International Journal of Marine Engineering Innovation and Research, Vol. 8(2), Jun. 2023. 351-359
(pISSN: 2541-5972, eISSN: 2548-1479)

Analysis of Performance Losses Related to Shaft Angle on Fishing Boats Using the Free Running Model Test Method

Aang Wahidin[1], Rachmad Tri Soelistijono[2], Fitri Hardiyanti[3], Lilik Subiyanto[4], Gaguk Suhardjito[5], Subagio So'im[6]

(Received: 20 March 2023 / Revised: 19 April 2023 /Accepted: 03 May 2023)

***Abstract*— Several traditional fishing boats in Sendang Biru, Malang Regency are of the sekoci type using an inboard engine drive system with the position of the propeller shaft installed at an angle to the ship's base line. Based on the theory can reduce the performance of the ship propulsion system up to (2-3)%. In this research, we analyzed how much performance was lost/decreased on the lifeboat type fishing boats installed above. The method we use is the Free Running Model Test by making a model of a traditional fishing boat type of lifeboat with a model size of Loa = 100 cm, Lwl = 80.72 cm, B = 19.7 cm, H = 10.68 cm and T = 5, 08 cm made of aluminum sheet. The Free Running Model Test uses 1 motor and propeller which has a thrust of 60 watts, remote control equipment uses the main component of the NRF24L01 transceiver which works at a frequency of 2.4 Ghz with a range of 240 meters to 1 kilometer with conditions without obstacles and camera equipment drone to record the track. The results of this study show that there is a decrease/loss of performance at a 3-degree angle of 0.24%, at a 5-d. gree angle of 0.49%, at a 10-degree angle of 2.52%, at a 15-degree angle of 4.41% and at an angle of 20 degrees of 6.48%.**

Keywords—mover; propeller shaft; angle (angle).

I. INTRODUCTION

Ship shafting system is the indispensable component of a ship power plant. The primary function of a ship shafting system is to carry out energy transfer from marine engine to propeller, transmit axial thrust produced by the rotation of propeller to the hull, and drive the ship ahead [15]. An accurate estimation of ship speed loss is required to verify ship propulsion performance in actual sea conditions [10]. A correct assessment of the ship speed loss in conditions of exploitation is becoming increasingly important for ship owners as well as ship designers [11]. Prediction of speed loss of ocean-going vessels is important for ship design, fuel consumption and 'sea margin' evaluation [13]. Most of the small crafts and navy ships are equipped with propellers mounted on inclined shafts as thrusters. In spite of its importance, the information on the forces generated by inclined shaft propellers is scarce [7]. Some traditional lifeboat type fishing boats use an internal propulsion system with the position of the propeller shaft mounted at an angle to the ship's base line. According to S.W Adji (2005) in a paper entitled Engine Propeller Matching the position of the ship's propeller shaft can reduce the performance of the ship's propulsion system by up to (2-3)% [2]. The most optimal conditions are on the rake of the propeller shaft 4 [5]. This can be the cause of reduced fishermen's income because ship operating costs increase due to decreased ship performance. So that there is a contradiction between the fishing potential in Sendang Biru and the welfare of the fishermen because there is a potential for a decrease in ship performance when carrying out fishing activities.

The potential for capture fisheries on the south coast of East Java is relatively large because the coast is directly connected to the Indian Ocean. East Java's southern coast stretches from Pacitan district to the Banyuwangi coast. Where fishing centers are in each district. In Malang Regency there is the largest fish landing center, namely Sendang Biru. And there are several types of traditional fishing boats as a means of catching fish. The potential for fish in the waters of southern Malang is relatively large, with the potential for marine fisheries production reaching 26,066.2 tons of fish per year. The fishing vessels in Sendang Biru are the lifeboat and payang vessels with aring purse seine and long line assisted by FADs. Some traditional lifeboat type fishing boats use an internal propulsion system with the position of the propeller shaft mounted at an angle to the ship's base line. According to S.W Adji (2005) in a paper entitled Engine Propeller Matching the position of the ship's

