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Estimation of Optimum Main Engine Power for a 14.5 m Wooden Purse Seine Vessel (Case Study of Motor Vessel Putra Abadi)

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***Abstract*— Small pelagic purse seine vessels in Jakarta are dominated by vessels with a length of 14.5 m. The vessel's hull construction was made by a traditional vesselyard using wood. The construction process only relies on the skills and habits of craftsmen. The choice of engine is only based on the size of the vessel and the price of the engine without calculating resistance. In general, the power of the purse seine main engine as the main mover is not suitable, causing wasteful fuel consumption. The fishing vessel engine used by MV Putra Abadi comes from a modified truck engine so that the fuel used does not comply with specifications. This research aims to determine the amount of power needed to move a Putra Abadi fishing vessel. The method used is direct observation by taking direct measurements of the dimensions of MV Putra Abadi. Next, the engine resistance and power are also calculated using the Holtrop resistance method in software. The Putra Abadi fishing vessel based on hydrostatic calculations showed that the block coefficient (Cb) is 0.425 at a speed of 7 knots, the resulting resistance is 2.5 kN. While at a maximum speed of 8 knots the BHP is 98.82. The power requirement of Putra Abadi fishing vessel according to this calculation is only 46% of the engine power currently used.**

Keywords— *fishing vessel, power engine, resistance, small pelagic*.

I. Introduction

Putra Abadi Motor Vessel (MV) based on the Fishing License is 8 gross tonnages (GT). According to the Law of the Republic of Indonesia Number 7 Year 2016, Putra Abadi is one of the small-scale fishing vessels. The vessel uses small pelagic purse seine gear and is moored at Pier T, Muara Angke Perikanan Nusantara Fishing Port (PPN), North Jakarta, Jakarta. The construction of the vessel's body is made by a traditional vesselyard using wooden materials. During the manufacturing process the vessel's construction relies on artisan skills and custom. The selection of the engine to be used on the vessel is chosen based on the size of the vessel and the fishers's consideration of the engine price. Generally, the use of the main engine power of purse seine vessels as the prime mover is not appropriate, which causes wasteful consumption of fuel [1];[2]. The vessel engine used by MV Putra Abadi comes from a modified truck motor. Used truck engines are the main choice as the main engine of traditional wooden vessels [3].

The vesselowner chose the propulsion motor power of MV Putra Abadi based on the habits of local fishers. The use of engine power that is greater than needs leads to waste of fuel. The fuel used has a fluctuating price and cannot be predicted in the future. The increase in fuel prices without being matched by an increase in fish prices is the cause of fishers's losses [4]. During the peak season, fishers sell fish at low prices and vice versa [5]. The increase in fuel prices is not proportional to the impact of the increase in fuel prices on fish prices [6]. Therefore, the selection of engine power that is determined based on the amount of vessel resistance needs to be calculated. The use of the right engine power can reduce the burden on fishers to purchase diesel fuel.

The research was conducted with the aim of assessing the amount of power required to drive the vessel. This goal was achieved by directly measuring the main dimensions of the vessel such as length, width, and depth. In addition, the vessel's speed was measured when heading to the fishing area and when returning to the port. Furthermore, calculating the resistance and engine power of the vessel using the Holtrop method in Naval Architecture Software. This research is expected to be useful for MV Putra Abadi in choosing the main engine that suits their needs.

I. METHOD

The tools used in this research are roll meter and laser distance meter to measure vessel dimensions, global positioning system to measure vessel speed, and Naval Architecture Software to analyze vessel resistance. The research was conducted on November - December 2022 at Muara Angke Perikanan Nusantara Port (PPN), North Jakarta, DKI Jakarta Province.

The vessel's propulsion motor power is calculated from the vessel's effective power (EHP) to the engine brake power (BHP). The calculation of effective power (EHP) is influenced by the total resistance (RT) value of the vessel which has been calculated by the Holtrop method using Student Version Naval Architecture Software. The vessel's hull is made from the measurements obtained, then modeled using software as shown in the Figure 1.

