Powering and Resistance Analysis of the 49 Meter Leganta Ship for Maritime Tourism in the Riau Islands Province

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Abstract. Prediction of ship resistance is the main factor in determining the main engine power. Prediction of resistance and powering of the Leganta 49 meter leisure boat is carried out on the Software Resistance software which is based on empirical calculations of Holtrop and Fung. By knowing the estimated ship resistance, an estimate of the power required to be able to operate optimally during the voyage is obtained. testing with a maximum speed of 21 knots on the Holtrop method gives a predicted result of the total resistance calculation RT of 664.2 kN with the required power of 8969.57 kW. Meanwhile, the Fung method gives a predicted result of the total resistance calculation RT of 624.4 kN with the required power of 8431.83 kW.

1 Introduction

Resistance is one of the main components that affect ship design. Calculation of ship resistance value during operation is very important because it affects the fluid flow, speed, and economic value of the ship during operation [1]. Resistance, also known as pull or drag, is a force that is opposite to the direction of ship motion, which acts on the ship's hull and inhibits the ship's ability to move forward [2]. According to [3], as a force that arises due to the interaction between the ship and the fluid, which causes the ship to experience resistance or obstacles in moving. Factors such as viscosity, mass density, and physical conditions such as waves or calm water conditions cause resistance to the ship's hull [4].

By predicting ship resistance, the propulsion power required to propel the ship can be estimated, so that the appropriate size and mass of the propulsion engine can be determined. In addition, ship resistance prediction also allows for the estimation of fuel consumption and operational costs, which can affect the efficiency of environmentally friendly transportation and logistics [5]. Accurate ship resistance prediction is essential for ship safety and manoeuvrability [6]. In addition, ship resistance prediction is carried out to maximize performance, such as service speed and fuel consumption [7]. Various methods have been

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developed to estimate ship resistance and the required propulsion power, and many studies and comprehensive literature studies have been carried out to understand the phenomenon of ship resistance. In recent decades, there has been significant progress in the development of methods and techniques for predicting ship resistance [8].

Resistance is a component that must be considered when selecting the main ship engine power because resistance can affect the operational costs of the ship related to fuel consumption. This is the reason why resistance is an important factor in achieving the ideal engine power level [9]. The specifications of the main ship engine fuel usage (SFR), power (MCR), sailing distance, and operating speed affect how much fuel it consumes [10]. In the study [11] using Software Resistance software using the Holtrop approach method to predict the hull resistance of a bulk carrier ship with the aim of obtaining the power requirements for the 8664 DWT ship.

One of the tourist ships designed to improve the Riau Islands tourism industry is the 49-meter Leganta. To move this ship, which has a fairly large size and is equipped with complete facilities, it requires quite a lot of power. To determine the right ship resources, the right resistance calculation is very important. This can improve operational efficiency and reduce costs. Prediction of resistance calculations and ship powering using Software Resistance software with the Holtrop and Fung empirical approach method [12], [13]. Calculation of the resistance of the 49-meter Leganta Leisure boat is very important to determine the appropriate ship powering needs. Thus, the ship can operate with high efficiency and reduce operational costs. Therefore, this study aims to calculate the resistance of the 49-meter Leganta Leisure boat using the Software Resistance software calculation with the Holtrop and Fung empirical approach method to determine the appropriate ship powering needs.

2 Methods

2.1 Resistances

Waves and wakes generated by moving ships can be observed and measured. The components of the wave and wake forces namely drag and wave making resistance, can be determined by making accurate measurements and calculations. Drag is defined as the difference between wave resistance and total resistance, assuming that surface roughness will not have a significant effect on ship resistance [14]. Ship drag consists of two main components, namely viscous pressure drag and frictional resistance. Viscous pressure resistance occurs due to the pressure force generated by the fluid flow on the outside of the ship, while frictional resistance occurs due to the frictional force between the fluid and the ship's surface. In ship resistance analysis, these components can be separated and calculated separately, so that the contribution of each component to ship resistance can be clarified [5]. Based on a study conducted by Lotar Birk in 2019 [15], ship resistance can be divided into three main components, namely frictional resistance (RF, CF), viscous pressure resistance (RVP, CVP), and wave resistance (RW, CW).