Aang Wahidin is with Departement of Shipbuilding Engineering, Surabaya State Shipbuilding Polytechnic, Surabaya, 60111, Indonesia. E-mail: aangwahidin@ppns.ac.id
Rachmad Tri Soelistijono is with Departement of Shipbuilding Engineering, Surabaya State Shipbuilding Polytechnic, Surabaya, 60111, Indonesia. E-mail: rachmad_tri@ppns.ac.id
Fitri Hardiyanti is with Departement of Shipbuilding Engineering, Surabaya State Shipbuilding Polytechnic, Surabaya, 60111, Indonesia. E-mail: fitrihardiyanti@ppns.ac.id
Lilik Subiyanto is with Departement of Electrical Engineering, Surabaya State Shipbuilding Polytechnic, Surabaya, 60111, Indonesia. E-mail: llksubiyanto@ppns.ac.id
Gaguk Suhardjito is with Departement of Shipbuilding Engineering, Surabaya State Shipbuilding Polytechnic, Surabaya, 60111, Indonesia. E-mail: gaguksh@gmail.com
Subagio So'im is with Departement of Marine Engineering, Surabaya State Shipbuilding Polytechnic, Surabaya, 60111, Indonesia. E-mail: bagiosoim@gmail.com

Figure. 1. The Sendang Biru traditional fishing boat is a lifeboat type with the installation of a propeller shaft forming an angle (angel)

propeller shaft can reduce the performance of the ship's propulsion system by up to (2-3)%.

II. METHOD

The method or way to achieve the research objective is to obtain performance losses on traditional fishing vessels, the lifeboat type in Sendang Biru, Malang Regency.

This can be the cause of reduced fishermen's income because ship operating costs increase due to decreased ship performance. So that there is a contradiction between the fishing potential in Sendang Biru and the welfare of the fishermen because there is a potential for a decrease in ship performance when carrying out fishing activities.

by making a lifeboat model with fiberglass (FRP) material where the model is made as similar as possible to the original condition. By placing the propulsion system in a lifeboat type fishing boat model, the angle of the propeller shaft can be adjusted (adjustable) in size. Furthermore, with remote control, the ship model can be run and the model system is also connected to a computer. With this method, the performance of the fishing boat model can be known from the data recorded on the computer. In this study, the analysis of performance loss related to the angle of the propeller shaft when installed on a traditional fishing boat of the lifeboat type in Sendang Biru, Malang Regency, forms

Figure. 2. “Lifeboat” type traditional fishing boat, in Sendang Biru Malang Regency.

In this study we want to analyze how much performance is decreased/lost in lifeboat-type fishing boats that install propulsors at an angle to the base line. The method we use to analyze the possible loss of propulsion system performance on traditional lifeboat-type fishing vessels is the Free Running Model Test method. Where the method is by placing electronic equipment connected to a computer wirelessly and can be controlled remotely. To obtain ship performance data

an angle of 0^0, 3^0, 5^0, 10^0, 15^0 and 20^0.

The purpose of this study was to determine the magnitude of the loss in performance of traditional fishing boats of the lifeboat type in Sendang Biru, Malang Regency where most of these types of vessels install their propulsion system at an angle (angel) to the ship's base line. What we want to know about the possible loss in the performance of the fishing boat is

