Main engine calculation for ferry Ro-Ro 500 DWT ship using electric propulsion

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Abstract. The development of the current design of electrical system to protect the environment in the world. The purpose of this research is to obtain an electric propulsion system and engine power needed by the Ferry RoRo 500 DWT ship. The analysis begins by calculating the total ship resistance using the software. Next, the calculation of determining the generator power is calculated by a mathematical method. Resistance of 500 DWT RORO ferry at 12 knots 67.7 kN service speed. The increase in ship resistance is affected by the volume of the hull below the waterline. The greater the volume the greater the value resistance ship to get. The power play engine generator required to fight the value of ship resistance at the ferry RORO service speed of 984.49 kW.

1. Introduction
Ship planning at this time has been developed using installed electrical and electronic devices. The development of the ship's electrical system is getting more detailed, where the electrical system has become part of the propulsion system. While the ship's drive system by using electricity is still limited to alternatives. The electrical system is used on special vessels with the best level of comfort. Cruise ships, warships, unmanned ships, and other special ships are slowly developing electric propulsion systems. The introduction of electric propulsion systems into marine transportation provides the benefits such as the reduction of environmental pollution and improvement of life quality standards in general.

One of the main problems for ship designers is concerning the determination of power requirements for electric power. The use of the main driving force of the ship varies greatly on each engine maker. To reduce power losses, the planner needs to consider the following main factors: optimization of the hull design that results in the least resistance of the ship; choose the type of material that is economical; the shape of the ship's bow that is efficient against waves from the front.

2. Method
Efficiency has a function as power to support the performance of the propulsion Should [1]. Based on [2], [4], power can be formulated with effective PE power to move a ship equal to the total thrust force, the resistance of the ship R against the ship's movement and speed v. Effective Horse Power (EHP) is the amount of power needed to overcome the drag force of the hull, so that the ship can move from one place to another with a service speed of Vs.

\[ PE = R_{\text{service}} \times V_s \]  

Where:

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Delivery Horse Power (PD) is the power absorbed by the propeller vessel to produce Push Power, or in other words DHP is the power in the channel by the motor motion to the propeller which then ship the conversion into a propelling force. Power in the propeller shaft or DHP tube is calculated from the ratio between the Effective Power or EHP with the Propulsive Coefficient or PC.

\[
PD = \frac{PE}{\eta} 
\]  
(2)

Where:
- PD = Delivery Horse Power (DHP)
- PE = Power Effective
- \(\eta\) = Efficiency

Shaft Horse Power (SHP) is the measured power to the area in front of the stern tube bearing of the ship's propulsion system. Here the ship has an engine room at the rear, with loss (2-3) %, taken at 2%. So the value of the efficiency of bearings and vane tubes or \(\eta_s\eta_b\) is 0.98.

\[
SHP = \frac{PD}{\eta_s\eta_b} 
\]  
(3)

Where:
- SHP = Shaft Horse Power (SHP)
- PD = Delivery Horse Power (DHP)
- \(\eta_s\eta_b\) = Efficiency of bearings (0.98)

Brake Horse Power (BHP) is brake power or power received by the axle transmission shaft drive system, which is then operated continuously to move the ship at its service speed (Vs). The amount of power the primary engine or PB needed in planning the propeller and the tube axis of the propeller is not separated by the value of efficiency system gears and transmission or \(\eta_G\) this as planned in relation the power transmission system between the main engine with propeller shaft installed system reduction gear. The gear system on this ship is planned to use a single reduction gear or Suckle Reduction Gear with a loss of 2%. For forwarding and reverse gear or Reversing Gear with 1% loss. From the data, the system can know the value of the efficiency of the transmission gear system or \(\eta_g\) of each system are: \(\eta_g = 98\%\) for a single reduction gears.

Where the total coefficient of energy conversion is driving the ratio between the power coming out of the propeller and the electrical energy input used by the ship's propulsion. Total efficiency there are six main components [5]:

\[
\eta = \eta_C + \eta_M + \eta_G + \eta_S + \eta_P + \eta_H 
\]  
(4)

Where:
- \(\eta_C\) = Efficiency of electronic power converter which gives input to the electric drive (0,65 to 0,99)
- \(\eta_M\) = Electric motor drive efficiency (0,45 to 0,97)
- \(\eta_G\) = Gearbox efficiency (0,95 to 0,97)
ηS = Shaft line efficiency (0.97 to 0.98)
ηP = Hull efficiency (0.98 to 1.4)
t = Thrust deduction fraction measured experimentally (0.1 to 0.3)
w = Wake fraction the vessel parameter (0.2 to 0.45)

The decrease in efficiency will affect the speed of the ship. Losing the efficiency value will decrease the speed down by 0.5 from the standard value [6]. Brake Horse Power (SCR) is the output power of the motors in the condition of Continues Service Rating.

\[ \text{BHP}_{\text{scr}} = \frac{\text{SHP}}{\eta_g} \]  \hspace{1cm} (5)

Where:
BHP_{scr} = Brake Horse Power Min (HP)
SHP = Shaft Horse Power (HP)
ηg = Efficiency gears box

The magnitude of the power of the main driving motor or main motor is the output power on a normal cruise or SCR, where the amount is 80% - 85% of the output power at maximum conditions or MCR. While the output power at the MCR conditions are as follows:

\[ \text{BHP}_{\text{mcr}} = \frac{\text{BHP}_{\text{scr}}}{0.85} \]  \hspace{1cm} (6)

Where:
BHP_{mcr} = Brake Horse Power Max (HP)
BHP_{scr} = Brake Horse Power Min (HP)