$$R_T = R_F + R_{VP} + R_W \tag{1}$$

2.2 Froude's Theory

In fluid mechanics, (Fn) is a non-dimensional number used to describe the relationship between the inertial force of fluid flow and the gravitational force. It shows how gravity affects the motion of a fluid or an object moving through a fluid. The Froude Number is often used in the analysis of ship motion in water, because it can clarify the characteristics of ship motion. The Froude Number was developed by William Froude in 1868 and is used as a reference for ship speed [15].

$$F_r = \frac{v}{\sqrt{gL_{WL}}} = Fr_s = Fr_M \tag{21}$$

2.3 Holtrop Method

The Holtrop method is an empirical method developed to calculate the predicted resistance of ships, which are generally tankers, general cargo, fishing vessels, tugs, containers, and frigates, in calm waters. This method calculates several parameters, such as hull shape, speed, and operational conditions, with the aim of providing accurate resistance estimates. The Holtrop method is an empirical method based on regression analysis of model test data and data testing conducted at MARIN (Maritime Research Institute Netherlands), located in Wageningen, the Netherlands [16], [17], [18], [19], [20], [21]. Air resistance usually has a very small effect, which is less than 4% of the total resistance, so its use is often ignored [22].

$$R_T = (1+k)\, R_F + R_{APP} + R_A + R_W + R_B + R_{TR} + R \tag{32}$$

2.4 Fung Method

Fung's method is one of the empirical methods that can be used to predict the resistance of Displacement ships with a stern transom hull shape. This method is generally used for ships larger than Compton. The regression results of this method are based on data from testing 739 models in the David Taylor model basin and consist of more than 10,000 data points [12], [13], [23].

2.5 Simulation Software

Software Resistance, an application developed by Bentley Systems, provides a facility to predict ship hull resistance. This application can read and measure ship designs automatically to obtain the required parameters, or parameters can be input manually without requiring an existing Software design file [12], [13]. Software Resistance is software used to predict ship hull resistance. This application can be used for various types of ships, from monohulls to multihulls. In its development, Software Resistance implements several different resistance prediction algorithms, which can be used according to the type of ship hull shape to be predicted [12], [13].

3 Results and Discussion

Principal dimension or main size of the ship is the main dimension of a ship's hull shape. The main dimensions of the Leganta 49-meter leisure boat are obtained from the results of linear regression of comparative ships, resulting in the main dimensions presented in Table 1. The main dimensions in Table 1 above are further developed through three-dimensional ship design modelling in Software Modeller so that the ship shape is obtained in accordance with the previously determined requirements. The determination of the main dimensions certainly pays close attention to the operational conditions of shipping in the waters of the Riau Islands.

Table 1. Principal Dimension

Item		Value	Units
Ship type	=	Leisure Boat	
Ship name	=	LEGACY	
Length Over All	=	49	m
Length Perpendicular	=	47.8	m
Length Waterline	=	45.5	m
Breath	=	10.1	m
Height	=	6.2	m
T (draft)	=	2.5	m
Vs (service speed)	=	20	Knot
Disp. (weight)	=	751.6	ton

Hydrostatic data is the physical and mechanical properties of the part of the ship that is immersed in water. Hydrostatic data is obtained from Software Modeller. Hydrostatic data of the Leganta 49 meter leisure boat is presented in Table 2. Hydrostatic data of the hull is very crucial in testing ship resistance prediction because it greatly affects the test results. The greater the volume of the hull and the WSA (Wetted Surface Area) of the ship's hull immersed in fluid, the greater the resistance produced and the power required is also greater, and vice versa if the volume of the hull and the WSA (Wetted Surface Area) of the ship's hull immersed in fluid is smaller, the resistance produced and the power required is also reduced [24].

The Line Plan Form of the 49-meter Leganta leisure boat is modelled using the 3D modelling software Modeller as shown in Figure 1. The modelling results in Software Modeller are exported to produce the line plan form of the three projections, namely sheer plan, body plan, and half breath plan. The results of the Software Resistance modelling are further processed in AutoCAD software to produce the final appearance as shown in Figure 2.