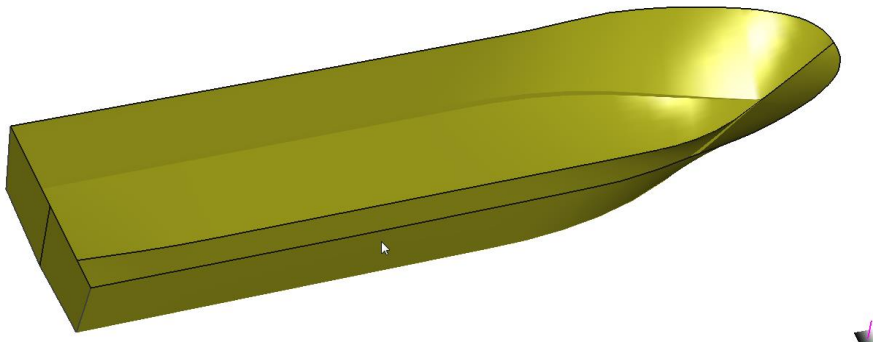

Figure. 3. Prototype hull design

related to the performance of the boat's speed and the activities at each stage of the research are as follows.

a. DC motors

The motors used for testing are 2 (two) DC electric motors, each of which drives 1 (one) propeller. This type of driving motor is a motor that is commonly used in RC (Radio Control) racing, brushless DC motors.

It is easy to use to record position data to SD memory card. The required operating voltage source is 5V / 3.3V compatible voltage making it compatible with Arduino boards, Leafmaple, IFlat32 and other compatible Arduino boards.

TABLE 1.
SHIP OF PRINCIPAL DIMENSION DATA AT SENDANG BIRU, MALANG

Principal Dimension	Ship 1	Ship 1	Ship 1
LOA (m)	13.5	17.5	15.8
B (m)	2.7	2.897	2.64
H (m)	1.6	1.37	1.28
T (m)	0.703	0.7	0.65
Displacement (ton)	7.88	12.52	9.4

b. NRF24L01 Remote Control Module

The remote control equipment uses the main component of the NRF24L01 transceiver which operates at a frequency of 2.4 GHz with a range of 240 meters to 1 kilometer under unhindered conditions.

c. Camera Drones

Arduino GPS shield GPS module breadout board designed Global Positioning System receiver with SD interface.

d. Propeller (Propeller)

The propellers used are those that are usually used by traditional fishermen.

e. Rudder

The shape and size of the rudder are adjusted to those used by traditional fishermen.