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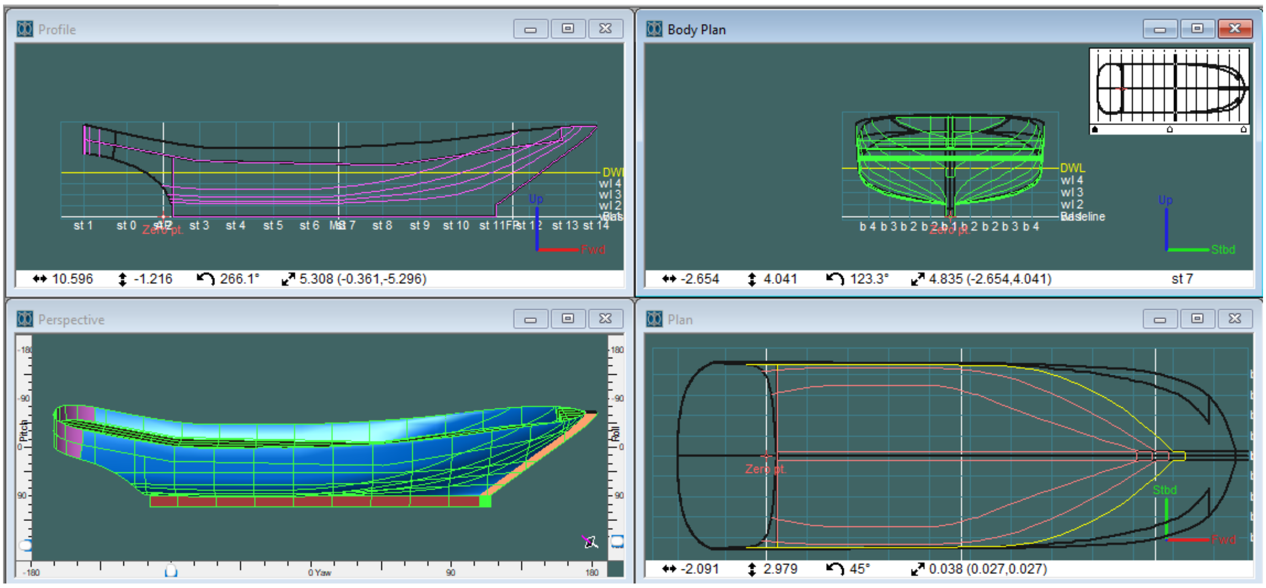

Figure. 1. MV Putra Abadi fishing vessel model

Based on this effective power, the value of propeller power can then be determined. The calculation of the vessel's effective power uses the equation as follows.

$$EHP = R_T \times V_S \ (HP) \quad (1)$$

with,
EHP : Effective Horsepower (HP)
RT : Resistance total (kN)
Vs : Vessel speed (knots)

Then the value of the propulsion motor power can be determined from the value of ηr or transmission efficiency which depends on the placement of the propulsion motor. The variable that affects the amount of propeller power is the value of w (wake fraction) using an empirical formula based on statistical calculations. Other variables are t (thrust deduction factor), ηp (propeller efficiency), and ηπ (relative rotative efficiency). Based on these variables, the price of propulsion coefficient (PC) is obtained. Wake fraction is determined using the empirical formula given by Taylor based on the block coefficient function:

$$w = 0.5\,C_b - 0.05 \quad (2)$$

Where,
w : Wake fraction
Cb : Coefficient block

The value of thrust deduction factor for single screw vessel according to [7] has been determined as 0.1. Hull efficiency is the ratio between the work done by the vessel, namely effective power and the work done by the propeller given in the following equation:

$$\eta_H = \frac{1-t}{1-w} \quad (3)$$

with,
η_H : Hull efficiency
t : Thrust deduction factor

Propulsive efficiency is defined as the ratio between effective power and delivered power given by the equation:

$$PC = \eta_H * \eta_p * \eta_{rr} \quad (4)$$

with,
PC : Propulsive efficiency
η_H : Hull efficiency
η_p : Propeller efficiency; 50%
η_{rr}: Propeller efficiency ratio; single screw = 1

