Redesign KCR 60m Bow with Axe Bow Type To Reduce Ship Resistance

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Abstract. Indonesian Navy continues to build 60 Meter Fast Missile Boat (KCR-60) is one of them and acts as a fast patrol boat and high-speed combatant ship in the archipelago warfare. The bow of the ship is an important part in the design of the ship as well as the bow of the KCR-60, because it is the most stressed, stressed from the waves, with the bow design that has a bow profile like an axe, the slender shape of the waterline is able to reduce the impact waves, increase the efficiency of the inflow rate, reduce the resistance of the vessel received so increase a better speed. This study changed the design of the Conventional Bow KCR-60 into the Axe Bow design concept with numerically calculated the total resistance of the Bow Bow design using the Holtrop method and performed a comparative analysis with the computing program MARIN DESPPC 1999 and Maxsurf Resistance V8i software. The results of this study found the total resistance value of KCR-60 Axe Bow type at 28 Knots speed was 364.2 KN and Conventional Bow type was 374.5 KN, the difference was 10.3 kN or 2.75% smaller than the Conventional Bow type in the analysis comparison of Maxsurf Resistance V8i software. For comparative analysis of the MARIN DESPPC 1999 program the total resistance value of the KCR-60 Axe Bow concept at 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.

1. Introduction

Indonesian government policy to realize as a global maritime axis must of course be offset by the readiness of all elements of the Navy, both the readiness of human resources and weapons system (defense equipment). Indonesian Navy continues to modernize with new procurement towards the 2024 Minimum Essential Forces (MEF), namely the addition of Combat ships, Navy aircraft and Marines[1]. Procurement of warships is very important to upgrade the combat capabilities of existing warships. Currently number of warships available is not enough to secure the entire territory of Indonesian waters which reaches 3.544.743,9 km²[2]. In order to meet the needs of the main weapons system (defense equipment), Indonesian Navy always prioritizes the domestic industry in accordance with the mandate of law number 16 of 2012 concerning the defense industry. In this regard the Navy has cooperated with state-owned corporation PT. PAL to build 20 units of 60-meter Fast Missile Boat (KCR-60). Curently 4 KCR units have been completed[3]. The existence of KCR-60 has a very strategic role in carrying out the task of maintaining the sovereignty of the territorial waters of the Republic of Indonesia. In accordance with operational requirements because KCR-60 is a warship capable of acting as a fast patrol ship as well as a combat ship (search and destroyer of enemy ships), which has high speed and maneuverability and can be operated optimally in shallow water.
KRI Sampari-628 is one of KCR-60 unit that has been operational but has not been able to reach maximum speed. Not yet achieved the maximum speed of the KRI Sampari-628 may be caused by several things, namely: errors in designing the hull and bow of the ship (Bow) resulting in relatively greater ship resistance, engine power installed is not in accordance with the needs of the driving force of the ship, propeller installed unable to channel all the power from the engine, errors in engine propeller matching [4]

Achieving the maximum speed of the ship is an important factor as well as a parameter / benchmark for the success of a ship's construction, so that in the design process the ship needs to take into account the ship's resistance and how much propulsion power will be used. The selection of the hull design of the ship and the design of the right bow type in this case Bow Type. These things can support the improvement of the effectiveness of ship shipping activities in terms of consumption / fuel consumption to the effectiveness of the shipping time because of the desired speed of the ship. With a good bow design can reduce the resistance value / resistance of the ship that is received such as breaking the wave resistance. The shape of the ship's bow design for the type of fast boat is mostly in the form of an oblique bow (conventional bow), in the current era the ship's bow design is upright or vertical (axe bow). Axe bow type ships are the development of the enlarged ship concept innovation that was designed and developed in 1995 by Delft University and Damen Shipyards. The concept of axe bow itself is a redesign of the bow direction of the ship which in its research and development is known to provide lower resistance / resistance values compared to the bow without the ax bow design. The formulation of the problem in this study are:

a) What is the effect of the change in the design of the KCR-60 bow hull using the ax bow type on the total resistance of KCR-60.

b) What is the ratio of resistance (resistance) to speed of conventional bow type bow design with ax bow type on KCR-60.

