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Design 30 GT Catamaran Fishing Boat with Variations of Hull Type and Inter-Demihull Length for Minimum Resistance

Kiryanto, Mohd Ridwan, Berlian Arswendo Adietya, Deddy Chrismianto, Anggita Rahmadhani Ayuningtiyas

Abstract*: Fuel savings are closely related to ship resistance. Research on reducing resistance continues to be done in various ways, ranging from hull modification, optimization of the propulsion system and the addition of polymer substances. Resistance are also influenced by ship's velocity and variations of inter-demihulls length. This challenge has been widely discussed by experts, especially the variety of inter-demihull length. This research aims to analyze the 30 GT catamaran fishing boat resistance with variations in hull type and inter-demihull length. The main aim is to get the obstacle characteristics of these variations. The advantage of this research lies in the more varied shapes and inter-demihull lengths of each model where the characteristics of the obstacles will also vary, so that this research can later be an alternative for the community in the use of catamarans to increase fishing productivity. The study was conducted using CFD (Computational Fluid Dynamics). From the results, one of the most optimal form of the model is the type of hull Symmetrical Hard Chine with a variation of S / L 0.5 at maximum speed.Tthis model has a wave resistance value of 9.87 kN, a viscous resistance of 5.04 kN, and a total resistance value of 14.92 kN. Where there is a reduction of the wave resistance of 12.1%, viscous resistance of 1.5%, and a total resistance of 8.779% from the original model. Another advantage of this type for the Purseseine Boat is the use of a fairly wide deck for the laying of fishing gear.

***Keywords* : Catamaran, Demihull, Ship Resistance.**

I. INTRODUCTION

The North Coast of Central Java is an area famous for having abundant fishery resources with a coastline along 502.69 km.

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***** Correspondence Author

Kiryanto*, Naval Architecture Department, Diponegoro University, Semarang, Indonesia. Email: kiryanto_dst@yahoo.com

Mohd Ridwan, Naval Architecture Department, Diponegoro University, Semarang, Indonesia. Email: mridwan@yahoo.com

Berlian Arswendo Adietya, Naval Architecture Department, Diponegoro University, Semarang, Indonesia.. Email: berliankapal@gmail.com

Deddy Chrismianto*, Naval Architecture Department, Diponegoro University, Semarang, Indonesia. Email: deddy.chrismianto@ft.undip.ac.id

Anggita Rahmadhani Ayuningtiyas, Naval Architecure Department, Diponegoro University, Semarang, Indonesia. Email: anggita.rahmadhani@gmail.com

Sloping coastal conditions and relatively calm sea conditions make the pantura area of fishing center to be quite large in Indonesia.

Of course, in the process of fishing it requires transportation, which commonly uses vessels. Research on the reduction of resistance continues to be done in various ways, ranging from hull modification, optimization of the propulsion system and the addition of polymer substances. The obstacles are also affected by the velocity of the ship and variations in the distance between hulls. This challenge has been widely discussed by experts, especially variations in the distance between the hull. Several studies of the distance between the hull systematically have been examined. One study concluded that the change in distance between the two hulls of the catamaran had a significant interference effect on viscous resistance [1].

Catamarans are a type of ship that has two hulls (demihull) where the hull one with the other hull is connected with the bridging structure [2]. This type of ship can be operated at a relatively high speed and still has economically acceptable fuel consumption. Additional resistance due to waves on catamarans is small and the seakeeping quality is relatively good for operating at fast speeds between 25 - 40 Knots [3].

The calculation of resistance from catamaran vessels has been done before with a range of S / L join distance 0.2: 0.3: 0.4 and also variations in speed fr 0.1-0.10 this study results in the greatest resistance coefficient values owned by the distance between the hulls with an S / L ratio of 0.4 at a value of fr <0.3. Whereas for fn 0.3-0.4 the largest resistance coefficient is owned by the S / L ratio of 0.2. At fr 0,4-0,10 the value of the greatest resistance coefficient is owned by the distance between the hulls ratio S / L0.4 [4]. Resistance calculation is done with other variations, namely S / L 0.3; 0.35; 0.4 results from these studies are an increase in resistance of 53.92% at S / L 0.3 and 60.38% at S / L 0.4 [5]. Other studies conducted on the same S / L resulted in generally catamarans with S / L 0.4 smaller resistance than variations in demihull distances, although not for all Froude numbers. In contrast to variations in S / L = 0.2 and 0.3 at Fr = 0.19 - 0.46 catamaran S / L = 0.3 smaller the resistance compared to S / L = 0.2, but for Fr = 0, 46-0.65 is almost the same. And at the end Fr = 0.65 catamaran S / L = 0.3 has a smaller resistance [6]. Based on the explanation above, the author intends to conduct research on the analysis of resistance.

