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A Review of Resistance of Fishing Boat Skipjack Pole and Line

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Abstract

Skipjack Pole and Line Fishing Boat are designed and constructed to catch big pelagic fishes like tuna (Thunnus spp) and skipjack tuna (Katsuwonus Pelamis). Previous study executed by the authors found that there is no ship complete database and specific resistance method to find the resistance parameter at early design phase. The purpose of this study is to find a proper existing method of ship resistance to be applied for this kind of ship. The study began with collecting the existing ship database then developed ship geometry in Maxsuf Software in order to develop ship parameters including ship model for model test. Model test procedure was executing based on standard procedure of testing model in towing tank. The result of model test was compared to some possible methods for fishing ship resistance such as Holtrop, Guldhammer, and Yamagata Methods. Results of model test was extrapolated to full-scale ship. All the resistance data of approach methods were compared to those of model test. It was found from the study that for all range of ship speed the method Guldhammer was very close to the results of model test. Particularly at service speed around 9 to 11 knots the differences are 2% to 4%. It may be concluded from the study that Resistance Method of Guldhammer may be applied to estimate the resistance of Skipjack Pole and Line at early design phase.

Keywords: *skipjack pole and line, resistance method, model test*

1. Introduction

Skipjack Pole and Line fishing boats are designed and operated to catch big pelagic fishes such as tuna (*Thunnus spp*) and skipjack tuna (*Katsuwonus Pelamis*). This kind of boats operate in many parts of Indonesian waters due to the dispersion of tuna fishes along the region and the influence of cross Pacific-Indian Oceans as habitat of such big pelagic fishes. The catchment product of Skipjack Pole and Line will provide domestic consumption and target of international export. In fact, those boats are designed without consideration of design requirements. They are designed and constructed based on their experience and skills. A survey executed by Hetharia (2021) concluded that many *skipjack pole and line fishing* boats were not equipped by ship documents that described the performances of the boats. This issue may affect ship design parameters and lead to unsuccessful operation. One parameter considered in this study was ship resistance where this parameter will affect the engine power and fuel consumption. Some approach methods are provided for evaluating the resistance at early design phase of skipjack pole and line such as: Holtrop, Guldhammer, Yamagata, and Doust methods. However, those methods are still questioned due to the requirements of the method and limitation of ship characteristics. Unlike other transports ships, have different loading conditions during operation which are: leaving home port, arrive at fishing ground, leaving fishing ground and arrive at home base. Such loading conditions give different ship displacements and for a constant engine power this condition will give different ship speed. In other word, for a constant displacement and speed the ship will give different engine power and fuel consumption. An estimation of engine power and fuel consumption should be provided at early design stage to give an understanding of engine power and fuel consumption for ship owner and operator. To do power estimation it would be better if an approach resistance method would be applied at early design stage. This study will evaluate several approach methods and compared to the results of experimental model in order to justify which method will be suitable for *skipjack pole and line* at early design stage.

As an approach this following section give an understanding of characteristics of ship and methods. *Skipjack pole and line fishing* boat has hull form of V-type. Doust method (Doust, 1959) is appropriate for trawlers with hull form U-type. Other methods of Holtrop (Holtrop, 1992) and Guldhammer (Gulhamer, 1969) are mostly applied for transport vessels with hull form suitable for a combination of U-type and V-type. Therefore, our study make comparison of model test results to computational results based on those three methods.

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2. Theoretical Review

2.1. Skipjack Pole and Line Fishing Boat

Skipjack Pole and line fishing boats are operated to catch *Tuna and Skipjack Tuna* fishes. They use fishing gear of pole and line which is operated by one fisherman. Hull material of this ship may be marine wood or steel. Recently, this ship operated by local shipowners where hull material is Fiberglas Reinforced Plastics (FRP) due to existence at local provides. Meanwhile, marine woods are rare in the nature and strict regulations provided by environmental institutions. In addition, steel material is difficult to be found at local site and even with higher price.