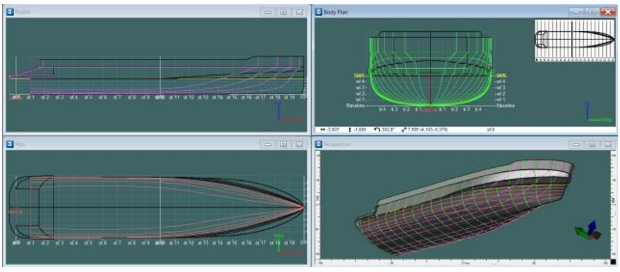

Fig. 1. Software Modeller Modelling

Table 2. Leganta 49 meter Hull Hydrostatic Data

Measurement		Value	Units
Displacement	=	751.6	T
Displaced Volume	=	733,255	m^3
Draft at Midship	=	2,500	meters
Immersed Depth	=	2,500	meters
Waterline Length (LWL)	=	45,547	meters
Maximum Beam at Waterline	=	10,102	meters
Wetted Surface Area	=	504,300	m^2
Maximum Sectional Area	=	21,233	m^2
Waterplane Area:	=	371,433	m^2
Prismatic Coefficient (Cp)	=	0.758	
Block Coefficient (Cb)	=	0.642	
Maximum Sectional Area Coefficient (Cm)	=	0.847	
Waterplane Area Coefficient (Cwp)	=	0.813	
Longitudinal Center of Buoyancy (LCB)	=	20,518	from the zero point (positive forward)
Longitudinal Center of Flotation (LCF)	=	21,372	from the zero point (positive forward)
LCB as Percentage of LWL	=	45,048	from the zero point (positive forward) % Lwl
LCF as Percentage of LWL	=	46,922	from the zero point (positive forward) % Lwl
Height of Center of Buoyancy (KB)	=	1,436	meters
Height of Center of Gravity (KG)	=	0,000	meters (fluid condition)
Transverse Metacentric Radius (BMt)	=	3,606	meters
Longitudinal Metacentric Radius (BML)	=	67,158	meters
Corrected Transverse Metacentric Height (GMt)	=	5,042	meters
Corrected Longitudinal Metacentric Height (GML)	=	68,594	meters
Transverse Metacentric Height (KMt)	=	5,042	meters
Longitudinal Metacentric Height (KML)	=	68,594	meters
Immersion per Ton (TPc)	=	3,807	tonnes per centimeter
Moment to Change Trim by 1 cm (MTc)	=	10,771	tonne-meters
Righting Moment at 1 Degree Heel (RM)	=	66,136	tonne-meters
Length to Beam Ratio	=	4,540	
Beam to Draft Ratio	=	4,013	
Length to Volume Ratio	=	5,051	
Precision	=	Highest	Highest precision at 215 stations

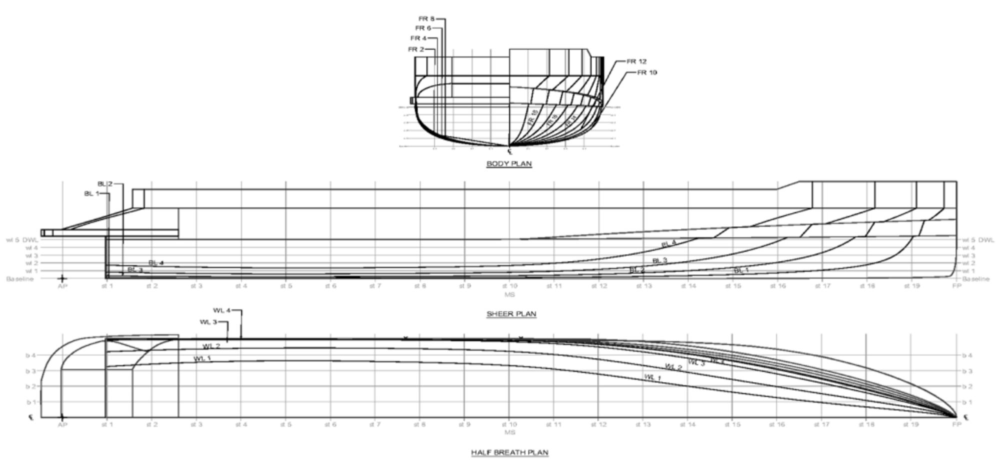

Fig. 2.LEGANTA Line Plan 49 meters

Before proceeding to the resistance testing stage on the Software Resistance software, it is necessary to check the correction of the hull dimension ratio. So as to maximize the results of the resistance calculation prediction on Software Resistance [12], [13]. The Holtrop Method correction is shown in Table 3 below.