The expected result would be a more optimal variations based on the characteristics of the resistance. So that itcan be an alternative to increase fisherman productivity.

II. METHOD

The analysis process for this study uses the computational fluid dynamics (CFD) method. The simulation step consists of:

1. Pre-processor
2. Solver Manager
3. Post-processor

In addition to the use of CFD software, there is an understanding that comes from books, journals which are then put together in a literature study so that it can help research to remain in line with the results to be achieved.

A. Ship's Dimension

Table 1 shows the main dimension of Purseseine fishing boat which are the objects of this research:

Table 1. Main Dimension of Purse Seine Boat

No	Item	Dimension	Unit
1	LOA	16,35	m
2	LWL	15	m
3	BOA	6,69	m
4	B	1,71	m
5	T	1,55	m
6	H	2,72	m
7	Cb	0,53	
8	Δ	43,16	ton
9	Vs	8	knot

B. 3D Model Analysis

Ship modeling is done using a modeling software. The ship models are the Asymmetrical Straight Inside Round Bilge, Symmetrical Hard Chine, and Straight Asymmetrical Hard Outside Chine (Fig 1 – Fig 3); which are then converted to IGS. Previously there had been calculations of resistance values based on the hull design models. The results of this study are that: the smallest resistance value out of 3 catamaran hull models (inner flat hull, symmetry and outer flat hull) is the inner flat hull which has the smallest resistance value [7], [8], [9].

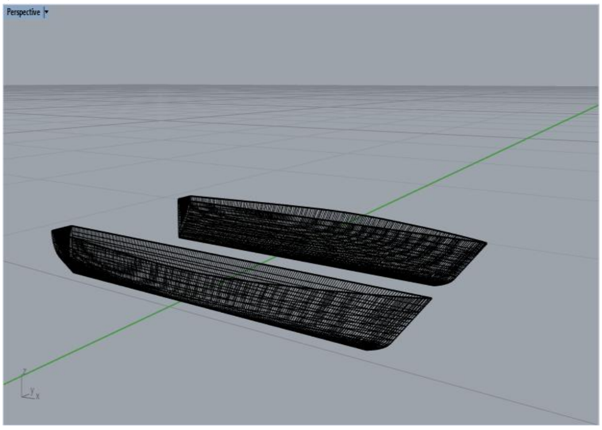

Fig. 1.Straight Asymmetrical Round Bilge Vessel Model

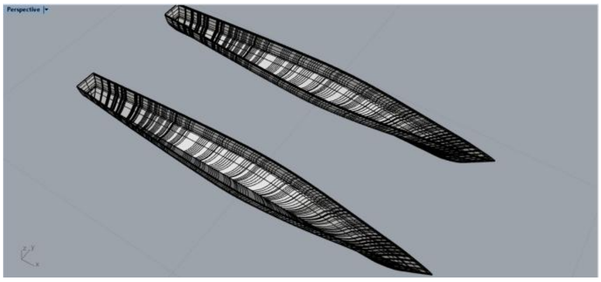

Fig. 2.Symmetrical Hard Chine Vessel Model

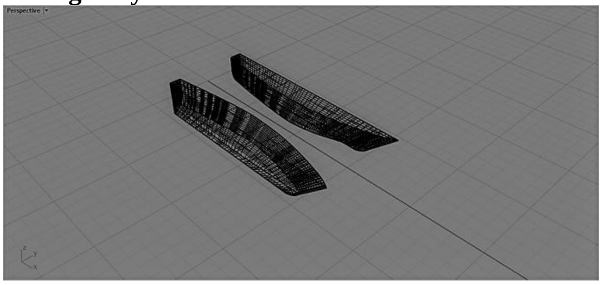

Fig. 3.Asymmetrical Outer Hard Hard Chine Vessel Model

C. Research Object Treatment

This research is focused on the effects caused after S / L variation of 0.35; 0.4; 0.5. The parameters gained are:

Fixed parameters:

1. Dimension Properties on the hull of the ship

Variable parameters:

1. Distance between the hull (S)
2. Vs based on Fr

This research was also conducted at the Computer Aided Ship Planning Laboratory in the Department of Naval Architecture Engineering using a ship modeling software and Tdyn 12 trial software. In this research, a PC with CPU (Central Processing Unit) specifications is used as follows:

1. Processor: Intel - Core i5 - 7200U - Dual Core
2. Memory: 1 TB
3. VGA: GeForce 920MX

III. RESULT AND DISCUSSION

After the model is made using a ship modeling software, then from the three models each made a variation of S / L 0.35; S / L 0.4; S / L 0.5. Fig 4 – Fig 12 show demihull models depend on variation of S/L.

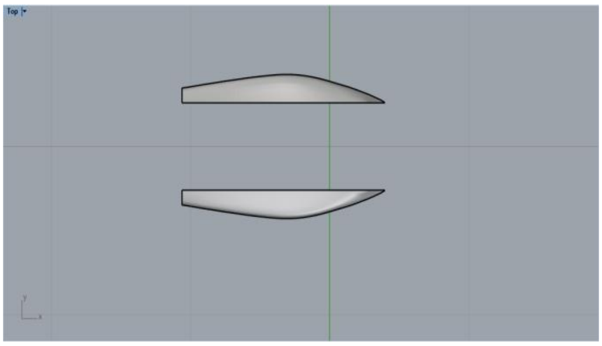

Fig. 4.Straight Asymmetrical Round Bilge In S/ L 0.35

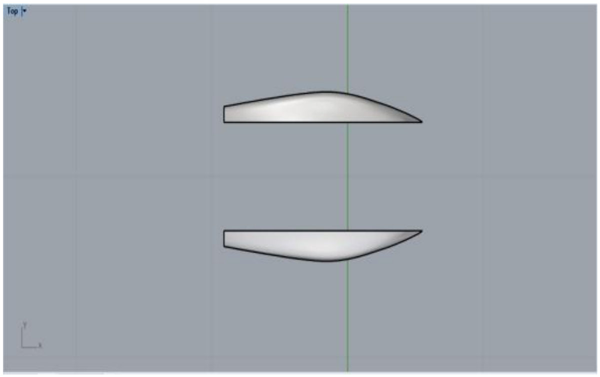

Fig. 5.Straight Asymmetrical Round Bilge in S/L 0,40