The amount of mechanical efficiency depends on the engine placement

$$\eta_{mekanis} = 0.97 \quad (5)$$

Furthermore, the calculation of Delivery Horsepower (DHP) with the following equation

$$DHP = \frac{EHP}{PC} \quad (6)$$

Shaft Horsepower (SHP) calculation using the following equation

$$SHP = \frac{DHP}{\eta transmisi} \quad (7)$$

Calculation of Brake Horsepower (BHP) based on the following equation

$$BHP = \frac{SHP}{\eta mekanis} \quad (8)$$

Furthermore, the addition of engine power caused by fouling (sea margin) in the Java Sea is 20% [1] and the calculation of BHP considers the engine margin with an addition of 15% [1].

II. Results And Discussion

A. Putra Abadi Motor Vessel

The motor vessel (MV) Putra Abadi is owned individually who is also its captain. The vessel has been based at the Nusantara Fisheries Port (PPN) Muara Angke since 2011. The vessel is made traditionally and is made of wood. Vesselbuilding is carried out in Bulakamba, Brebes Regency. The current owner of the vessel is the second owner and took it to Muara Angke. The bow of the vessel is "V" shaped, in the middle it has a "U" shape (round bottom) and at the stern it tends to be flat (flat bottom). The insulated fish storage space in the vessel's hull is divided into 6 hatches.