Table 3. Holtrop method parameters

L/B	4,732	Fulfil	3.9	<	L/B	<	15
T/T	4.0	Fulfil	2.1	<	T/T	<	4.0
CP	0.758	Fulfil	0.55	<	CP	<	0.85

Table 4. Function Method Parameters

V/L3	0.00671	Fulfil	0.00057	<	V/L 3	<	0.01257
T/T	4.04	Fulfil	1,696	<	T/T	<	10,204
CP	0.758	Fulfil	0.526	<	CP	<	0.774
Cx	0.847	Fulfil	0.556	<	Cx	<	0.994
i.e.	18,400	Fulfil	14,324	<	i.e.	<	23,673
L/B	4,731	Fulfil	2.52	<	L/B	<	17,935
Cwp	0.813	Fulfil	0.662	<	Cwp	<	0.841

From the results of the dimensional correction of the Holtrop and Fung empirical approach methods respectively in Table 3 and Table 4 above, good geometric conformity was obtained so that it meets the parameter limits that have been set by each method [12], [13]. Then the results of the resistance test of the Leganta 49 meter leisure boat have been carried out using two different test methods, namely the Holtrop method and the Fung method. The test results obtained from these two methods show high consistency and accuracy. The Holtrop method is an empirical method developed to calculate the prediction of ship resistance. In the resistance test of the Leganta 49 Meter ship, the Holtrop method shows good results and is in accordance with the data obtained from the test. In addition, the Fung method also shows good results in the resistance test of the Leganta 49 meter ship.

In the resistance test of the 49-meter Leganta ship, the Fung method showed results that were in accordance with the data obtained from the test. Figure 3 and Figure 4 present graphs of the results of the Total RT and power resistance calculations on the hull of the 49-meter Leganta ship. The results of both show good agreement with a relatively minimal difference between the two methods. The calculation of the total RT resistance prediction between the two methods shows varying results with a difference between ±26.3% to 6.4%. The power prediction also shows a variation in the difference that is not very significant, namely between ±26.3% to 6.4%.

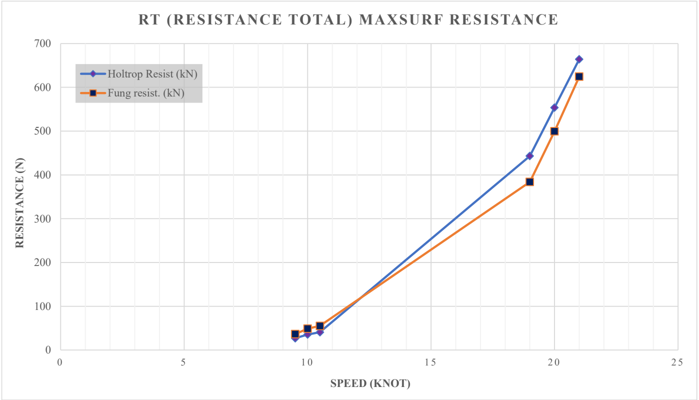

Fig. 3. Total Resistance Test Results Graph RT (kN) Software Resistance

Fig. 4. Software Resistance Power (kW) Test Results Graph

Testing was conducted at two main speeds including average speed and maximum speed. The test speed was conducted at ±5% according to the reference and guidance on testing in ITTC 7.5-02-02-01 [25]. The test results with a maximum speed of 21 knots on the Holtrop method provided a predicted calculation result of the total resistance RT of 664.2 kN with the required power of 8969.57 kW. Meanwhile, the Fung method provided a predicted calculation result of the total resistance RT of 624.4 kN with the required power of 8431.83 kW.

4 Conclusion

The results of this study are to determine the prediction of total resistance RT and powering on the Leganta 49 meter leisure boat. Resistance and power predictions are carried out on the Software Resistance software which is calculated based on the Holtrop and Fung empirical approach with varying differences ranging from ±26.3% to 6.4% in both methods respectively on the prediction of total resistance and Power. The test results with a maximum speed of 21 knots on the Holtrop method provide a predicted calculation result of the total resistance RT of 664.2 kN with the required power of 8969.57 kW. Meanwhile, the Fung method provides a predicted calculation result of the total resistance RT of 624.4 kN with the required power of 8431.83 kW.

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