ASRO JOURNAL
http://asrojournal-sttal.ac.id/index.php/ASRO

Volume 15, Number 02, pp.1-9
April-June 2024
ISSN: 2460-7037
E-ISSN: 2722-5763

THE ANALYSIS OF THE INFLUENCE OF MODIFICATION OF BOW DESIGN WITH AXE BOW TYPE ON TOTAL RESISTANCE ON 60 METER FAST MISSILE SHIPS

Wawan Kusdiana[1], Aris Tri Ika[2], Valentinus Yudo[3], Abdul Rahman[4], Syaifi[5]

[1,2,3,4,5]*Naval Technology College, Bumimoro-Morokrembangan, Surabaya 60187, Indonesia*
wawan@sttal.ac.id

DOI: https://doi.org/10.37875/asro.v15i02.545

Manuscript received 31st March 2024, Revised 12nd April 2024, Published 19th April 2024

ABSTRACT

The bow of the ship is an important part in the design of the ship, as is the bow of the KCR-60, because it is the part that experiences the greatest pressure, stress from the crashing waves, with the Axe Bow bow design which has a bow profile like an axe, the slender shape of the waterline is able to reduce impacts. waves, increase the efficiency of the inflow rate, reduce the resistance the ship receives, resulting in better speed. This research changes the Conventional Bow KCR-60 design into the Axe Bow design concept and calculates the total resistance of the Axe Bow design numerically using the Holtrop method and carries out comparative analysis using the MARIN DESPPC 1999 computing program and Maxsurf Resistance V8i software. The results of this research show that the total resistance value of the KCR-60 Axe Bow bow type at a speed of 28 Knots is 364.2 kN and the Conventional Bow type is 374.5 kN, a difference of 10.3 kN which is 2.75% smaller than the Conventional Bow type in the analysis. Maxsurf Resistance V8i software comparison. For comparative analysis of the 1999 MARIN DESPPC program, the total resistance value of the KCR-60 Axe Bow concept at a speed of 28 Knots is 283.6 kN and the Conventional Bow type is 288.1 kN, the difference is 4.5 kN, 1.56% smaller than the Conventional type Bow.

Keywords: *KCR-60, Axe Bow, MARIN DESPPC 1999, Holtrop.*

1. INTRODUCTION

The Indonesian Navy has collaborated with PT. PAL to build 20 units of 60 Meter Fast Missile Boats (KCR-60) (tribunnews, 2018) and by 2019 4 units of KCR-60 have been built. The existence of the KCR-60 has a very strategic role in carrying out the task of protecting the sovereignty of the territorial waters of Republic of Indonesia. In accordance with operational requirements, the KCR-60 is a warship that is prepared to be able to act as a fast patrol ship as well as a combatant ship (search and destroyer of enemy surface ships), which has high speed and agile maneuverability and can be operated optimally in the archipelagic warfare theater (Hardjono, 2017).

Warship is a KCR-60 unit that is operational but has not been able to reach maximum speed. According to calculations from the PT. PAL shipyard/yard using a shaft power (PS) of 5396 kW at a draft of 2.4 m, the maximum speed of the KCR-60 can reach 28 knots. However, based on the results of the draft condition of 2.4 m and the use of 100% MCR engine power (PB=5760 kW, PS=5702.4 kW) this ship was not able to reach a maximum speed of 28 knots. The maximum speed of the KCR-60 in these conditions only reached 23.3 knots (Akhmat Nuryadin, Sekolah Tinggi Tekhnologi Angkatan Laut, 2015). The maximum speed of the Warship has not been achieved, possibly due to several things, namely: errors in designing the hull and bow of the ship (Bow) which resulted in relatively greater ship resistance, the installed engine power did not match the ship's propulsion power requirements, the propeller installed is not able to distribute all the power from the engine, errors in engine propeller matching

Achieving the maximum speed of a ship (according to initial construction requirements) is an important factor as well as a parameter/benchmark for the success of building a ship, so that in the ship design process it is necessary to take into account the resistance of the ship and how much power the propulsion engine will use. To get maximum results, the construction of a ship requires accurate power predictions through model tests and numerical calculations via software or manual calculations.

Volume 15, Number 02, pp.1-9
ISSN: 2460-7037
E-ISSN: 2722-5763

However, this calculation will give rise to several problems, including analysis of resistance, selection of appropriate and optimal engine power and in accordance with ship resistance, analysis of engine propeller matching (Akhmat Nuryadin, 2015), selection of ship hull design and type design. the right bow of the ship in this case Bow Type. These things can support increasing the effectiveness of ship shipping activities both in terms of fuel consumption/usage to the effectiveness of shipping time due to achieving the desired ship speed. Due to the problem of not meeting the maximum speed of the KCR-60 Warship when carrying out operations, the author wishes to study further the above problems related to bow type selection and in this research the author will only concentrate on research and analyzing the The bow of the ship, especially the design of the ship's bow, includes the stem or bow type design.

The shape of the bow for fast boats is mostly in the form of a slanted bow (conventional bow), in the current era designs are starting to be developed for the bow of ships in the form of an upright or vertical bow (axe bow). The ax bow type ship is a development of the enlarged ship concept innovation which was designed and developed in 1995 by Delft University and Damen Shipyard. The axe bow concept itself is a redesign of the shape of the ship's bow which in its research and development is known to provide a lower resistance value compared to a bow without an axe bow design (Romadhoni, 2016).

