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Hull Form Optimization of Fishing Vessels by Adoption of Stern Wedge and Bilge Keel

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ABSTRACT: The most recent ships incorporate a number of significant design enhancements to improve the vessel's seaworthiness. Bulbous bow, bilge keel, stern wedge, stern tunnel, spray rails, and others are examples. A stern wedge is a small modification of the buttock lines aft of station 19 1/2. The use of this hull design feature on small high-speed planning craft for the purpose of improved powering performance is an accepted naval architectural practice. However, its use on fishing vessels is uncommon. A bilge keel is a marine gear that reduces the tendency for a ship to roll. Hull shape modifications such as bilge keel can potentially increase safety by reducing roll motions. These enhancements have not been adopted or evaluated on fishing vessels, despite the fact that they have been employed on seagoing ships. The installation of bilge keels on fishing vessels was found to have a significant influence on the roll motion of the vessels, boosting their safety and efficiency. When compared to normal trawlers, the installation of bilge keels increased roll period by at least 40% and reduced roll amplitude by 16%.

KEYWORDS: Bilge keel, Resistance, Roll motion, Roll decay simulation, Stern wedge, Seakeeping, Trawler.

1. INTRODUCTION

Fishing is a demanding and labour-intensive activity, and most fishermen operate in harsh conditions with boats that aren't up to the task. As a result, fishing boats are engaged in the bulk of global maritime accidents, resulting in the loss of many lives each year. The annual fuel consumption of mechanised and motorized fishing fleet of India has been estimated at 1220 million litres of fuel in 2000 [10]. Introducing resistance reduction technologies can save millions of litres of fuel annualy. Roll motion has a significant impact on the safety and performance of operating boats by reducing the effectiveness of the fishermen as well as the onboard equipment. To improve the safety and efficiency of fishing vessels, significant improvements in safety or performance enhancement are required. To lower the risks of capsizing of fishing vessels due to the large roll motion under extreme sea and weather conditions some form of roll damping such as bilge keel could be used. The purpose of this study is to determine if bilge keels can be successfully adopted on fishing trawlers with satisfactory results and identify their performance impact using theoretical calculations.

2. MATERIALS AND METHODS

2.1 Stern Wedge

A trawler with a displacement of 86.9 tonnes and a waterline length of 19 metres was designed for the study as shown in the figure 1 below.

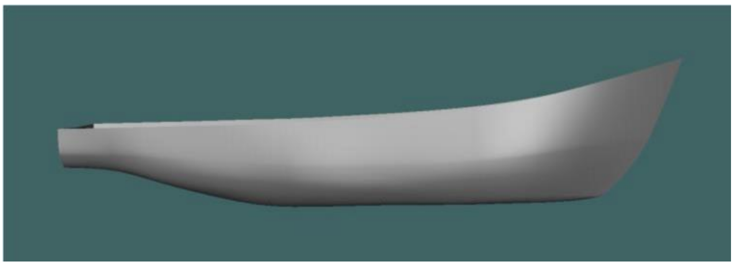

Figure 1. Conventional trawler model

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Initially the model's total resistance was calculated for a range of speeds using holtrop resistance equations. The Holtrop method computes a dimensional total resistance which is broken down into several components: frictional resistance, appendage resistance, wave-making resistance, resistance due to bulbous bow near the water surface, pressure resistance due to immersed transom, model-ship correlation resistance, and air resistance. This was done for speeds from 0 – 12 knots.

After obtaining resistance values for the initial model, a stern wedge with a stern angle of 10 degree and length of 365.74 mm which is 2% of the waterline length was installed (figure 3). The Holtrop resistance for this model was also calculated as before.

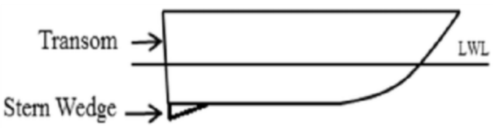

Figure 2 Hull with a stern wedge

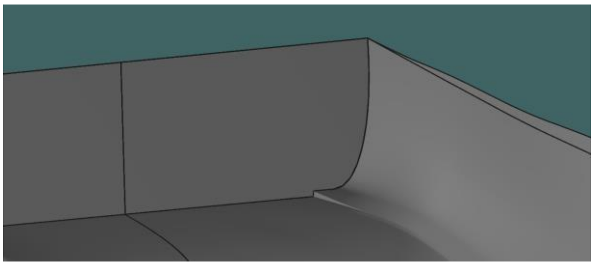

Figure 3. Trawler with 10 -degree stern wedge

Most models showed almost similar resistance values. The same was repeated with stern angles of 7- and 15-degree stern wedges and their resistance values calculated.

2.2 Bilge Keel

Since roll motion decreases the effectiveness of fisherman and aboard equipment, it has a significant impact on the safety and performance of operating boats. Furthermore, the boats are at risk of capsizing due to severe roll motions generated by strong sea and weather conditions. As a result, it is vital to analyse the trawler's roll responses and, if appropriate, utilise roll stabilising measures to lower the roll amplitude. In comparison to other active or passive roll stabilisers like anti-roll fins and anti-roll tanks, bilge keels are significantly easier to manufacture, especially for boat builders, and they don't require any additional operations by fishermen during the sailing course.