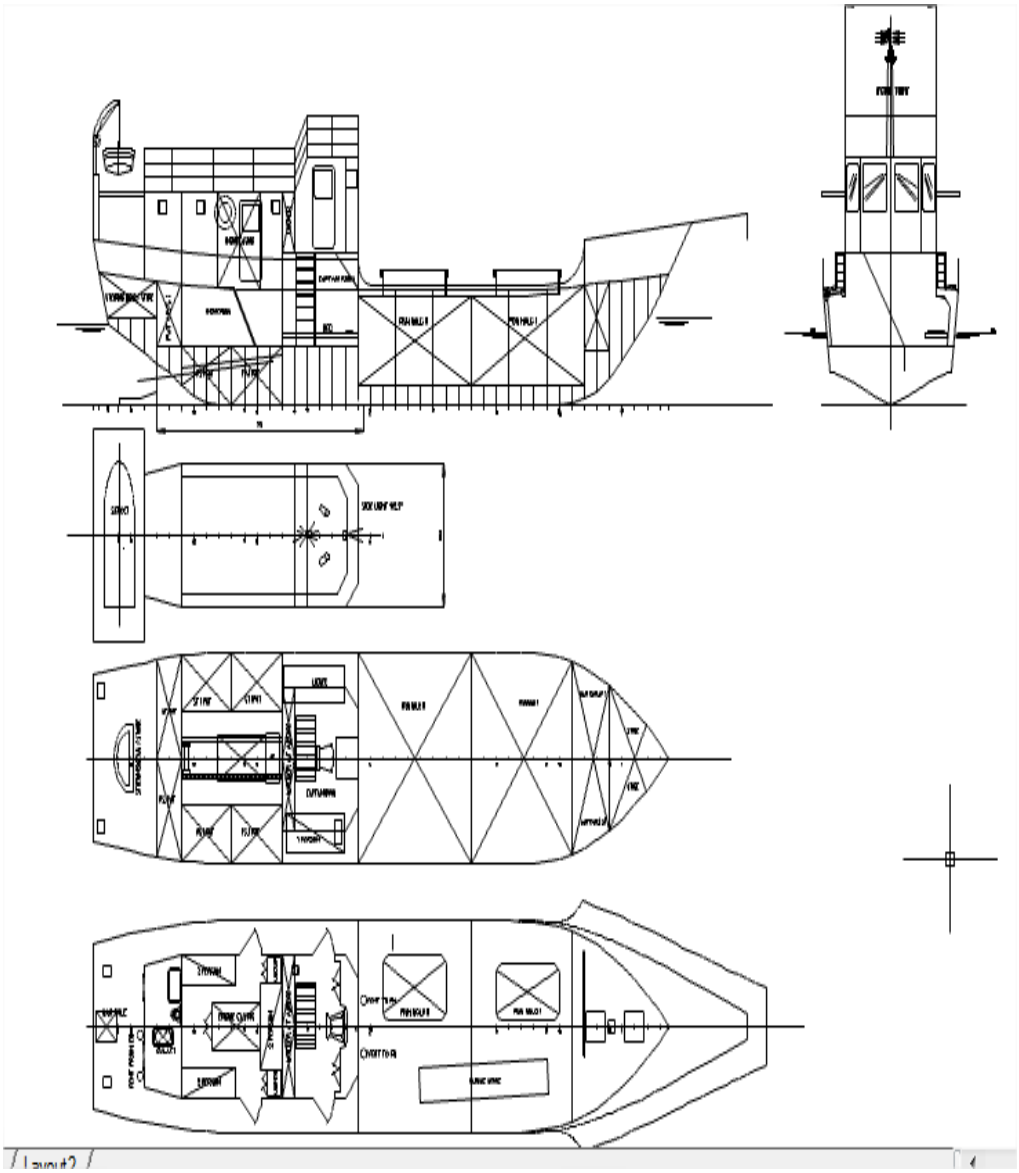

Figure. 4. Prototype hull design

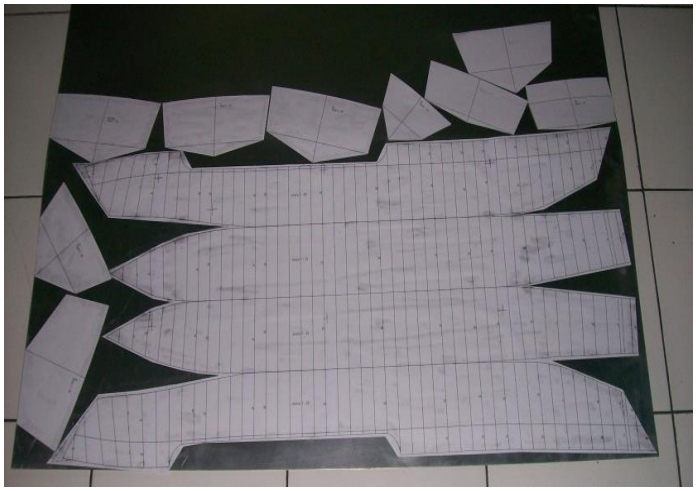

Figure. 5. Cutting construction component

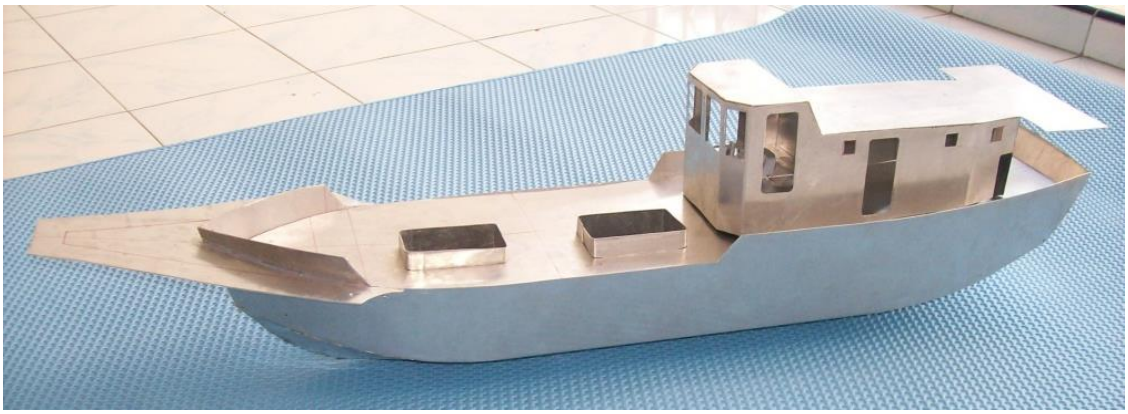

Figure. 6. Assembly of construction components

Figure. 7. Model free running model test

Figure. 8. Implementation of ship speed testing

III. Results and Discussion

A. Survey Data

The results of the survey data carried out on site to obtain the hull shape for the test model are as follows in figure 5. In Sendang Biru, there are 2 types of traditional fishing boats in this area. The first is a fishing boat that uses outriggers on the right and left sides of the ship and the second is a fishing boat without outriggers with an engine position inside which is familiarly called the ship's name 'lifeboat'.

B. Test Model Design (Free Running Model Test)

Based on the comparison of the main sizes above, the ideal ship size with a total length of 22 meters is as follows:

Lwl = 20.18 meters
B = 4.94 meters
H = 2.67 meters
H = 1.27 meters
Vs = 12 knots

The following is an overview of the prototype design of traditional fishing boats in the Prigi, Trenggalek and Sendang Biru areas, Malang. Which will be used for making the Free Running Model Test test model.

C. Making the Free Running Model Test Model

The test model was made of aluminum plate material with a thickness of 1 mm with the following hardening steps. After the construction components are cut, it is continued with the assembly of the construction components, resulting in the following model shape.

D. Making the Components for the Free Running Model Test

The propulsion of the model uses 1 motor and propeller which has a thrust of 60 watts. The remote control equipment uses the main component of the NRF24L01 transceiver which works at a frequency of 2.4 Ghz with a range of 240 meters to 1 kilometer with conditions without obstruction. To vary the angle of the propeller shaft, it is done by adjusting (adjustable) the propeller shaft. To record the test trajectory using the free running model test method, it can be recorded on a computer using a camera drone.

The results of assembling all the hull components and the automatic control drive equipment then realized the test model of a traditional fishing boat, the lifeboat type, as the Free Running Model Test model.

TABLE 2.
SHIP SPEED TEST RESULT DATA

Propeller Shaft Angle (Degrees)	Mileage (m)	Traveling time (s)	Speed (m/s)
0^0	1,8	4	0,45
3^0	1,8	4,0096	0,449
5^0	1,8	4,02	0,448
10^0	1,8	4,10	0,439
15^0	1,8	4,18	0,431