The purpose of this paper is to identify the effect of changes in bow design using the ax bow type on ship performance, specifically on the resistance factor and to determine the percentage difference in resistance if there is a difference from the test results.

2. Ship Resistance And Calculating Methods

2.1 Ship Resistance
In ship design, a common factor that plays an important role is the ship custody or the ship resistance will be experienced by the ship when moving. A form of ship with the smallest resistance or the smallest resistance value is one of the objectives in ship planning, which means that the power requirements will be smaller so that it will save fuel use, meaning a lighter engine and smaller dimensions so as to increase the loading capacity of the ship. The ship's resistance at a speed is the force of the fluid acting on the ship so that the force is against the movement of the ship. The resistance will be the same as the fluid force component that works parallel to the axis of the ship's movement, therefore the amount of pressure on the area around the hull will produce waves on the surface of the fluid[5][6].

The occurrence of opposing tangential forces with the direction of motion of the hull is caused by fluid viscosity factors and hull motion shown in figure 1.

![Figure 1. Waves flow caused by the hull of the ship](Resistance and Propulsion Modul II ,S.W. Adji 2009)
Based on the two resistances, it is known as Wave Making Resistance and Viscous or also known as Frictional Resistance. Viscosity can cause changes in flow around the hull which will gradually increase the pressure to the end of the hull. As a result of this condition often also known as Viscous Pressure Resistance, or Form Resistance (depending on the shape of the hull)[7]

Ship resistance:

a. Friction Resistance ($R_f$).
b. Residual Resistance ($R_R$).
c. Viskos Resistance ($R_v$).
d. Pressure Resistance ($R_P$).
e. Pressure Resistance Viskos ($R_{PV}$).
f. Wavemaking Resistance ($R_W$).
g. Air Resistance
h. Rudder Resistance.

2.1.1 Ship Resistance Calculation Method.

Method of Calculation of ships resistance have several approaches to get it, both for use on merchant ships / merchant ships or special vessels / Special Purpose Vessels, where warships are one of the categories of these special ships. In this final project, 2 methods are considered as the most suitable approach to find out how much additional resistance due to sea and wind waves caused by the weather in real or actual conditions. The 2 methods are based on computer software and computer programs, namely Maxsurf Advance V8i software and MARIN DESPPC 1999 programs.

2.1.2 Ship Bow Design

The bow of the ship is the most important part in designing a ship and is the first part to come into contact with water. With a good bow shape can reduce the value of the received ship resistance such as breaking wave resistance. The shape of the bow design varies such as the bow shape without the bulb, the bow using the bulb, and other special bow shapes.

The angle formed by the bow of the ship by the waterline is called a rake. For ships that use a blunt bow shape will get a greater resistance value than ships that use a slim bow shape. With the blunt bow shape the greater the loss of power, the resistance received must be reduced. The results of studies on the influence of the bow on increasing resistance show that the most effective way is to sharpen the shape of the bow of the ship.[8].

2.1.3 Axe Bow Type Definition

Axe Bow is a type of bow that divides the waves at the bow of a ship, which is generally characterized by vertical rods and entry (front hull) that are narrow and relatively elongated or shaped like an axe, a relatively high freeboard, with a slight protruding downward, so that the bow profile resembles an axe, but regarding the design concept of the axe bow as already explained it is not absolutely necessary as the description, the main basic concept of the design is in the bow immersed in water / seawater (under the water line) relatively straight vertical like an axe as shown in figure 2.
Figure 2. Ship Model with axe Bow (Indonesian Hydrodynamic laboratory)

The bow axe bow type design has a slender shape to the waterline so it can reduce obstacles, reduce wave impact, reduce slamming and increase the efficiency of the inflow so as to produce a better speed[9][10][11][8][12]. The bow design like this makes the waves finely solved.