3. Methodology

Main text narrative: **Times New Roman (10 pt).** This template is a summary of research results with a minimum of 5 pages. The maximum number of pages is 10, excluding references. **all section must be written in English.**

3.1. Ship and Model Data

A sample of fishing boat Skipjack Pole and Line MV. YORA 01 (Figure 1) was selected in this study.. In addition, model scale of $\lambda = 25$ was selected to represent the model dimensions. The dimensions and other characteristics of full-scale ship and the model are presented at Table 1 below

Figure 1. Full-Scale Skipjack Pole and Line Fishing Boat Yora 01

Table 1. Ship and Model Data MV. YORA 01

No	Ship Parameters		Lambda $\lambda = 25$	Ship Speed = 10 knots
		Unit	Full-Scale Ship	Ship Model

1	Length Overall, L_{OA}	m	18.85	0.75
2	Length of Waterlines, L_{WL}	m	16.26	0.65
3	Length Between Perpendiculars, LBP	m	15.21	0.61
4	Beam, B	m	4.20	0.17
5	Beam of Waterline, Bwl	m	3.30	0.13
6	Deck Height, H	m	2.01	0.08
7	Draft, T	m	1.11	0.04
8	Weight Displacement, ▲	tonnes	31.78	0.002
9	Volume Displacement, ▼	m^3	31.00	0.00198
10	Wetted Surface Area, WSA	m^2	69.24	0.11
11	Midship Area, A_M	m^2	3.18	0.0051
12	Block Coefficient, C_B	-	0.45	0.45
13	Prismatic Coefficient, CP	-	0.65	0.65
14	Midship Coefficient, CM	-	0.73	0.73
15	Longitudinal Center of Buoyancy, LCB	m	7.22	0.29

3.2. Developing of Ship Lines Plan

Lines plan of the ship was developed based on the real ship dimension before the study (Hetharia, 2022). Then the lines plan was developed based on *Maxsurf Software.* This document was developed and used to find other ship parameters, particularly in constructing the model. The lines plan of the model are presented at Figure 1.

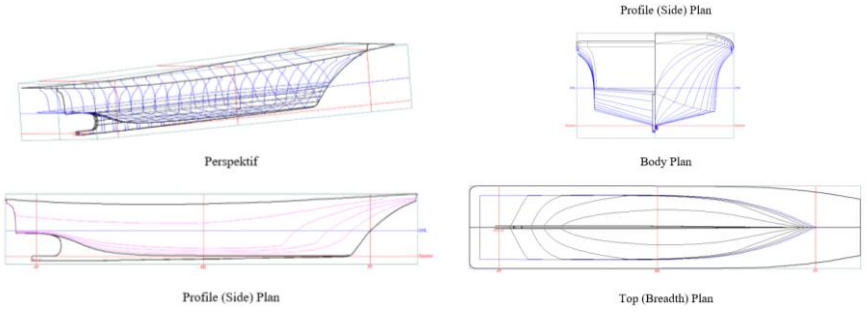


Figure 2. Lines Plan of The Model

Table 2. Parameters for Model Test

No	Parameters	Unit	Value

A	**Full-Scale Ship**	**^{o}C**	**25**
1	Sea Water Temperature		
2	Density	kg.sec^2/m^4	104,302
3	Kinematic Viscosity	m^2/sec	9,4252E-07
4	Froude Number Model, Fns	---	varied
5	Reynold Number Model, Rns	---	varied
6	Parameter $\sqrt{}$(g.L_{WL})	m/sec	12,631
7	Parameter ½ ρ S	kgf s^2/m^4	3611,13
8	Parameter L_{WL}/ ν	Sec/m	1,73E+07
B	**Ship Model**	**Unit**	**Value**
1	Fresh Water Temperature	^{o}C	20
2	Density	kg.sec^2/m^4	998,10
3	Kinematic Viscosity	m^2/sec	1,02865E-06
4	Froude Number Model, Fnm	---	Varied
5	Reynold Number Model, Rnm	---	Varied
6	Parameter $\sqrt{}$(g.L_{WL})	m/sec	407,56
7	Parameter ½ ρ S	kg s^2/m^4	3600,646
8	Parameter L_{WL}/ ν	Sec/m	44715889,76
9	Gravity constant, g	m/sec^2	9,81
10	Measured travel length, L	m	10,97
11	Correlation coefficient, CA	---	0,0004
12	Air Resistance, CAA = 0,001 (AT/S)	---	0,00021

3.3. Developing of Ship Model

Ship model was developed based on frame arrangement and covered by model cover. Lines plan edited from Maxsurf Software was applied to develop frame and hull shell of the model. Those materials are arranged and tighten by glue to construct ship model. Some added filler material was added to developed the curvature of model. Turbulence stimulator type sand stripe was attached at model hull to create laminar flow on model hull (see Figure 3, 4, and 5).

