binomical Persada.2016.

[6] Prayoga,Bagus Nandika. "*Desain Self Propelled Oil Barge (SPOG) Untuk Distribusi Crude Oil Di Kabupaten Sorong, Papua Barat*", Tugas Akhir S-1, Teknik Perkapalan, Surabaya,2015.

[7] Dynamic Positioning Conference."*Basic Of Dynamic Positioning"*. Houston:Kongsberg Simrad Inc, 1998.

[8] Sorensen,J Asgeir."*Dynamic Positioning System Overview And Trends"*, Department Marine Of Teknologi, Norwegian University OF Science And Technology, Norwegian, 2013