Figure. 2. Main engine of MV Putra Abadi

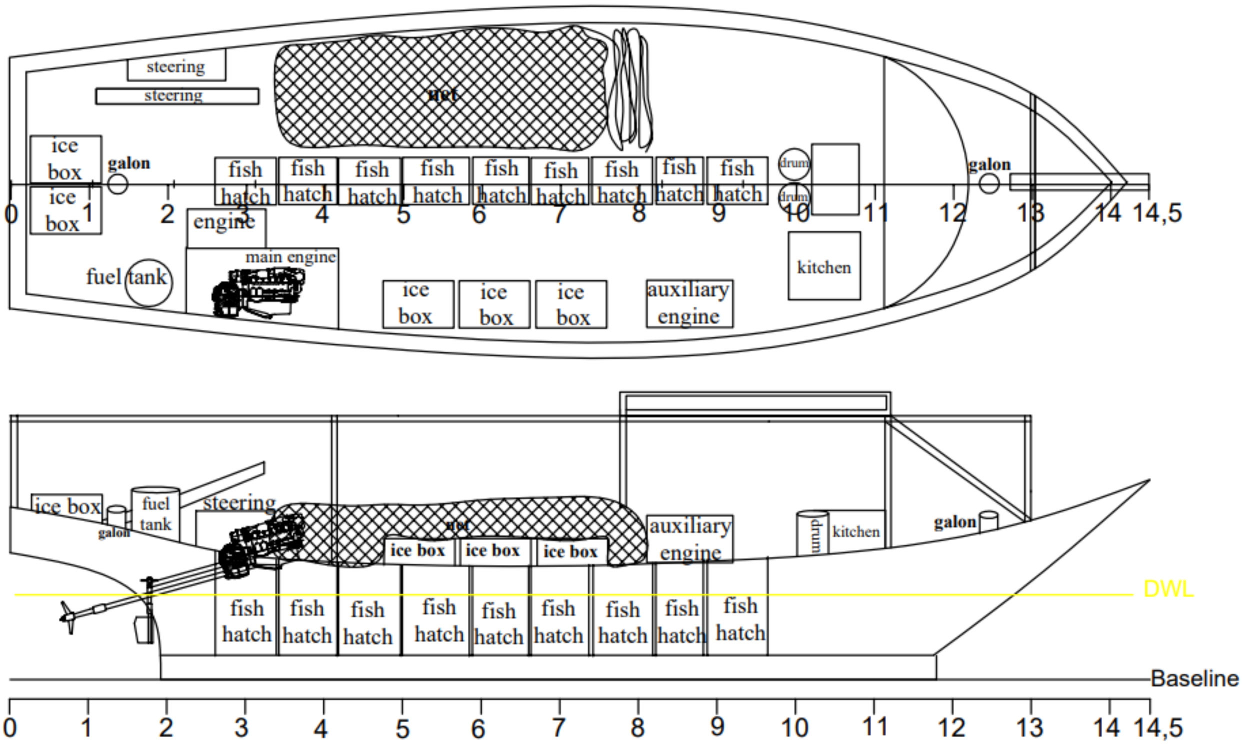

Figure. 3. General arrangement of MV Putra Abadi

TABLE. 1.
THE CALCULATION OF HYDROSTATICS

Measurement	Value	Units
Displacement	25.31	t
Volume (displaced)	24.691	m^3
Draft Amidvessels	1.200	m
Immersed depth	1.200	m
WL Length	10.778	m
Beam max extents on WL	4.492	m
Wetted Area	53.496	m^2
Max sect. area	3.255	m^2
Waterpl. Area	40.685	m^2
Prismatic coeff. (Cp)	0.704	
Block coeff. (Cb)	0.425	
Max Sect. area coeff. (Cm)	0.606	
Waterpl. area coeff. (Cwp)	0.840	

This vessel has the number GT. 8 No. 1721/BE which is based at the T PPN Muara Angke pier. The length overall (LoA) of the vessel is 14.51 m, the maximum width of the vessel is 4.4 m, the height of the vessel is 1.2 m. The number of vessel propellers consists of 4 leaves. Fishing operations using small pelagic purse seine fishing gear in one vessel (one vessel system). The available fishing aids consist of a winch and a scoop. The winch functions to help pull the net when hauling. The scoop is used to collect fish collected in the net.

The engine that MV Putra Abadi uses a Mitsubishi PS 100 and 4 stroke with diesel fuel (Figure 2). The engine has been used since MV Putra Abadi is based at Muara Angke Fishing Port or is technically 12 years old. The boat owner carries out maintenance only if the engineer thinks it is necessary or if the engine is damaged. The fuel storage tank for the auxiliary engine is different from the main engine. The fuel for the auxiliary engine has its own container in the form of a small jerry can. This research does not calculate fuel consumption from auxiliary engines.

This fishing vessel is the only one that still uses small pelagic purse seine fishing gear at Muara Angke Fishing Port. The purse seine has a mesh size of 1 inch, a ring diameter of 12 cm, a net length of 300 m and a net depth of 50 m. The top rope, bottom rope, buoy rope, weight rope and net are made of polyethylene (PE). The buoy part is made of polyvinyl chloride (PVC), the weight is made of lead, and the ring is made of metal.

General arrangement of MV Putra Abadi is presented in Figure 3. Based on observations, the dominant cargo layout is on the vessel's deck. The engine is located on the vessel deck (outboard engine). The location of the main engine is on the right side near the stern of the vessel. The position of the main engine and the diesel drum is close to each other to facilitate the flow of diesel to the engine. The solar drum is 60 cm in diameter and 90 cm high. The calculated volume of the tubular drum is 254 L. However, fishers generally only fill diesel drums with a maximum of 200 L or 80% of the drum volume. The Putra Abadi fishing vessel based on hydrostatic calculations (Table 1) shows that the block coefficient (Cb) is 0.425

B. Resistance and Engine Power of MV Putra Abadi

Calculation of vessel resistance is carried out with the help of Naval Architecture Software. The vessel's resistance is analysed to determine the propulsion power requirements using the Holtrop method. The value of vessel resistance is affected by the shape of the hull underwater, and the shape of the hull can affect the characteristics of fluid flow which will result in the size of the resistance [8].