BHP (MCR) has become the data that is used as a reference in implementing pr OSes elections motor Engine Selection Process. Ship resistance parameters are directly related to the hull when moving. In the design of the ship the main procedures required compatibility between the hull and the ship's propulsion system. Traditionally factors in ship resistance are ship hull obstacles, wave resistance, air resistance, and ship speed. The general formula for ship resistance can be seen in the following [4]:

\[ F = F_L + F_d = F_w + F_A + m \frac{dv}{dt} \]  \hspace{1cm} (7)

Where:
F = Total force requested from the propeller;
F_L = Static hull resistance;
F_d = Dynamic resistance;
F_w = Water resistance;
F_A = Air resistance;
m = Ship displacement;
v = Ship velocity versus water (1 to 50 m/s [3])

In stable ship conditions, just rely on static strength. But when the ship maneuvers, the burden will dramatically increase. Resulting in the sudden fulfillment of electrical power causes disruption to the electrical unit. It could be said to exceed the ship's weight when sailing. The application of propulsion electric system needs to be considered the thrust generated by the propeller. The thrust will be greater to rotate the propeller to reach the desired speed. Comparison with the conventional electric
propulsion system is very efficient compared to diesel and turbine in dynamic conditions. The ship's maneuverability is increasing well and in a dynamic ship position. Especially when the ship is at the dock either leaning or reducing the level of collision with other ships. As shown [3] the torque and speed relationship curves are significantly different. Following formula (1)-(4) the condition for power is not proportional to the ideal propeller rotation speed in formula (7).

3. Results and Discussion
Case study of electric power propulsion estimation of the main engine ferry Roro 500 DWT. This ferry has an overall length of 45.50 meters; ship width of 12 meters; ship height of 3.2 meters; 2.15 meters ship draft; speed of 12 knots. The ferry is equipped with front and rear ramdoor doors. Ferry passenger capacity is 202 persons; crews 18 persons; car 12 trucks and 7 sedans. The calculation starts from making the ferry model into the MaxSuft education software. Model making is carried out to obtain ferry hydrostatic data. Data from model making can be seen in table 1 below.

Table 1. Ferry RORO 500 DWT Hydrostatic data

| Item          | Value   | Unit | Holtrop |
|---------------|---------|------|---------|
| LWL           | 37,802  | m    | 37,802  |
| Beam          | 11,802  | m    | 11,802  |
| Draft         | 1,95    | m    | 1,95    |
| Displaced volume | 565,06  | m^3  | 565,06  |
| Wetted area   | 440,393 | m^2  | 440,393 |
| Prismatic coeff. (Cp) | 0,753  |      | 0,753   |
| Waterpl. area coeff. (Cwp) | 0,867  |      | 0,867   |
| 1/2 angle of entrance | 36,9    | deg. | 36,9    |
| LCG from midships(+ve for'd) | -1,911 | m    | -1,911  |

Figure 1. Resistance of the curve ship ferry 500 DWT

Determination of engine power is done by using hull speed with 80% hull efficiency. To get a detailed analysis, the division of ship prisoners calculation is done. Calculation of prisoners varies based on the draft draft height. In detail can be seen in the picture below. The prisoners on a 1 meter
draft produce a value of 44.5 kN. For a 1.5 meter draft boat, the value of ship resistance is 57.1 kN. Whereas in the draft 1.95 meters the value is 67.7 kN. The value of ship resistance is linear. This shows the influence of the value of ship resistance is affected by the wetted area. Value wetted area of a row of draft 1 meter $330.747 \text{ m}^2$; draft 1.5 meters $388.637 \text{ m}^2$; draft 1.95 meters $440.393 \text{ m}^2$.

The results of power engine calculations using the Holtrop 500 DWT ferry method. Starting from 1 meter draft 343.238 kW; draft 1.5 meters 440.358 kW; draft 1.95 meters 522.427 kW. The addition of the draft fundamentally affects the engine power of the ship. The increase in engine power increases linearly with the speed of the ship. The ship's speed began to increase from 8 knots to 12 knots. The increase in speed between 10 to 12 knots there was a significant increase due to 77.503 kW to 522,427 kW at the full draft. This occurs at such speeds that the engine is in ideal working condition.

Waveforms at the full draft and at full speed of waves generated by the laminated waveforms. Waves generated due to the shape of the hull below the surface of the water. The laminar waveform of the effect is a linear increase in speed boats. Based on the calculation of engine power using the Holtrop method obtained EHP 522.42 KW (700.58 HP). Efficiency values following formula (4) from the calculations obtained 0.67. Delivery hours power division between EHP with efficiency (2) is 1044.77 Hp. Transmission from the engine to the SHP propeller in formula (3) is 1066.09 Hp. D aya output of the motor peng ger ak on condition Services Continues Rating system transmission efficiency motors with a value of 1122.2 Hp produce. Next, the output power needed by the ship to
Sail (6) is 1320.23 Hp which is equivalent to 984.49 kW. This value is used as a reference in the Roro 500 DWT ferry engine selection process.

4. Conclusion
For energy system analysis, the propulsion must be separated from the propulsion. Analysis of the engine load must be able to convert the ship in static and dynamic conditions. While the analysis of speed, transmission system, and propeller must be able to encourage the use of engine power. Prisoners ship ferry RORO is obtained by variation of the draft vessel to 1 meter, 1.5 meters, and 1.95 meters. The ship's detainees at the full draft condition and full speed of 67.7 kN. Ship resistance on the 1.5-meter draft was 57.1 kN, while the lowest draft obtained a value of 44.5 kN. In theory, the increase in ship resistance due to changes in the volume of the body of the ship under the waterline by 565.06 m³. The efficiency value has a very significant influence on the determination of the engine power of the ferry RORO 500 DWT. The calculation results show the need for electric generator power to be able to drive the 500 DWT ferry boat BHP mcr power is 1320.23 Hp equivalent to 984.49 kW.

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