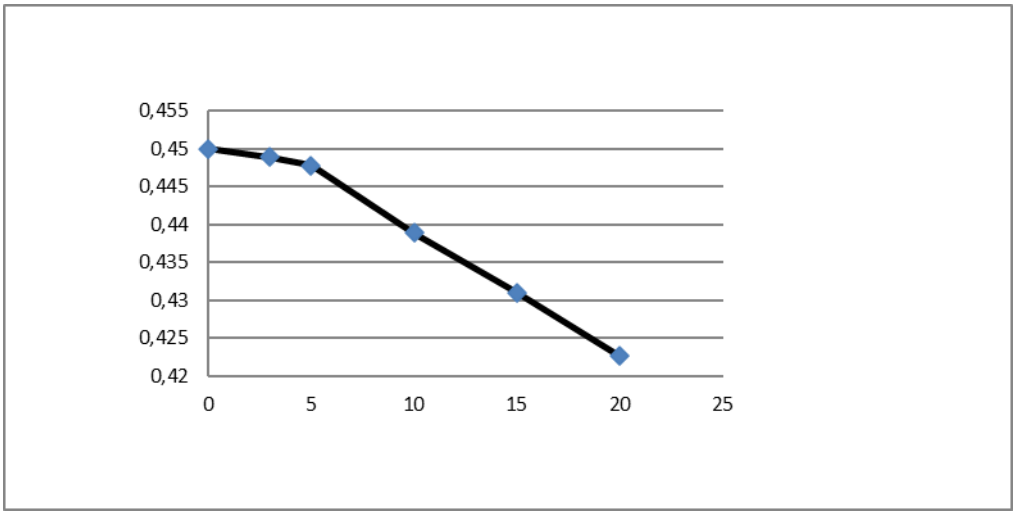

Figure. 9. Ship speed performance graph

Figure. 10. Implementation of circular motion testing (turning circle)

TABLE 3.
SHIP SPEED TEST RESULT DATA

Propeller Shaft Angle (Degrees)	Mileage (m)	Traveling time (s)	Speed (m/s)
0^0	2,89	17,00	0,54
3^0	2,90	17,08	0,53
5^0	2,91	17,17	0,53
10^0	2,97	17,88	0,52
15^0	3,02	18,57	0,51

Implementation of the Free Running Model Test

1. Ship Speed Performance Testing.

Testing on the test model using the free running model test method was carried out to obtain the performance of the ship's speed at the angle of the propeller shaft when installed on a traditional lifeboat type fishing boat of: 0^0, 3^0, 5^0, 10^0, 15^0 and 20^0.

The performance results of the ship's speed at the angle of the propeller shaft when installed on a traditional fishing boat of the lifeboat type are: 0^0, 3^0, 5^0, 10^0, 15^0 and 20^0 can be visualized with the following graph.

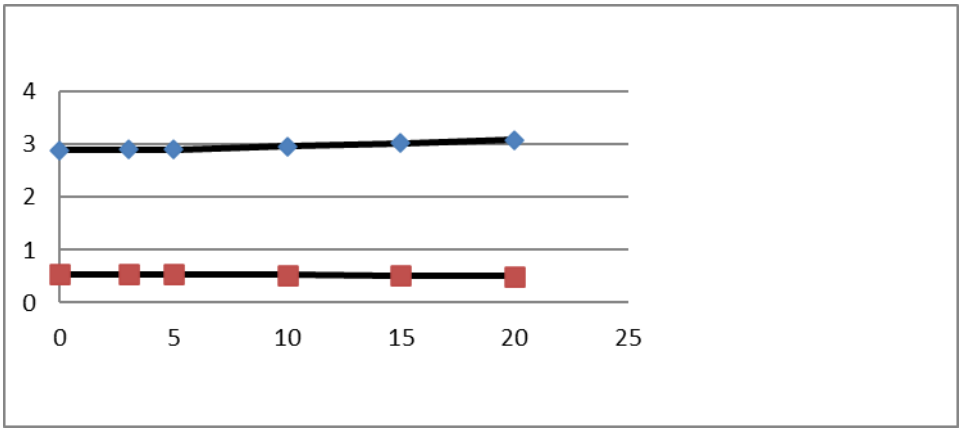

Figure. 11. Graph of the ship's turning circle performance for 35^0 turns

2. Circular Motion Performance Testing (turning circle)

Testing on the test model using the free running model test method was carried out to obtain the ship's turning circle performance by moving the rudder angle 350 to the left and 350 to the right, at the angle of the propeller shaft when installed on a traditional fishing boat of the lifeboat type. of: 0^0, 3^0, 5^0, 10^0, 15^0 and 20^0.