Figure 3. Development of Model Based on Frame and Plank

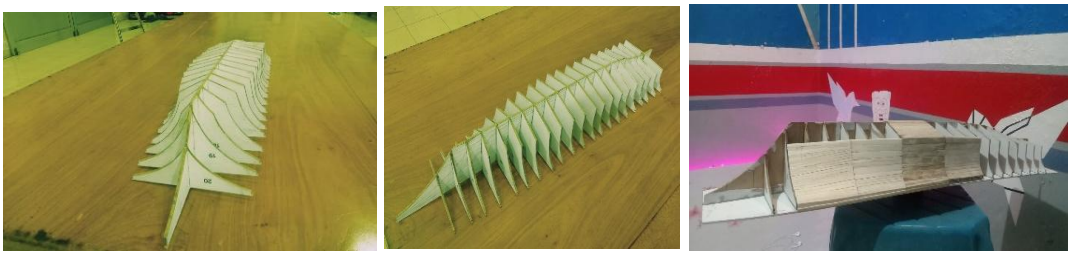


Figure 4. Arrangement of Hull Model

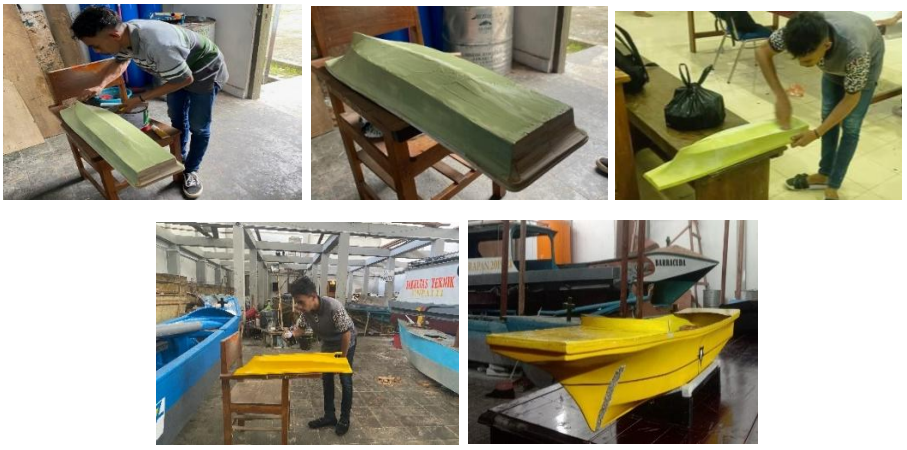


Figure 5. Developing model hull curvature

3.4. Setting-Up Model on The Towing Tank

In order to avoid mistakes in executing model test then several standard jobs should be considered as follows:

1. Setting position of towing post of model at LCB and Shaft Propeler Thrust of full-scale ship. This issue should be fit at dimension of model
2. Calibration of load cell should be executed before the test to ensure the proper record of load cell
3. All external effects of Blockage effect, Side Wall effect and shallow water effect should be avoided.
4. A turbulence stimulator should be added to create turbulence flow as it in full-scale ship.
5. Running the model should be at calm water where this will take time between the running,

Several documents of setting-up model are presented at Figure 6 to Figure 8.