TABLE. 2.
THE COEFFICIENT VALUE OF PROPULSION POWER CALCULATION

Coefficient	Symbol	Value
Wake fraction	w	0.1625
Thrust deduction factor	t	0.11375
Relative rotative efficiency	η_{rr}	1
Hull efficiency	η_H	1.074626866
Propeller efficiency	η_P	0.5
Efficiency mekanis	η_M	0.98
Propulsive efficiency	PC	0.537313433

The resistance on a fishing vessel is also influenced by the placement of the vessel's main engine, the more the main engine approaches forward perpendicular, the greater the resistance that occurs because the thrust of the vessel is greater [9]. Netting on purse seine vessels is still done manually, so the large dimensions of purse seine vessels affect the number of crew members involved because they require more power during fishing operations [10]. So, the main engine power calculation is for a vessel size with the same specifications. The calculation data for each coefficient is presented in Table 1. Furthermore, the calculation results considering the speed used can be seen in Table 1.

Based on Table 2, it is found that MV Putra Abadi with a service speed of 7 knots requires 38 HP of power. The addition of sea margin is used to anticipate resistance the increase of vessel resistance due to sea animals sticking to the vessel's hull (fouling). The value of the sea margin in the Java Sea is 20% -25% [1]. Apart from that, there is an engine margin 15% of the remaining engine power. As the speed continues to increase, the resistance value also continues to increase so that the resistance will follow the increase in the speed of the vessel [11]

TABLE. 3.
POWER CALCULATION RESULTS USING THE HOLTROP METHOD

***Speed* (kn)**	***Holtrop resistance* (kN)**	***Holtrop power* (EHP)**	**DHP**	**SHP**	**BHP**	**BHP (*sea margin*)**	**BHP (*engine margin*)**
0.5	0	0.01	0.01	0.02	0.02	0.02	0.02
1	0	0.06	0.10	0.11	0.11	0.14	0.16
1.5	0.1	0.18	0.33	0.33	0.34	0.43	0.50
2	0.2	0.40	0.74	0.76	0.77	0.97	1.14
2.5	0.3	0.75	1.40	1.43	1.46	1.82	2.15
3	0.4	1.27	2.36	2.40	2.45	3.07	3.61
3.5	0.5	1.97	3.66	3.73	3.81	4.76	5.60
4	0.6	2.88	5.37	5.48	5.59	6.99	8.22
4.5	0.8	4.07	7.57	7.72	7.88	9.85	11.59
5	1	5.60	10.42	10.64	10.85	13.57	15.96
5.5	1.2	7.60	14.14	14.43	14.73	18.41	21.66
6	1.5	10.49	19.52	19.92	20.33	25.41	29.89
6.5	2	14.85	27.64	28.20	28.78	35.97	42.32
7	**2.5**	**19.89**	**37.02**	**37.77**	**38.54**	**48.18**	**56.68**
7.5	3	25.74	47.90	48.88	49.88	62.34	73.35
8	3.8	34.68	64.54	65.86	67.20	84.00	98.82

Therefore, the amount of power required by MV Putra Abadi is 56 HP. According to this calculation, MV Putra Abadi only needs 56% of the engine power currently used. In addition, it is possible that the main engine of MV Putra Abadi has experienced a decrease in engine power due to several things, as explained by [12], that engine performance is damaged due to polluted turbines, dirty air filters/compressors, dirty air conditioners, and poor fuel injection. This is in accordance with research by [1] which states that the use of main engine power for purse seine vessels in Pekalongan is inappropriate, resulting in fuel waste. The choice of propulsion system for traditional vessels is generally determined based on the habits and traditions of local fishers [2].

III. CONCLUSION

Based on measurements on the Putra Abadi vessel, the overall length (LoA) of the vessel is 14.51 m, the maximum width of the vessel is 4.4 m, the height of the vessel is 1.2 m. The bow of the vessel is “V” shaped, the center is “U” shaped (round bottom) and the stern tends to be flat (flat bottom). Putra Abadi fishing vessel based on hydrostatic calculations showed a block coefficient (Cb) of 0.425 at a speed of 7 knots, the resulting resistance was 2.5 kN. The power requirement of the Putra Abadi fishing vessel according to this calculation is only 46% of the engine power currently used.

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