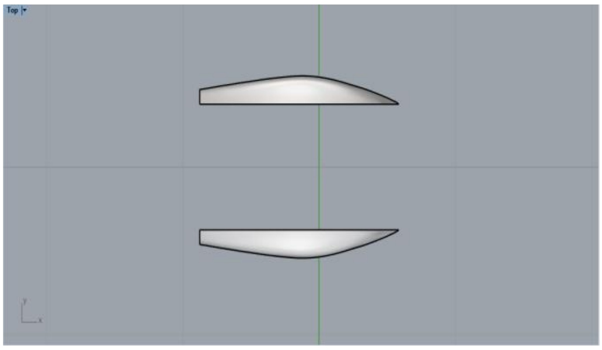

Fig. 6.Straight Asymmetrical Round Bilge in S/L 0,50

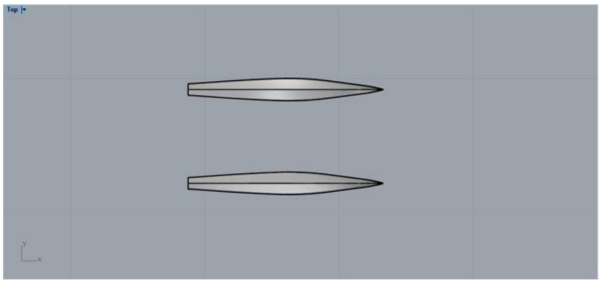

Fig. 7.Symmetrical Hard Chine in S/L 0,35

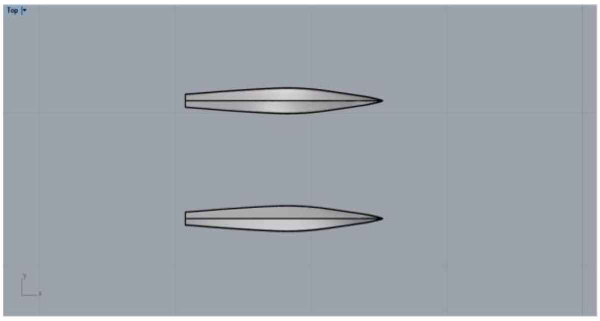

Fig. 8.Symmetrical Hard Chine in S/L 0,40

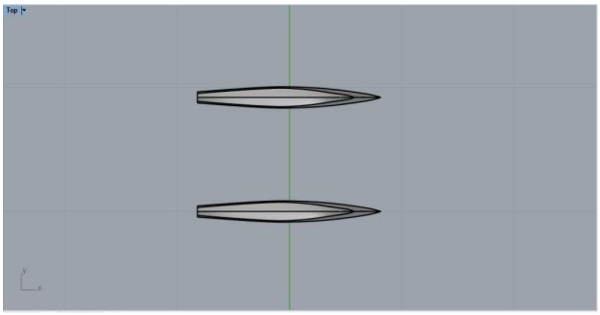

Fig. 9.Symmetrical Hard Chine in S/L 0,50

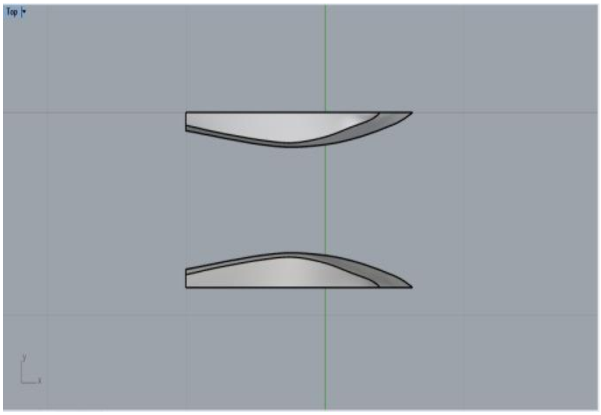

Fig. 10. Asymmetrical Outer Hard Hard Chine in S/L 0,35

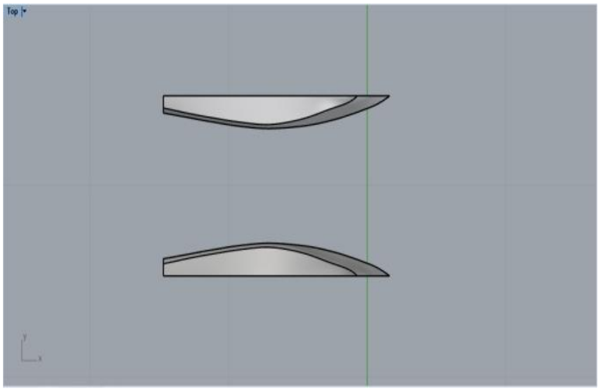

Fig. 11. Asymmetrical Outer Hard Hard Chine in S/L 0,40

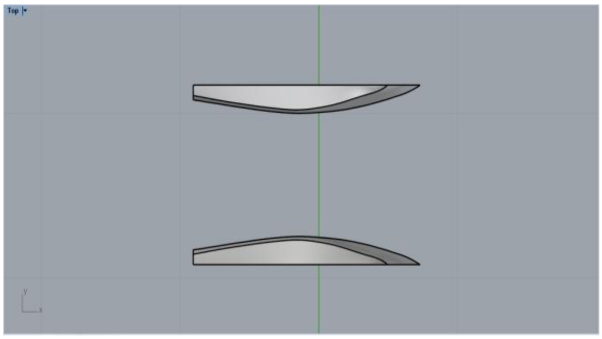

Fig. 12. Asymmetrical Outer Hard Hard Chine in S/L 0,50

A. Resistance Calculation

Ship resistance is the drag force of the fluid media which is passed by the ship when operating at a certain speed. Ship resistance analysis using Tdyn Software is carried out before and after S / L variations. This analysis is carried out with 3 variations of speed (Table 2).