2. LITERATURE REVIEW

2.1 State of the art

The Axe Bow concept is a concept that redesigns the shape of a ship's bow, which in previous research can provide a lower resistance value compared to a bow without an Axe Bow shape. The analysis was carried out on six degrees of freedom, especially vertical movements, namely heaving, pitching and rolling on regular waves which are presented in the Response Amplitude Operator (RAO's) graph. By entering the speed and wave angle variation parameters, namely 0°, 45°, 90° and 180°, the graph can see the sub-critical, critical and very critical values for each movement. Calculations were carried out with the help of Seakeeper ver.13 computing software, (Romadhoni, 2016).

A 48 meter utility vessel using the axe bow type can reduce resistance by 1.23% using the holtrop method and can reduce fuel consumption by 40 liters/hour. Analysis of the application of the axe bow type is not only good in reducing resistance but also good in terms of ship stability, this is proven by meeting IMO chapter 3 regulations (Prastyawan, 2013), (Oni, 2015).

By using two types of ship bow models, including the A model ship bow shape and the B model ship bow shape, it is hoped that we can compare the efficiency points when the ship carries out turning circle maneuvers. This prototype ship is equipped with devices such as an electric drive system, propeller and also a rudder drive system. All instrument components are completely integrated in the prototype vessel. Tests were carried out in the maneuvering ocean basin at the Hydrodynamics Technology Center. The maneuver test that will be carried out is a turning circle with an angle of 35 deg. Evaluation of the prototype ship includes advance distance, transfer and tactical diameter in each turning circle test according to regulations from the International Maritime Organization (Aji Gunawan, 2018).

2.2. Resistance

Resistance is calculated using an empirical formula. This method is very practical for extrapolating model results to a prototype (full scale). The ship calculation method consists of:

a. Metode *Froude*

William Froude was the first researcher to introduce a breakdown of total prisoners into several components

$$R_{TM} = R_{FM} + R_{RM}$$

dimana :

R_{TM} : Total Resistance from experiments on the model

R_{FM} : Resistance of friction

R_{RM} : resistance of residuance

Furthermore, Froude assumes that the model's residual resistance is correlated with the ship's displacement, (R_{RM} / Δ_M) = (R_{RS} /Δ_S). Against the speed at which it can be obtained from ($V_M / \sqrt{gL_M}$) = ($V_S / \sqrt{gL_S}$) where the wave pattern of the model and the ship is the same.

With the Froude method, these results can be extrapolated to a prototype (full scale) by applying the resistance coefficient

$$C_{TS} = C_{FS} + (C_{TM} - C_{FM})$$

b. Methode *Form Factor*

Hughes (1959), introduced a method for use in ship model correlation where the total resistance is the sum of 3 (three) resistance components:

1) Friction resistance as surface resistance with the same area and length as the model.
2) Form resistance as resistance beyond the limits of the above items in the case of a hull that is submerged quite deeply. Hughess assumed that for a streamlined hull in turbulent flow, it can be expressed as proportional to the friction resistance.
3) Free surface resistance as wave resistance (CW) is the reduction of total resistance (CT) from

Volume 15, Number 02, pp.1-9
ISSN: 2460-7037
E-ISSN: 2722-5763

the sum of friction resistance (CF) and form resistance (CF0) from the model,
With the equation:

$$C_T = C_F + C_{F0} + C_W$$

where :

$C_{F0} = kC_F$

$C_T = (1+ k) C_F + C_w$

(1+k) is called the form factor and can be obtained from experiments at low speeds where the CW can be neglected.

3. RESULT AND DISCUSSION.

a. Redesign Axe Bow.

In this redesign process, the main part that received major changes was the bow of the ship which previously used a conventional bow type, which was changed to an ax bow type, especially in the stem section, while the other parts of the hull/Wetted Surface Area (WSA) were completely There will automatically be changes even though the changes are not too many/not too big, and in this redesign process the parameters mentioned above must be taken into account by always carrying out controls that focus on the ship's main data and hydrostatic data in each redesign process. Controlling parameters can be seen in the 'Parametric Transformation' menu or in the 'Calculate Hydrostatic' menu, which is in the 'Data' toolbar and by controlling the size and position coordinates of 'control points'.

b. Hydrostatic Data.

The hydrostatic data of the KCR 60 bow type ax bow model needs to be verified by referring to several hydrostatic data of the conventional bow type KCR 60 model bow which are used as parameters. The ax bow is relevant for testing and comparison with the KCR 60 conventional bow type regarding resistance. Below in Table 1 is the hydrostatic data for the conventional bow type KCR 60 model:

Table 1. The Hydrostatic Data for The Conventional Bow Type KCR 60 Model

	Measurement	Value	Units
1	Displacement	451,6	t
2	Volume (displaced)	440,562	m^3
3	Draft Amidships	2,570	m
4	Immersed depth	2,570	m
5	WL Length	54,909	m
6	Beam max extents on WL	7,233	m
7	Wetted Area	470,349	m^2
8	Max sect. area	11,970	m^2
9	Waterpl. Area	324,817	m^2
10	Prismatic coeff. (Cp)	0,670	
11	Block coeff. (Cb)	0,432	
12	Max Sect. area coeff. (Cm)	0,644	
13	Waterpl. area coeff. (Cwp)	0,818	
14	LCB length	24,572	from zero pt. (+ve fwd) m
15	LCF length	23,013	from zero pt. (+ve fwd) m
16	LCB %	44,750	from zero pt. (+ve fwd) % Lwl
17	LCF %	41,911	from zero pt. (+ve fwd) % Lwl
18	KB	1,752	m
19	KG fluid	0,000	m
20	BMt	2,784	m
21	BML	139,388	m
22	GMt corrected	4,536	m
23	GML	141,139	m
24	KMt	4,536	m
25	KML	141,139	m
26	Immersion (TPc)	3,329	tonne/cm
27	MTc	11,607	tonne.m
28	RM at 1deg = GMt.Disp.sin(1)	35,749	tonne.m
29	Length:Beam ratio	7,591	
30	Beam:Draft ratio	2,815	
31	Length:Vol^0.333 ratio	7,216	
32	Precision	Highest	214 stations

From the hydrostatic data of the KCR 60 bow ax bow model above it can be seen that the displacement, volume displacement and basic size of the ship are each valued at 451.6 tons for

Volume 15, Number 02, pp.1-9
ISSN: 2460-7037
E-ISSN: 2722-5763

displacement and volume displacement at 440,562 meters³, the size data is in accordance with or the same as the data KCR 60 model conventional bow type which is the parameter.

c. Model Analize Total Resistance.

To analyze the difference between the bow of a conventional bow type ship and the bow of an ax bow type ship on the KCR 60 model in terms of resistance, it is necessary to carry out several tests to find out how big the difference in total resistance is when working on the conventional bow type KCR 60 model bow and the KCR 60 type model. the direction of the ax bow at each speed simulation in calm water conditions. The speed simulation variations used in this research are 5 speed variations, namely speed simulations of 15 knots, 20 knots, 25 knots, 28 knots and 30 knots with the aim of knowing the changes in resistance values that occur as the ship's speed increases to facilitate the analysis process. Model testing in this research was carried out with the help of analysis programs and analysis software, namely the MARIN DESPPC 1999 program and Maxsurf Resistance V8i software.

As explained above, data processing and analysis of the conventional bow type KCR 60 model on resistance is carried out using 2 (two) types of computer calculation analysis, namely using the help of an analysis program and analysis software, namely the MARIN DESPPC 1999 program and the Maxsurf Resistance V8i software. The results of data processing / calculations from the analysis program and software are as follows

In analyzing the resistance of the KCR 60 bow axe bow type model using the Maxsurf Resistance V8i software, several parameters are used, namely the selection of the calculation approach used to calculate the resistance of the ship which is based on the type of ship which is closely related to the geometry of the ship model, this is a form of initial data validation which shows that the geometric approach of the ship model to the real ship is the same or not much different, and which is further based on the simulation parameters of certain ship speeds in calm water conditions.

The speed parameter is important for determining the resistance produced by a ship because the resistance value is directly proportional to the ship's speed, so the resistance value obtained will be greater with increasing ship speed. At this stage the calculation method chosen is the Holtrop method, this is because the characteristics of the conventional bow type KCR 60 model are ships with one hull (monohull). Data processing of total resistance values on ship speed using the Holtrop calculation method in the Maxsurf Resistance V8i software was carried out using a running program process using ship speed simulations of up to 35 knots with the assumption that the test was carried out at the ship's maximum draft (draft 2.57 meters) and was assumed to be carried out under conditions calm waters. The graphic display of the results of running the total resistance value calculation program with ship speed can be seen in Figure below:

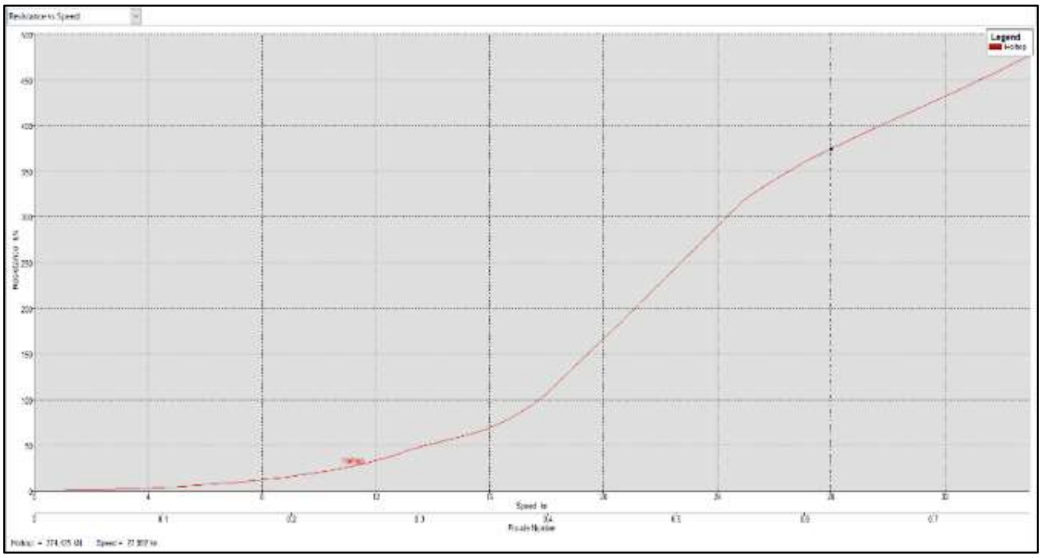


Figure 1. The graphic display of the results of running the total resistance value calculation