The seakeeping performance of the traditional trawler was verified before the bilge keel was designed by charting the righting lever (GZ) curve of the vessel. A roll stabiliser, such as a bilge keel, is required to improve the vessel's seakeeping characteristics. Because the angle of deck edge immersion of the vessel was found to be 37.5 degrees from the GZ curve, a roll decay simulation was run with a 37.5 degree beginning angle of heel. The vessel is heeled to 37.5 degrees with a fixed trim of 0 degrees and kept for 5 seconds for the roll decay simulation. The vessel is then free to roll until it comes to a stop. The heel angles corresponding to a continuous series of time stamps are calculated and recorded.

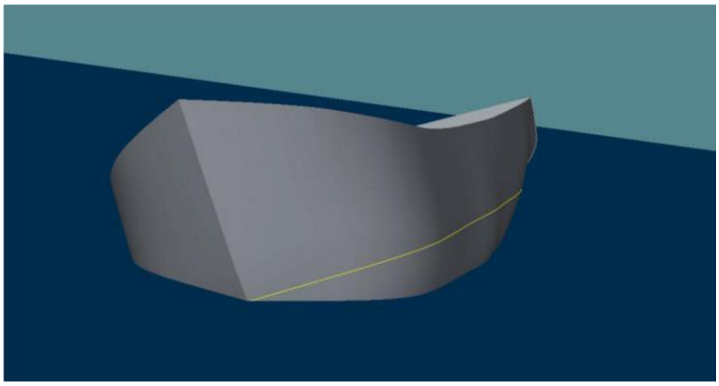

Figure 4 .Roll decay simulation graphical representation of conventional trawler

A rectangular bilge keel was selected due to the difficulties faced in analysis when using more complex shapes of bilge keel. The width, length and thickness are the two main dimensions of the bilge keel. Bilge keel's width is typically 3 to 5% of the width

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of the boat. Therefore, a bilge keel 4% of the boat's width was used, resulting in a 20.4 centimetre bilge keel. For the purposes of this study, the bilge keel thickness was set to 0 and it was treated as a surface body. Usually the length of the bilge keel varies from 25 to 75 % of the vessel's waterline length. But, due to the shape of a trawler being different from other vessels and shorter parallel mid-body, the length was set to 3 metres. It was fixed at the parallel mid-body of the vessel at a length of 8.9 metres from the aft at a depth of 80 cm from the waterline.

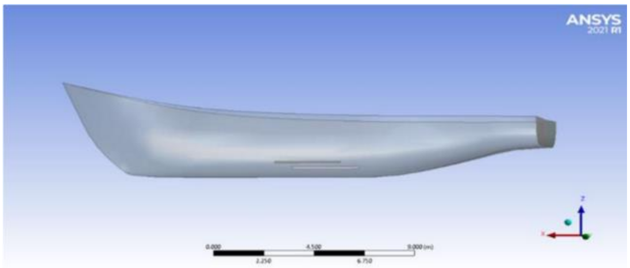

Figure 5. X-bow inspired trawler with bilge keel attached

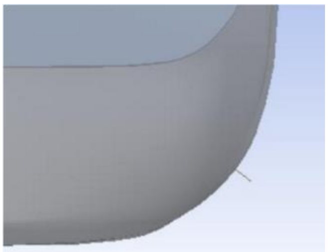

Figure 6. Transverse view of the bilge keel attached on a trawler

The same roll decay simulation was performed as before on the vessel with the bilge keel attached and compared to the model without bilge keel.

3. RESULTS AND DISCUSSION

3.1 Stern Wedge Resistance Results

The models with different stern wedge angles showed almost similar resistance values. The resistance values of various stern wedge angles were calculated and is shown below.

Table 2 Total resistance of models with various stern wedge angles

Speed (knots)	Total Resistance (N)			
	Without wedge	7° wedge	10° wedge	15° wedge
1	77.82	78.16	78.21	78.25
2	281.24	282.47	282.64	282.48
3	598.42	601.04	601.4	601.06
4	1025.81	1030.3	1030.93	1030.34
5	1589.95	1597.13	1598.2	1597.24
6	2454.67	2456.88	2469.06	2467.36
7	4020.29	4024.09	4049.39	4045.93
8	7765.08	7765.04	7827.77	7819.36
9	12840.91	12837.93	13013.44	12996.7
10	18496.23	18490.34	18663.69	18640.51
11	32828.48	32815.44	33161.04	33116.95
12	49631.93	49600.59	50270.14	50199.27

It is clear that the installation of 7° stern wedges on fishing vessels does provide a slight reduction in resistance for speeds above 8 knots with the resistance reduction increasing with speed. But, it also causes an increase in resistance by 1% at lower speeds.

3.2 Bilge Keel Roll Damping Results

The roll decay simulation was done for the trawler model with a heel angle of 37.5° and fixed trim of 0°. The model showed a roll period of 4.4 seconds and also come to a complete rest in 95 seconds respectively. To improve the seakeeping characteristics

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of this vessel and increase the roll period to a human comfortable range of 8-10 seconds a roll stabilizer such as bilge keel is necessary.