Table 2. Variation of speed vessels

No	Froude Number	Full Speed	Speed Model
1	0,3	3,601 m/s	1,151 m/s
2	0,33	4,115 m/s	1,266 m/s
3	0,43	5,144 m/s	1,649 m/s

Table 3. Wave resistance of the CFD simulation results

Model Design	*Fr*	*S/L*	*Original Rw(kN)*	*S/L*	*Variation Rw(kN)*
RB As In	0,3	0.2	6,3307	0,35	6,19
	0,33		7,29		7,26
	0,43		14,4		14,1
	0,3			0,4	6,15
	0,33				6,96
	0,43				13,97
	0,3			0,5	5,93
	0,33				6,86
	0,43				13,18
HC Sim	0,3	0.2	4.04	0,35	3.99
	0,33		4.52		4.61
	0,43		11.23		10.7
	0,3			0,4	3.95
	0,33				4.56
	0,43				10.2
	0,3			0,5	3.95
	0,33				4.54
	0,43				9.87
HC As Out	0,3	0.2	5,47	0,35	5,45
	0,33		6,58		6,38
	0,43		13,8		14,36
	0,3			0,4	5,14
	0,33				6,19
	0,43				12,65
	0,3			0,5	5,14
	0,33				6,13
	0,43				12,38

Table 3 and Fig 13 – Fig 15 can be seen that at the condition of the Fr (0.3 - 0.43) velocity, all variations of the hull type in the S / L variation (0.35; 0.4; 0.5) have increased due to the higher speed, the pressure of the wave will also increase, but from the above results after the variation of S / L wave resistance, all types of hull's resistance has decreased from the original model. The decrease can be seen in the correction table. In the Asymmetric Outer Straight Hard Chine hull variations at S / L 0.35, the maximum speed in the (condition of Fr (0.43)) has increased from the initial model before variation. The wave resistance increases if the velocity (Fr) increases up to Fr 0.43. due to the re-formation of waves in the middle of the hull. In the above conditions when the demihull distance is widened again in the S / L variation (0.4; 0.5) the wave resistance decreases due to wave breaking and spray. In previous studies, it has happened where for one S / L configuration, the wave resistance increases if the velocity (Fr) increases up to Fr ≈ 0.5. At Fr 0.5 the value of the wave resistance will begin to decrease because there is also the influence of the wave on demihull.