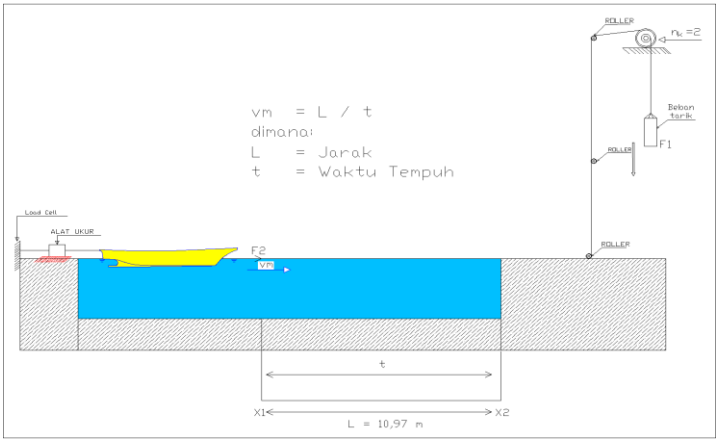


Figure 6. The System of Falling Weight for Model Test

Figure 7. Setting-Up The Model

Figure 8. Model Test is Underway

4. Result and Discussion

4.1. Results of the Study

The model was tested at Towing Tank of Faculty of Engineering, Pattimura University. The measurement of distance, time and force were executed manually. Travel distance was set for 15 meters and net distance was set for 0.8 times travel distance for constant speed after subtracting initial acceleration and final deceleration. Time travel was measured by using stopwatch. Resistance force was measured by using falling weight after reducing some frictional factors affected by rollers of the system.

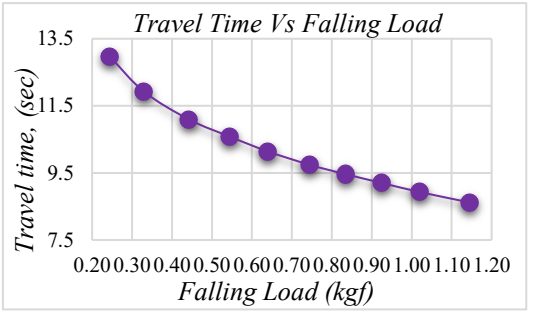


Figure 3. Curve of Travel Time vs Falling Load

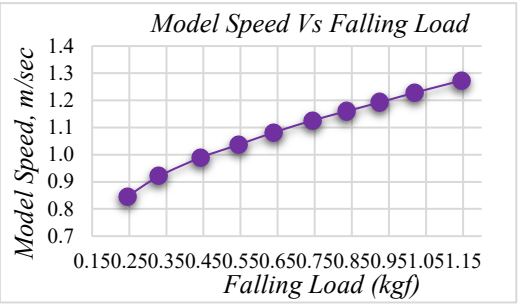


Figure 4. Curve of Model Vs Falling Load

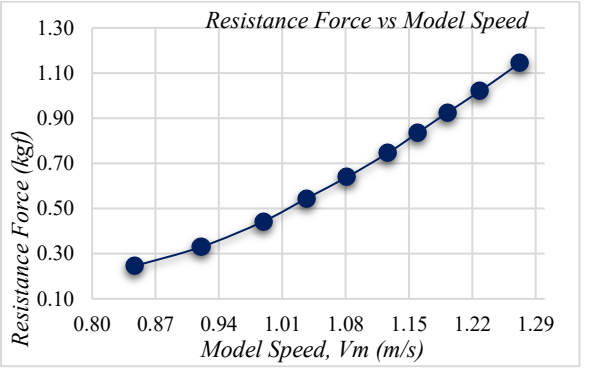
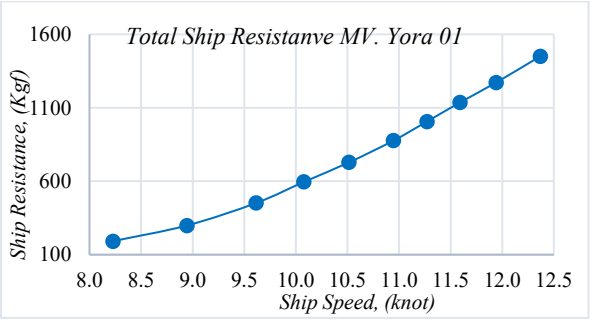
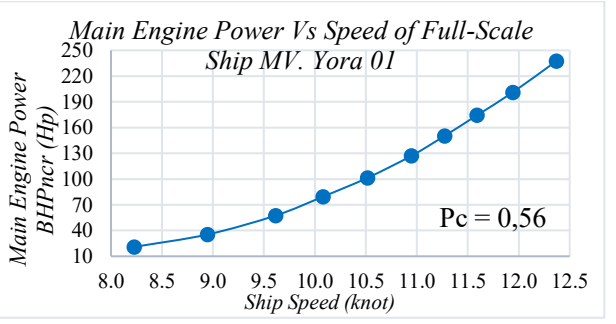