The performance results of the ship's turning circle by moving the rudder angle 35^0 to turn left and 35^0 to turn right, at the angle of the propeller shaft when installed on traditional fishing boats of the lifeboat type are: 0^0, 3^0, 5^0, 10^0, 15^0 and 20^0 can be visualized with the graph as follows in figure 12.

IV. Conclusion

With a test model made of 1 mm thick aluminum with model sizes Loa = cm, Lwl = 80.72 cm, B = 19.7 cm, H = 10.68 cm and T = 5.08 cm. The model is equipped with 1 motor and propeller which has a thrust of 60 watts. The remote control equipment uses the main component of the NRF24L01 transceiver which operates at a frequency of 2.4 GHz with a range of 240 meters to 1 kilometer under unhindered conditions. As well as assisted by drone cameras to record the test trajectory with the free running model test method so that it can be recorded on a computer. Based on the tests carried out on the free running model test, this research found that there was a decrease/loss of ship speed and turning circle performance at an angle of 3 degrees by 0.24%, at an angle of 5 degrees by 0.49%, at an angle of 10 degrees is 2.52%, at an angle of 15 degrees is 4.41% and at an angle of 20 degrees is 6.48%.

Acknowledgements

We thank the Surabaya State Shipbuilding Polytechnic (PPNS) through P3M for providing funding for this research. And to the head of the non-metal laboratory and Cadd laboratory who have supported the implementation of this research.

References

[1] J S Carlton Marine Propellers and Propulsion Second Edition, ISBN: 978-07506-8150-6, Global Head of Marine Technology and Investigation, Lloyd's Register, Butterworth-Heinemann is an imprint of Elsevier, Linacre House, Jordan Hill, Oxford OX2 8DP, 30 Corporate Drive, Suite 400, Burlington, MA 01803, USA, Copyright © 2007, John Carlton. Published by Elsevier Ltd. All right reserved

[2] Adji, Suryo W. 2005. *Engine Propeller Matching* (online) http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CC8QFjAA&url=http%3A%2F%2Fml.scribd.com%2Fdoc%2F38994571%2F4-195SuryoAdjiENGINEPropellerMatching&ei=ogWUcecJ4rlrAe0zoBQ&usg=AFQjCNELIzHyP3j5PhGF_dohVdCU8xZAGw&sig2=9iJRediN9eaR9aZN3dsQ&bvm=bv.46751780,d.bmk

[3] Harvald, A, 1988. *Tahanan dan Propulsi Kapal.Airlangga Press, Surabaya*.

[4] Ji-Woong Lee, Quang Dao Vuong, Byongug Jeong and Jae-ung Lee, "Change in Propeller Shaft Brhavior by Fluctuating Propeller Force During Ship Turning", applied sciences MDPI, Published: 17 May 2022

[5] Agoes Santoso, Irfan Syarief Arief , Ngizuddin Masro'i , Semin "Effect of Main Engine Placement and Propeller Shaft Inclination on Ship Performance", *International Journal of Marine Engineering Innovation and Research, Vol. 6(1), Mar. 2021. 53-64, (pISSN: 2541-5972, eISSN: 2548-1479)*

[6] Xiao Lang, Wengang Mao"A semi-empirical model for ship speed loss prediction at head sea and its validation by full-scale measurements" *Department of Mechanics and Maritime Sciences,* Ocean Engineering 209 (2020) 107494, journal homepage:www.elsevier.com/locate/oceaneng

[7] A Lungu" Hydrodynamic loads and wake dynamics of a propeller working in oblique flow " (2020) IOP Conf. Ser.: Mater. Sci. Eng. 916 012055

[8] Xiao Lang & Wengang Mao " A Practical Speed Loss Prediction Model at Arbitrary Wave Heading for Ship Voyage Optimization" Journal of Marine Science and Application, https://doi.org/10.1007/s11804-021-00224-z, Received: 17 December 2020 / Accepted: 27 April 2021