From the data from the process of running the program to calculate the value of total ship resistance to ship speed up to 35 knots using the Holtrop method in the Maxsurf Resistance V8i software (attachment 4), then sample experimental data for 5 speed variations was determined, namely speed variations of 15 knots, 20 knots, 25 knots, 28 knots and 30 knots as the main data that will be used as comparative data as in Table below:

Volume 15, Number 02, pp.1-9
ISSN: 2460-7037
E-ISSN: 2722-5763

Table 2. The Comparative Data Between Speed and Resistance

Vs (Knot)	Total Resistance (kN)
15	59,4
20	166,4
25	319,6
28	374,5
30	403,6

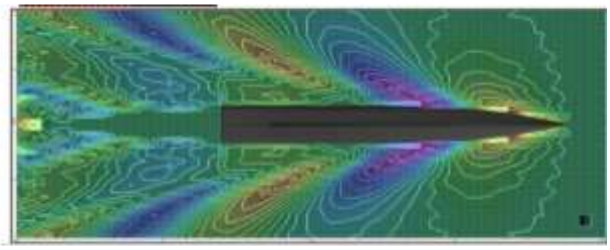


Figure 2. Speed 15 Knot

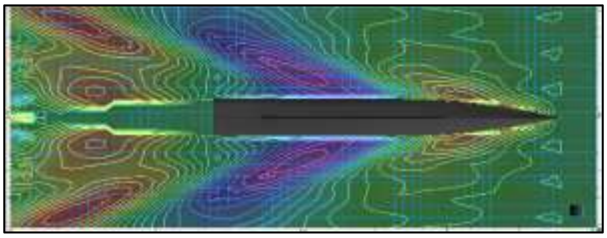


Figure 3. Speed 20 Knot

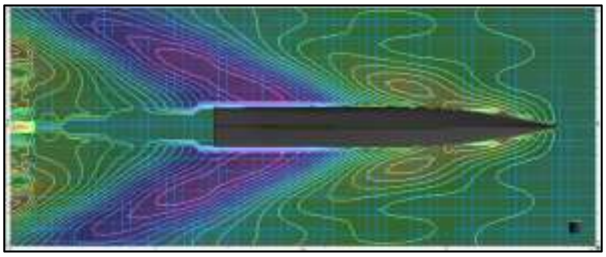


Figure 4. Speed 25 Knot

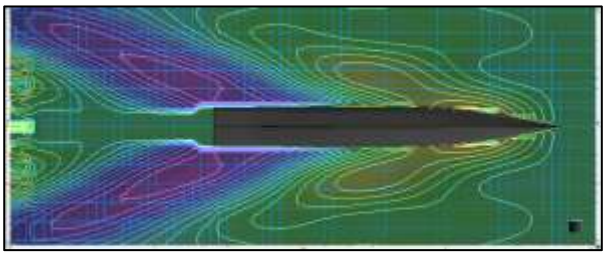


Figure 5. Speed 30 Knot

By using a calculation approach with the Holtrop calculation method. The analysis in calculating this resistance is assumed to be in calm water conditions and the calculation parameters are given in conditions of the maximum draft of the ship (draft 2.57 meters). For speed simulation variations used in this process, sample data from 5 speed variations is also used, namely speed simulation parameters of 15 knots, 20 knots, 25 knots, 28 knots and 30 knots.

In the running process, the resistance calculation for the 5 speed variations can be carried out/processed at the same time as in the running process using the Maxsurf Resistance V8i software. The total resistance value data and the total resistance graph resulting from the running program (attachment 5) can be seen in the table below:

Table 3. The Comparative Data Between Speed and Resistance

Vs (Knot)	Total Resistance (kN)
15	70,4
20	153,9
25	249,4
28	288,1
30	313,2

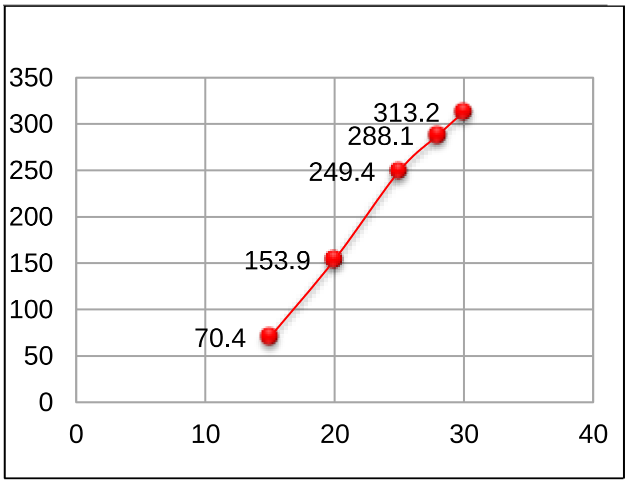


Figure 6. Maxsurf Resistance V8i software

In the numerical calculation of the resistance of the KCR 60 bow type ax bow model using the Maxsurf Resistance V8i software, certain parameters are used, namely the selection of a calculation approach based on the type of ship which is closely related to the geometry of the ship model and which is then based on certain ship speed simulation parameters in calm water conditions. Apart from the speed simulation parameters, the resistance calculation approach method is also an important parameter in knowing the total resistance value at each ship speed. The resistance calculation approach method chosen for this model is the same as the resistance calculation approach method for the conventional bow type KCR 60 model, namely the Holtrop method, this is because the characteristics of the KCR 60 model ax bow type are ship models with one hull (monohull). Below are the total resistance values for speed analysis results from the Maxsurf Resistance V8i Software:

Volume 15, Number 02, pp.1-9
ISSN: 2460-7037
E-ISSN: 2722-5763

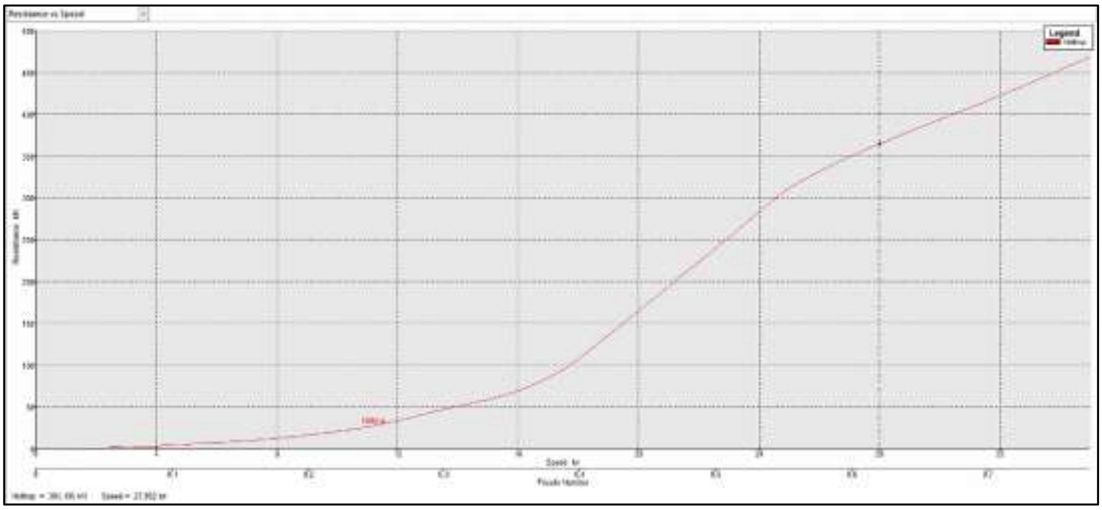


Figure 7. The graphic display of the results of running the total resistance value calculation

Table 4. The Comparative Data Between Speed and Resistance

Vs (Knot)	Total Resistance (kN)
15	58,5
20	164,2
25	311,4
28	364,2
30	393,3

Resistance V8i when simulated moving with 5 speed variations can be seen in figures below:

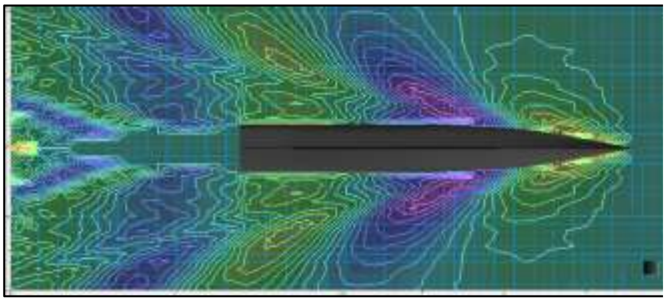


Figure 8. Speed 15 Knot

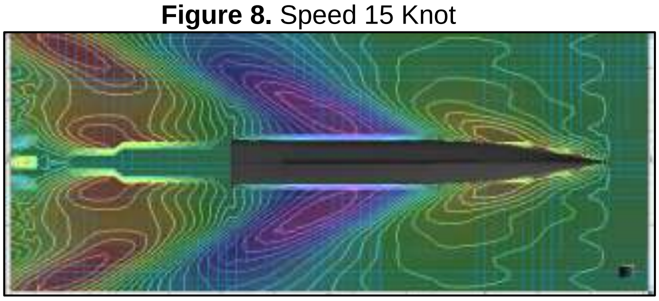


Figure 9. Speed 20 Knot

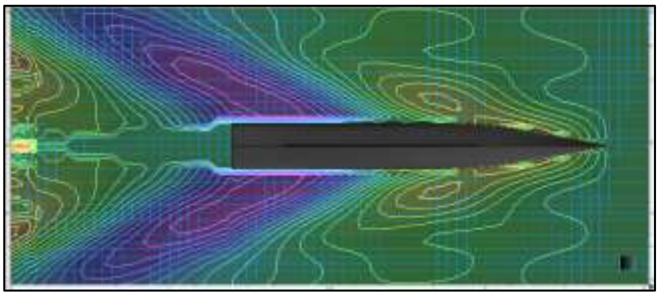


Figure 10. Speed 25 Knot

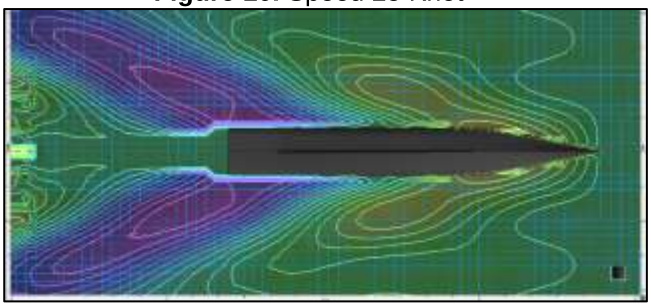


Figure 11. Speed 28 knot

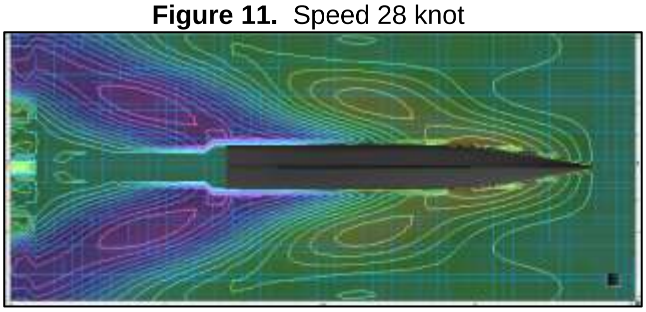


Figure 12. Speed 30 Knot

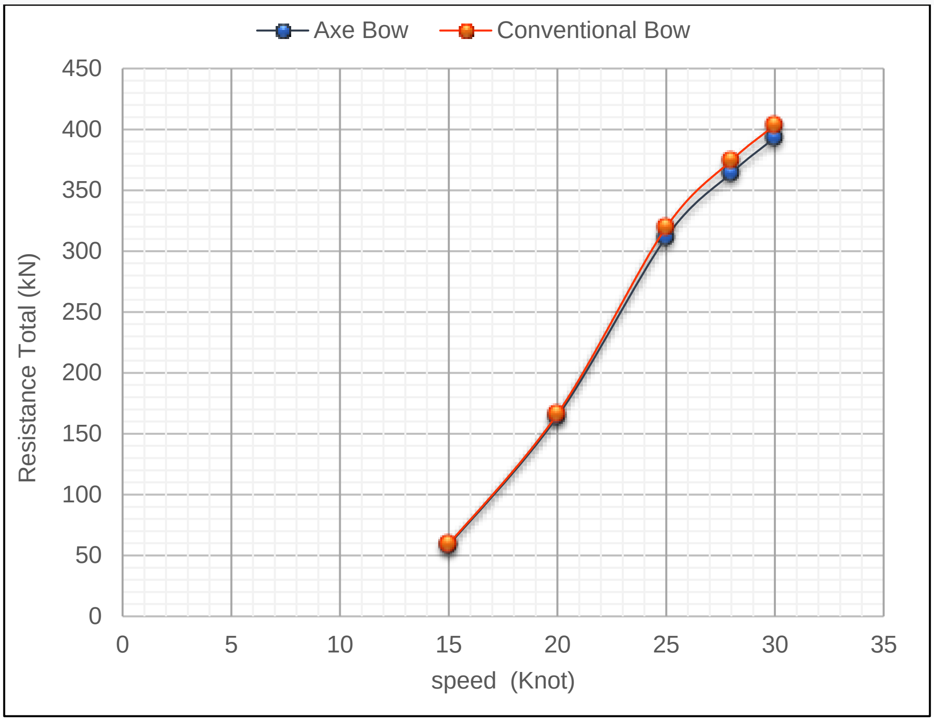
d. Comparative Analysis of Total Resistance of Conventional Bow and Ax Bow Types

From several tests on the conventional bow type KCR-60 model and the previous KCR-60 ax bow type model (in sub-chapter 4.2), several data were obtained from the analysis of total resistance calculations with the help of software and analysis

Volume 15, Number 02, pp.1-9
ISSN: 2460-7037
E-ISSN: 2722-5763

programs, namely the Maxsurf Resistance V8i software and the program MARIN DESPPC 1999 which in the data processing and calculations uses the Holtrop method as a calculation approach method. To determine the effect of modifying the bow design of the 60 M Fast Missile Ship (KCR-60), it is necessary to carry out a data comparison/comparison method on the total resistance value between the conventional bow type KCR-60 model and the ax bow type KCR-60 model. The data comparison method in question is data comparison based on the Holtrop method in the Maxsurf Resistance V8i software and data comparison based on the Holtrop method in the MARIN DESPPC 1999 program.

From the analysis of the comparison of total resistance, it is hoped that it will be possible to know the effect of modifying the bow design of the 60 M Fast Missile Ship (KCR-60), namely how large the percentage and value of the difference in total resistance obtained in each data comparison of the total resistance value between the conventional bow type and the bow type. ax bow. The comparative analysis of total resistance can be described as follows:



From reading the graph data above (figure of 0.9 kN (the total resistance value of the ax bow type is 1.51% lower than the conventional bow type) while at a ship speed of 20 knots the difference in total resistance value between the two increases to 2.2 kN (the total resistance value of the ax bow type is higher low 1.32% of the total resistance value of a conventional bow type). With the increase in ship speed from 25 knots to a speed of 30 knots, there is an increase in the ship's total resistance graph, the total resistance of the ax bow type and the total resistance of the conventional bow type show a significant difference with a percentage difference of up to 2.75% which is positive in terms of reducing ship resistance.