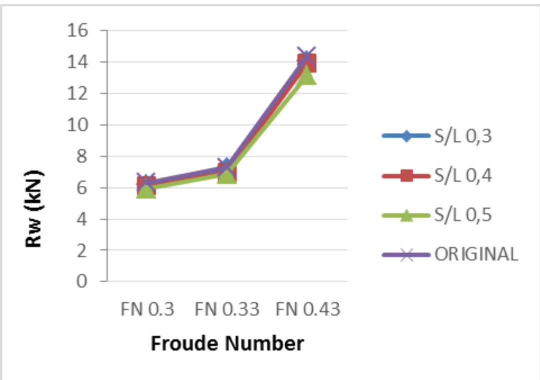

Fig. 13. Wave resistance result on Straight Asymmetrical Round Bilge

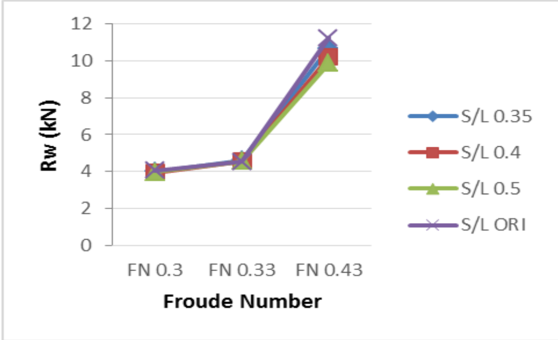

Fig. 14. Wave resistance result on Symmetrical Hard Chine

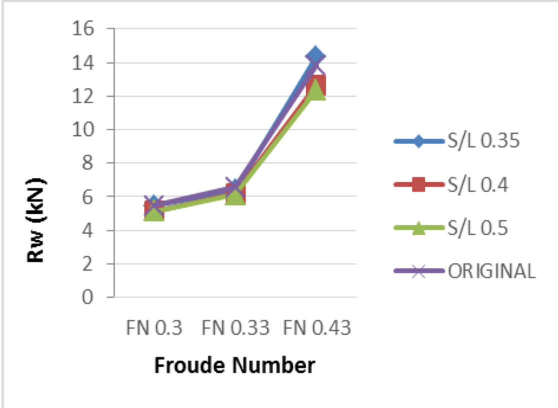

Fig. 15. Wave resistance result on Asymmetrical Outer Hard Hard Chine

Table 4. Viscous Force of the CFD simulation results

Model Design	*Fr*	*S/L*	*Original Rv(kN)*	*S/L*	*Variation Rv(kN)*
RB As In	0,3	0.2	2.92	0,35	2.82
	0,33		3.46		3.33
	0,43		5.60		5.36
	0,3			0,4	2.92
	0,33				3.46
	0,43				5.59
	0,3			0,5	2.92
	0,33				3.46
	0,43				5.59
HC Sim	0,3	0.2	2,63	0,35	2,62
	0,33		3,12		3,11
	0,43		5,11		5,06
	0,3			0,4	2,61
	0,33				3,10
	0,43				5,04
	0,3			0,5	2,61
	0,33				3,10
	0,43				5,04
HC As Out	0,3	0.2	2,70	0,35	2,71
	0,33		3,19		3,21
	0,43		6,39		5,20
	0,3			0,4	2,61
	0,33				2,71
	0,43				3,20
	0,3			0,5	2,70
	0,33				3,19
	0,43				5,13

Table 4 and Fig 16 – Fig 18 can be seen that at the condition of Fr (0.3-0.43) all hull variations in S / L (0.35; 0.4; 0.5) experience a decreased number compared to the model before the variation. But we can see that the higher the speed of the viscous resistance rises due to more surface of hulls are exposed to sea water. In previous studies, it had occurred where during the process of increasing the viscous resistance at Fr = 0.18 - 0.65 the value of Rv will always be increased. The magnitude of Rv between midel NB and B2 is 0.02% and NB and B4 are 0.03% at Fn 0.66. Viscous resistance continues to rise along with the increase in speed because the higher the speed, the greater the friction force is also in accordance with Newton II's law [10].