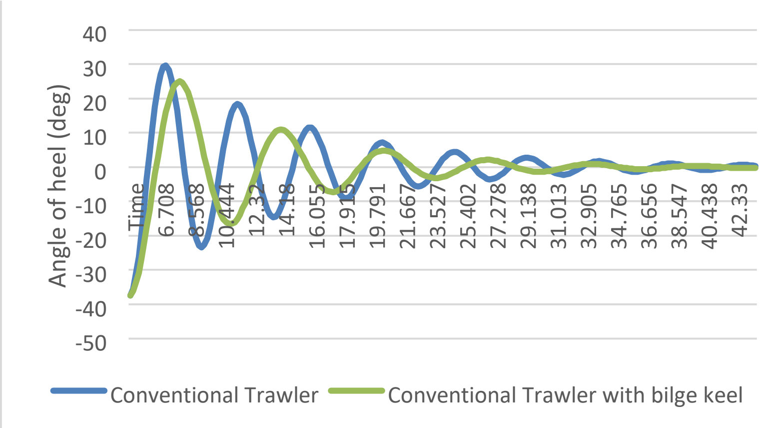

Figure 5. Roll decay simulation of conventional trawler with and without bilge keel attached

From figure 5 which represents roll decay simulation of the trawler it is clear that there is a significant increase in roll damping when bilge keel is attached for vessel. There is a clear increase in roll period and a reduction in amplitude for both cases with bilge keels. The roll period of the conventional trawler increased to 6.4 seconds from 4.4 seconds which is a 43% increase in roll period. There is also a 16% reduction in roll amplitude for the trawler when fitted with a bilge keel. The vessels with bilge keel comes to a complete rest in 67s compared to the original time 95 seconds.

The human range for comfortable roll period is from 8 to 10 seconds. When bilge keels are attached the vessel tends towards this comfort range. Therefore, bilge keels are necessary for the comfort of fishermen on onboard.

Table 1. Summary of percentage changes for trawler with bilge keel attached w.r.t trawler without bilge keel

Model	Percentage increase in roll period (%)	Percentage decrease in roll amplitude (%)	Percentage decrease in time to come to rest (%)
Trawler with bilge keel attached	43	16	29

4. CONCLUSIONS

Although the installation of 7° stern wedges on fishing vessels does provide a slight reduction in resistance for speeds above 8 knots with the resistance reduction increasing with speed, it also causes an increase in resistance by 1% at lower speeds. There the feasibility of stern wedges on fishing vessels are debatable and would require further research and development.

The installation of bilge keels on fishing vessels was found to have a significant influence on the roll motion of the vessels, boosting their safety and efficiency. When compared to normal trawlers, the installation of bilge keels increased roll period by at least 40% and reduced roll amplitude by 16%. As a result, such an enhancement can reduce the risk of capsizing caused by excessive roll motion in harsh sea and weather conditions, as well as improve the efficiency of equipment and fisherman onboard.

Due to the limitations of this study, the results are based on numerical analysis and will require further model and tank tests to confirm the results. Also, the location, geometry and angle of the bilge keel could cause improved performance. The most favourable of these factors for a trawler need to be found using further research. But, as far as this study is concerned bilge keel seems to be highly promising and worthy hull form optimizations for a fishing trawler.

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REFERENCES

1. Galappaththi, U.I.K., Jayathunga R.D.S., 2019 , *The Effect of Drag Force Reduction for Fuel Efficiency Optimization of Fishing Vessels* , Proceedings of the 6th Annual Research Symposium, University of Ruhuna.
2. Praveen, D.S.Ch., Kumar, S., Bhattacharyya, V., 2021 , Design study of stern tunnel wedge shapes for a low draft shallow water vessel, Taylor & Francis Group.
3. Kiryanto, Hadi, E.S., Firdhaus, A., 2019, *Total resistance analysis on bow form model ulstein X-bow with various angle of flare and stem angle*, Department of Naval Architecture, Faculty of Engineering, Diponegoro University, Semarang, Indonesia
4. Liu, W., Demirel, Y.K., Djantmiko, E.K.,2018, *Bilge keel design for the traditional fishing boats of Indonesia's East Java* , International Journal of Naval Architecture and Ocean Engineering.
5. Molland, A.F.,Turnock, S.R., Hudson, D.A., 2011, *Ship resistance and propulsion*, Cambridge, New York, Cambridge University press
6. Baiju M. V., Vipin Kumar V., Dhiju Das P. H., Muhammed Sherief P. S., Leela Edwin, 2017, *Mechanised Fishing Vessels of India*, Cochin, Central Institute of Fisheries Technology
7. Andersen, P. and Guldhammer, H. (1986), *Resistance Estimates – Guldhammer and Harvald's Method*, Fundamentals of Ship Hydrodynamics: Fluid Mechanics, Ship Resistance and Propulsion, John Wiley & Sons Ltd., Washington, DC, USA.