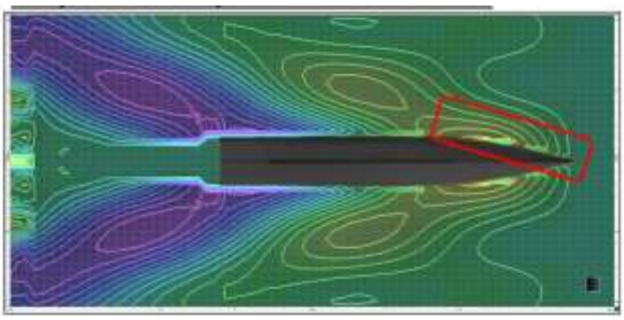


Figure 13. Conventional Bow speed 30 knot

Volume 15, Number 02, pp.1-9
ISSN: 2460-7037
E-ISSN: 2722-5763

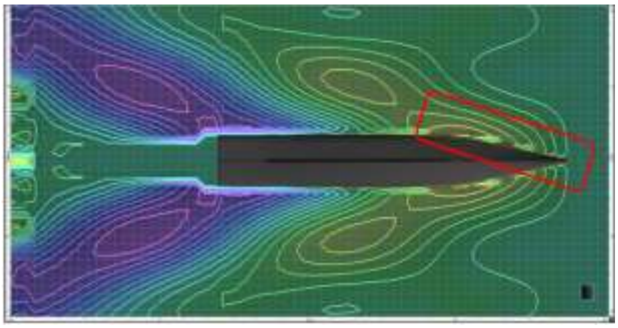


Figure 14. Axe Bow Speed 30 Knot.

In the image above is a comparison of the contour visualization / wave pattern that occurs when the ship is simulated moving at a speed of 30 knots, it can be seen from the color display and wave pattern that occurs around the bow of the KCR 60 ax bow model ship, it is slightly better / slightly calmer than conventional bow type, as well as in the stem area (in the part marked with the red line) it is clear that the difference in the wave pattern that occurs at the entry angle of the stem area looks smoother than the conventional bow type, this occurs because the shape of the ax bow type is smoother. thin so that it further reduces wave resistance.

From the overall comparison data of total resistance values for each test speed variation above, it can be seen that the KCR 60 ax bow type model has a lower/smaller total resistance value than the conventional bow type KCR 60 model, with the highest percentage difference in total resistance value. amounting to 2.75% at a speed of 28 knots, which is also the service speed of the KCR 60 model, so that based on comparative analysis of data from Maxsurf resistance software analysis using the Holtrop method with the assumption of calm water conditions, it can be concluded that the influence of the ax bow type The KCR-60 model provides a positive function, namely a smaller/lower total resistance value compared to the conventional bow type KCR-60 model with the highest total resistance difference value of 10.3 kN at simulated speeds of 28 knots and 30 knots, whereas The highest percentage difference in total resistance value is 2.75% at the KCR 60 model service speed, namely at a speed of 28 knots.

4. CONCLUSION.

Based on the results of this research, it can be concluded that:

a. Calculation analysis using the MARIN DESPPC 1999 program with the Holtrop method in calm water conditions and in maximum draft conditions (full load) shows that the influence of redesign/modification of the bow type (especially the stem and bow parts of the submerged ship) on the KCR-model 60 conventional bow types into the KCR-60 ax bow type model can provide a smaller total resistance value or can reduce the total resistance of the ship by 1.56% at a service speed of 28 knots.

b. Calculation analysis using Maxsurf Resistance V8i software with the Holtrop method in calm water conditions and in maximum draft conditions (full load) shows that the influence of redesign/modification of the conventional bow type (especially the stem and bow parts of the submerged ship) on the model The KCR-60 model, the KCR-60 bow ax bow type, can reduce the total resistance value to be smaller than the conventional bow type KCR-60 model or can reduce the total resistance of the ship by 2.75% at a service speed of 28 knots.

c. The effect of redesigning/modifying the bow of a conventional bow type ship (especially the stem part and the submerged part of the bow of the ship) to become a conventional bow type ship's bow is able to reduce the total resistance of the ship to be.

ACKNOWLEDGEMENT

The authors greatly acknowledge the support from Indonesia Naval Technology College STTAL Surabaya Indonesia for providing the necessary resources to carry out this research work. The authors are also grateful to the anonymous reviewers and journal editorial board for their many insightful comments, which have significantly improved this article.

REFERENCES

Adi, P. (2013). Analisa Penerapan Bulbous Bow pada Kapal Katamaran untuk Meningkatkan Efisiensi Pemakaian Bahan Bakar. *JURNAL TEKNIK POMITS Vol. 3, No. 1*, F-13.

Aji Gunawan, Teknik Sistem Perkapalan Universitas Hang Tuah. (2018). Analisis Manuver Kapal Pada Haluan Axe Bow Melalui Pendekatan Uji Coba Kapal Prototipe .

Akhmat Nuryadin, Sekolah Tinggi Tekhnologi Angkatan Laut. (2015). Analisa Propulsi Kapal Cepat Rudal 60 Meter (KCR 60 M) Dengan Metode Perbandingan.