Figure 3. Wave Differences in Axe Bow and Ordinary Bow / Conventional Bow (Prastyawan 2013)

2.2 Main Ship Size
The object of research is a 60 m fast patrol boat with the following technical data [4] and figure 4:
- Design speed : 28.00[knots]
- LOA : 59.5 [meter]
- Length on Waterline : 55.2 [meter]
- LBP : 53.71[meter]
- Breadth Moulded : 7.23[meter]
- Displacement : 468.20 [Ton]
- Draft Full load : 2.60m
- Block Coefficient : 0.391
- RPM Engine : 600.0[1/Min]
2.3 Discussion

In this paper several steps are carried out:

a. Initial modelling of the KCR-60 by creating a 3D computer model design for the KCR-60 using Maxsurf Modeler Advanced Software. The making of the 3D KCR-60 computer model was made by two KCR-60 models using the existing KCR-60 design data base, while the design of the two ships' bow was different. The first is the existing KCR-60 design (existing ship), KRI Sampari-628 KCR-60 version batch 1 with conventional bow type, the second design is the KCR-60 bow axle bow type.

b. Analysis using the Maxsurf Enterprise V8i Software with several variations of speed and variations of simulation are variations in speed to reach a maximum speed value (30 knots), while the simulation variation in calm waters[4] uses the Holtrop method because the characteristics of KCR-60 are one hull (monohull).[13]

c. Analysis using MARIN DESPPC 1999 program.

The research methodology can be seen in the following flow chart Figure 5:

![Flow Chart](image-url)

**Figure 5. Flow Chart**
The first stage is redrawing lines plans as shown in Figure 6. The second stage is redesign lines plan become axe bow on maxsurf modeler advance V8i as shown in Figure 7.

The initial stage in analyzing the influence of modification / redesign of the bow KCR-60 that uses the axe bow type against obstacles and speed is the process of modeling the ship (KCR-60) Conventional Bow type using 3D design software namely Maxsurf Modeller Advance V8i software which is then for the testing phase and processing data using several analysis programs from the Maxsurf Resistance V8i software and using the MARIN DESPPC 1999 program, which all play a role in processing resistance calculation data that occurs on ships by testing several specified speed variations. For testing carried out in several variations of speed to
determine changes in ship resistance values that occur based on changes in ship speed that is increasingly improved; The speed variations to be used are 15 knots, 20 knots, 25 knots, 28 knots and 30 knots.

In this study the ship's 3D model used for the varied test is the KCR-60 conventional bow bow type and the KCR-60 bow bow type model made from the conventional bow KCR-60 model that has been redesigned. Then the model analysis of total ship resistance is carried out as shown at figure 8:

a. Conventional bow type using software Maxsurf Resistance.

b. Conventional bow type using Marin DESPPC 1999 program.

c. Axe bow type using Maxsurf Resistance software.

d. Axe bow type using Marin DESPPC 1999 program

Figure 8. Comparison graph of the total resistance value of Conventional Bow and Ax Bow using Maxsurf Modeler Advanced V8i data

The final stage that needs to be carried out is to analyze the comparison of the total resistance value of conventional bow type and axe bow type, respectively based on the results of data from the Maxsurf Resistance software running process and from the 1999 Marin DESPCC program as shown at Figure 9.

Figure 9. Comparison graph of the total resistance value of Conventional Bow and Axe Bow using MARIN DESPPC 1999 data.
3. Conclusion

From the analysis and calculation of total resistance with the help of software and analysis programs, namely the Maxsurf Resistance V8i software and the MARIN DESPPC 1999 program using the Holtrop method, several conclusions can be obtained as follows:

Effect of redesign / modification of the bow of the ship (especially the stem and the bow section of the ship being immersed) on the conventional bow type KCR-60 model into the KCR-60 bow type model Axe bow is able to reduce the total resistance of the ship to be smaller so that it gives a positive effect on speed the ship to increased speed.

Analysis of calculations using the MARIN DESPPC 1999 program with the Holtrop method in calm water conditions and maximum draft conditions (full load) shows that the effect of redesign / modification of the bow type (especially the stem and bow section of the ship being immersed) on the KCR-60 model conventional bow type into the KCR-60 axle bow bow type can provide a smaller total resistance value or be able to reduce the total ship resistance by 1.56% at a service speed of 28 knots. As for the analysis of calculations using the Maxsurf Resistance V8i software with the Holtrop method in calm water conditions and maximum draft conditions (full load) shows that the effect of redesign / modification of the conventional bow bow type on the KCR-60 model becomes the KCR-60 model of the bow type axe bow can reduce the total resistance value of the ship to be smaller or be able to reduce the total resistance of the KCR-60 model conventional bow bow type by 2.75% at 28 knots service speed.

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