Figure 5. Model Resistance Vs Model Speed

Total resistance and Main Engine Power (BHP_{NCR}) of full-scale ship is presented at Figure 6



(a. Total Resistance)



(Main Engine Power, BHP_{NCR})

Figure 6. Full-Scale Ship Resistance MV. Yora 02

The resistance of model test was compared to result of three approach methods which are Holtrop, Guldhammer and Yamagata is presented at Figure 8. Meanwhile Figure 9 presents the comparison of ship main engine power based on the result test to those of three approach methods.

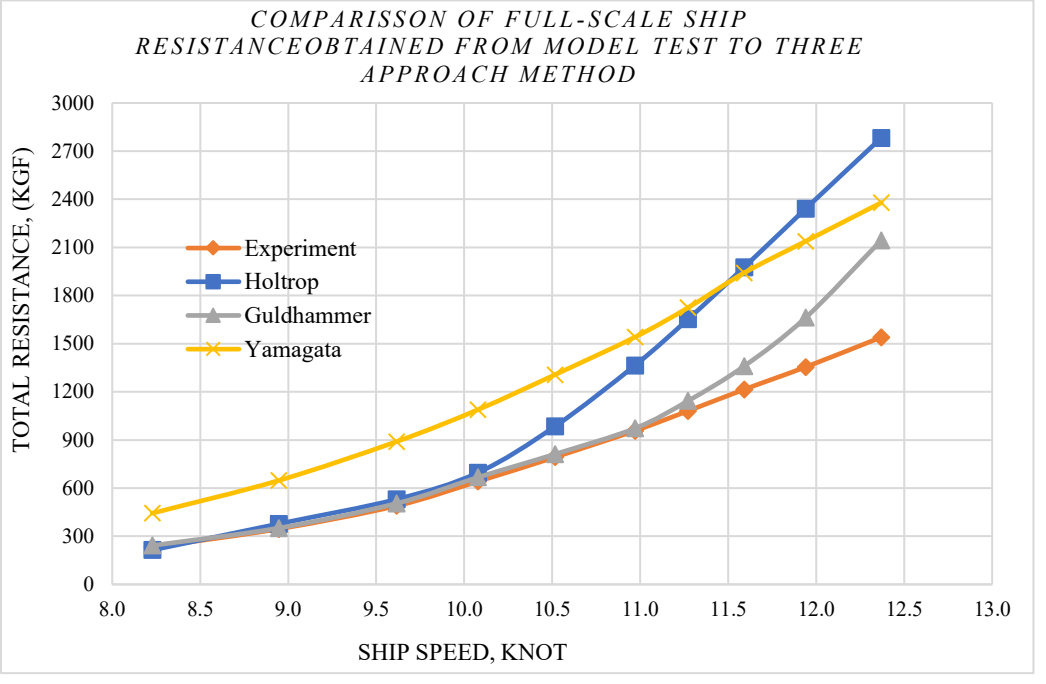


Figure 8. Full-Scale Ship Resistance of Four Approaches

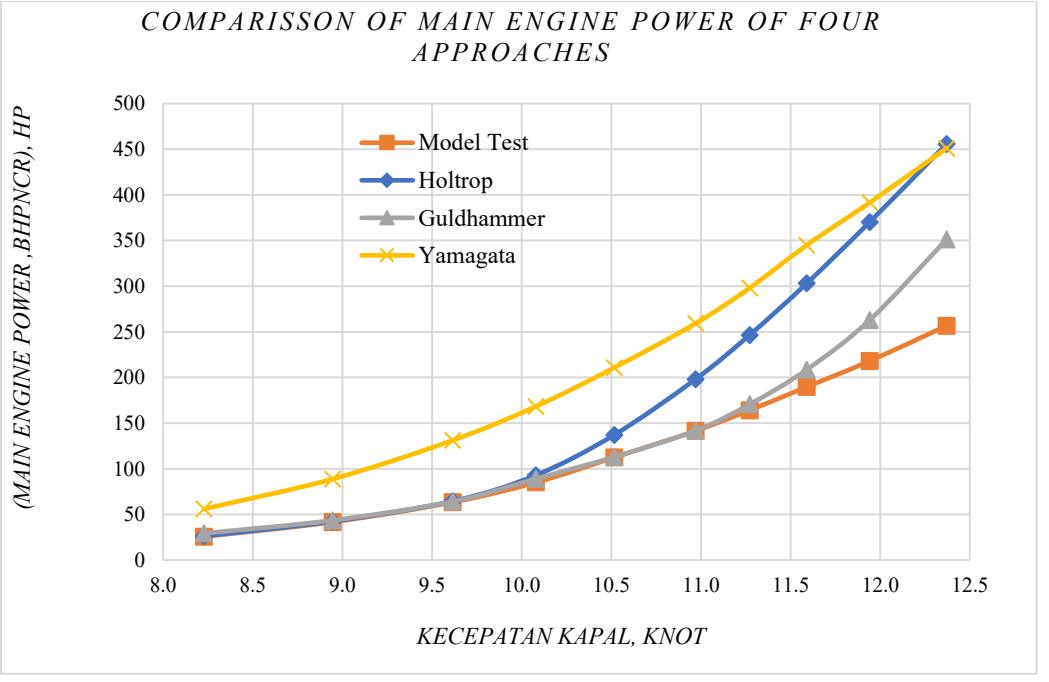


Figure 9. Full-Scale Main Engine of Four Approaches

Table 3. Comparison of Full-Scale Ship Resistance

No	Comparison of Resistance	Unit	Ship Speed, knot						
			8.23	*8.95*	*9.61*	*10.08*	*10.52*	*10.97*	*11.27*
1	Holtrop / Model Test	%	7.52	8,42	7.71	7.83	19.48	29.83	34.59
2	Gulhammer / Model Test	%	4,37	**1.57**	**2.98**	**3.85**	**2.32**	**1.50**	5.49
3	Yamagata / Experiment	%	91.58	46.62	45.00	41.07	39.33	37.86	37.33

4.2. Discussion

The results of resistance ship model *Skipjack Pole an Line* Yora 02 was compared to three approach methods which are Holtrop, Guldhammer and Yamagata. It was seen that those three approaches methods give difference results in number as well as trend curves. In general, it may be said that those three approach methods have limitation of defining ship geometry and dimensions. In addition, the definition of hull form of fishing boat may be differs from the kinds of hull form of U-type compared to V-Type applied for Skipjack Tuna Pole and Line which designed for hunting fast fish combined to cargo to store caught fishes.

From the existing results, there are some comments as discussed below:

1. Experiment of model test was executed based on standard model test where the results were acceptable.
2. Those four approaches (model test and three methods) are in appropriate curve trendline except Holtrop method is little bias at ship speed above 11 knots.
3. All comparison of model test to the approach model presented at Table 3 for all range of ship speed gives a general comment of Holtrop and Yamagata methods give large difference to the model test meanwhile, Guldhammer method give small difference especially at service speeds 9 to 11 knots.

5. Conclusion and Recommendation

5.1. Conclusion

Results of the study conclude:

1. Three approach methods give similar trend resistance curve of *Skipjack Pole and Line Fishing* boat however, Guldhammer method give less difference of result compared to that of model test
2. For a close range of service speed around 10 knots (9 to 11 knots) the difference of model test result compared to Guldhammer method the difference is 2 % to 4 %.
3. It may be conclude that an approach resistance method for Fishing boat Skipjack Pole and Line is Guldhammer method.

5.2. Recommendation

1. A method applied to estimate resistance force of Fishing Boat Skipjack Pole and Line at early design phase is Guldhammer Method.

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