[9] Shukui Liu, Baoguo Shang and Apostolos Papanikolaou "On the resistance and speed loss of full type ships in a seaway", SHIP TECHNOLOGY RESEARCH (SCHIFFSTECHNIK) https://doi.org/10.1080/09377255.2019.1613294, Received 28 November 2018, Accepted 25 April 2019

[10] Haruka NAKANO, Kentaro, KUROKI, Yoshiko SATO, Masahiro MAEDA, Kuniaki MATSUURA "Ship speed loss estimation using wave spectrum of encounter" 978-1-5386-1654-3/18/$31.00 ©2018 IEEE

[11] Jasna Prpic-Oršic, Kenji Sasa, Marko Valcic, Odd Magnus Faltinsen " UNCERTAINTIES OF SHIP SPEED LOSS

EVALUATION UNDER REAL WEATHER CONDITIONS" Proceedings of the ASME 2018 37th International, Conference on Ocean, Offshore and Arctic Engineering, OMAE2018, June 17-22, 2018, Madrid, Spain OMAE2018-78514

[12] Mingyu Kim, Olgun Hizir, Osman Turan, Sandy Day, Atilla Incecik "Estimation of added resistance and ship speed loss in a seaway" Ocean Engineering journal homepage: www.elsevier.com/locate/oceaneng, Available online 27 June 2017

[13] Zhenju Chuang, Sverre Steen " Prediction of Speed Loss of a Ship in Waves" Second International Symposium on Marine Propulsors smp'11, Hamburg, Germany, June 2011

[14] Mingyu Kim, Olgun Hizir, Osman Turan, Sandy Day, A Study on Ship Speed Loss due to Added Resistance in a Seaway, Final officia lISOPE 2016 conferencepaper

[15] Kai Chen, Xincong Zhou, Li Qin, Xuan Zhao "Theoretical research of power flow on ship shafting systems" The 3rd International Conference on Transportation Information and Safety, June 25 – June 28, 2015, Wuhan, P. R. China

[16] Zhiquan Liu, Hongzhang Jin, Michael John Grimble, Reza Katebi "Ship roll stabilization control with low speed loss" 978-1-4799-3646-5/14/$31.00 ©2014 IEEE

[17] So-Yeon Kim, Young-Doo Yoon, *Student Member, IEEE*, and Seung-Ki Sul, *Fellow, IEEE, "*Suppression of the Thrust Loss for the Maximum Thrust Operation in the Electric Propulsion Ship", 1-4244-0947-0/07 $25.00 © 2007 IEEE.

[18] Jinhyun Kim, Jonghui Han, Wan Kyun Chung and Junku Yuh "Accurate Thruster Modeling with Non-Parallel Ambient Flow for Underwater Vehicles" (2005)

[19] J. U. Duncombe, "Infrared navigation—Part I: An assessment of feasibility," IEEE Trans. Electron Devices, vol.ED-11, pp. 34–39, Jan. 1959.

[20] M. Nur Habib, E. R. de Fretes, S. T. A. Lekatompessy, (2021) pengaruh kemiringan poros baling-baling terhadap kecepatan perahu ketinting. Proseding seminar nasional "ARCHIPELAGO ENGINEERING" 2021, p-ISSN 2620-3995, e-ISSN 2798-7310

[21] Ahmad Munawir, Gatut Rubiono, Haris Mujianto, 2017. *Studi Prototipe Pengaruh Sudut Kemiringan Poros Baling-Baling Terhadap Daya Dorong Kapal Laut* (online). Jurnal V-Mac, Vol 2 No 1:18-24, 2017, ISSN 2528-0112.

[22] Budi Utomo, 2012. *Peranan Baling-Baling Pada Gerakan Kapal* (Online). Jurnal Vol. 33 No.2 Tahun 2012, ISSN 0852-1697.