Alferd.M.Kracht. (1978). Design Of Bulbous bow. *SNAME Transcation Vol 86*, 198-199.

bangka tribun news. (2017, 05 13). *indonesia butuh 500 kapal patroli untuk jaga wilayah perairan*. Retrieved from bangka tribun news: https://bangka.tribunnews.com

Bayu Kurniawan, Teknik Sistem Perkapalan Universitas Hang Tuah, Balai Teknologi Hidrodinamika. (2018). Analisa Tahanan Kapal Patroli Dengan Haluan Axe Bow Yang Tervalidasi Oleh Pengujian Model.

Volume 15, Number 02, pp.1-9
ISSN: 2460-7037
E-ISSN: 2722-5763

Deddy Chrismianto, Teknik Perkapalan Universitas Diponegoro. (2014). Analisa Pengaruh Modifikasi Bentuk Haluan Kapal Terhadap Hambatan Total Dengan Menggunakan CFD. *Kapal*.

Departement Tekhnik Perkapalan, Universitas Diponegoro. (2017). Optimasi Bentuk Haluan Kapal Ferry untuk Mendapatkan Olag Gerak yang Terbaik di Daerah Kepulauan Mentawai. *Jurnal Teknik Perkapalan*.

Eng, M. (2014). Ship Design. In M. E. Co.Ltd, *Ship Design* (p. 38). Tokyo.

Febriyanto. (2011). Optimisasi bentuk bulbous bow dengan menggunakan koneksi (link) antara Maxsurf dan Microsoft Excel. *ITS-Undergraduate-16380-4106100063-Paper.pdf*, 1.

G.Kuper. (2002). Resistance and Porpulasion 1. In G.Kuper, *Consideration for the Bow form* (p. 15). Wagenigen: Delft University and Technology.

Harahap, R. R. (2018). Analisa Pengaruh Sudut Masuk Kapal Perintis 750 Dwt Terhadap Slamming Kapal Dengan Penambahan Anti-Slamming Bulbous Bow Tipe Delta (Δ – Type) Menggunakan Metode Cfd. *Jurnal Teknik Perkapalan - Vol. 6, No. 1 Januari 2018*, 39.

Hardjono, S. (2017). STUDY ON THE FAST MISSILE CRAFT (KCR) OF 60 M AT THE SEASTATE CONDITION OF THE WEST AND EASTERN INDONESIAN. *M.P.I. Vol.11*.

Harnita. (2011). Studi Pengaruh Bentuk Bulbous bow terhadap tahanan kapal layar motor tradisional melalui uji model. *harnita (D311 06 002)*, 2.

harnita. (2011). " Studi Pengaruh Bentuk Bulbous Bow Terhadapa Tahanan Kapal layar Motor Tradisional Melalui Uji Model.". *harnita (D311 06 002)*, 2.

Kracht. (1970). A Theoretical Contribution to the wave Resistance Problem of Ship Bulb Combinations: Verification of the Negativiness of the Interaction Term. *Ship Research March*, 197-217.

Kuiper, G. (2003). Wave Resistance. In R. D. System, *Resistance and Porpulsion 1* (pp. 117-119). Netherlands: Delft University of Technology.

Marsetyo. (2014). *Sea Power.* Jakarta: Gramedia.

Mitsui, E. (2014). Ship Design. In M. E. Co.Ltd, *Mitsui Eng and Ship Buillding Co.Ltd* (p. 38). Tokyo.

Nova, B. H. (2017). Analisa Penambahan Bulbous Bow Pada Kapal Perintis 750 DWT Guna Mengurangi Efek Slamming. *Jurnal Teknik Perkapalan - Vol. 5, No. 1 Januari 2017*, 253.

Oni, R. (2015). Analisa Pengaruh Bentuk Lambung Axe Bow pada Kapal High Speed Craft Terhadap Hambatan Total. *Kapal, Vol. 12*.

Prastyawan, A. (2013). Analisa Penerapan Bow tipe Axe untuk mengurangi Konsumsi Bahan Bakar pada Utility Vessel 48 Meter. *Jurnal Teknik POMITS Vol. 2*.

Prastyawan, A. (2013). Analisa Penerapan Bow tipe Axe Untuk mengurangi konsumsi Bahan Bakar Pada Utility Vessel 48 Meter. *JURNAL TEKNIK POMITS Vol.2,No.2* , G-166.

Romadhoni. (2016). Analisa Olah Gerak Kapal di Gelombang Regular pada Kapal Tipe Axe Bow.

Romadhoni. (2016). Analisa Olah Gerak Kapal di gelombang Reguler pada Kapal Tipe Axe Bow.

Romadhoni. (2017). ANALISA PERBANDINGAN BENTUK LAMBUNG BULBOUS BOW KEPALA HIU MARTIL TERHADAP HAMBATAN TOTAL KAPAL. *JURNAL INOVTEK POLBENG, VOL. 07, NO. 1, JUNI 2017*, 42.

Sumartojo, I. (2006). *Teori Bangunan Kapal I.* Surabaya: Kobangdikal.

SV.AA.Harvald. (1983). *Resistance and Propulsion of Ship.* Denmark: John Wiley and Sons .

Sv.Aa.Harvald. (1992). *Tahanan dan Propulsi Kapal.* Surabaya: Airlangga University Press.