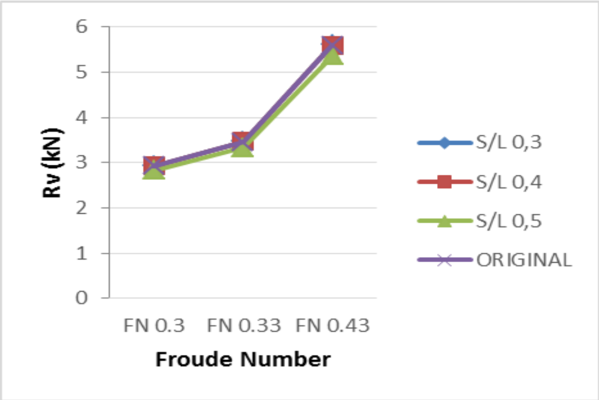

Fig. 16. Viscous resistance result on Straight Asymmetrical Round Bilge

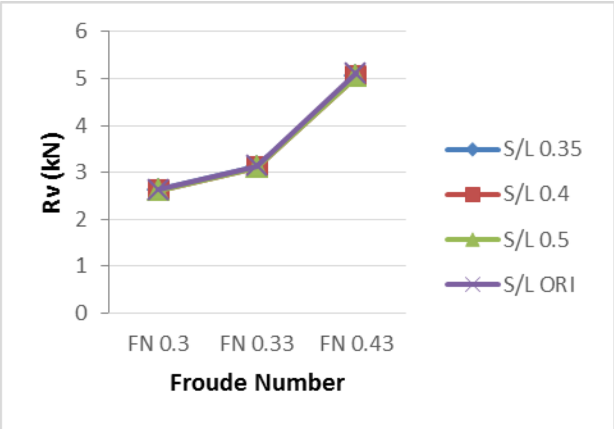

Fig. 17. Viscous resistance result on Symmetrical Hard Chine

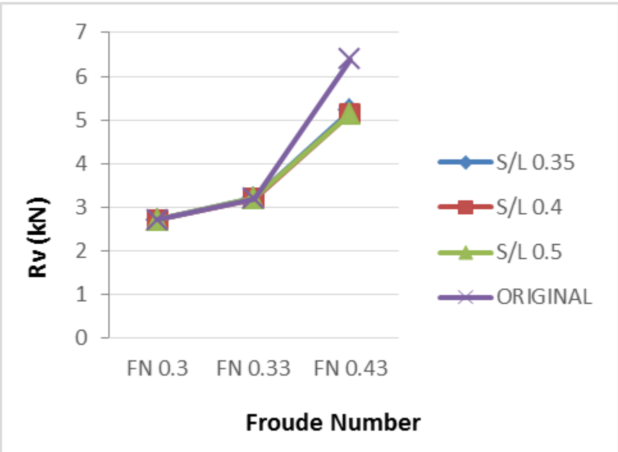

Fig. 18. Viscous resistance result on Asymmetrical Outer Hard Hard Chine

Table 5. Total Resistance of the CFD simulation results

Model Design	*Fr*	*S/L*	*Original Rt(kN)*	*S/L*	*Variation Rt(kN)*
RB As In	0,3	0.2	9,25	0,35	9,12
	0,33		10,75		10,73
	0,43		19,99		19,71
	0,3			0,4	9,08
	0,33				10,43
	0,43				19,57
	0,3			0,5	8,76
	0,33				10,20
	0,43				18,55
HC Sim	0,3	0.2	2,63	0,35	6,62
	0,33		3,12		7,72
	0,43		5,11		15,76
	0,3			0,4	6,56
	0,33				7,66
	0,43				15,26
	0,3			0,5	6,57
	0,33				7,65
	0,43				14,92
HC As Out	0,3	0.2	2,70	0,35	8,16
	0,33		3,19		9,59
	0,43		6,39		19,57
	0,3			0,4	7,84
	0,33				9,39
	0,43				17,52
	0,3			0,5	7,84
	0,33				9,59
	0,43				17,79

Table 5 and Fig 19 – Fig 21 can be found that the total resistance of all variations of S / L (0.35; 0.4; 0.5) under Fr (0.3 - 0.43) decreases. Due to the value of the wave resistance and viscosity resistance has decreased.

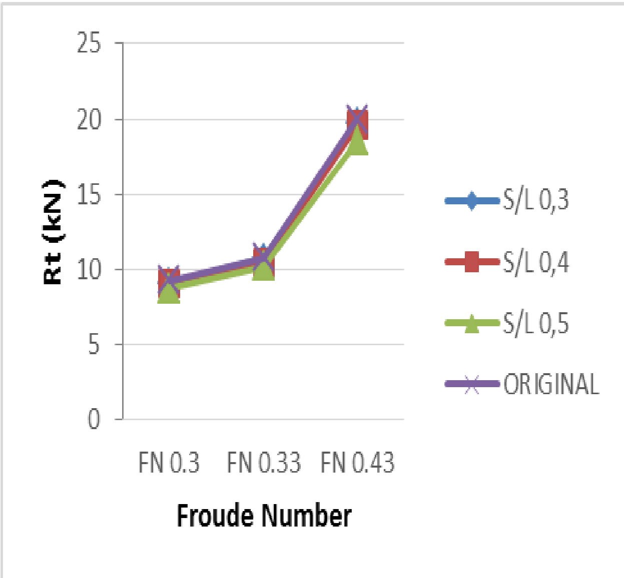

Fig. 19. Total resistance result on Straight Asymmetrical Round Bilge

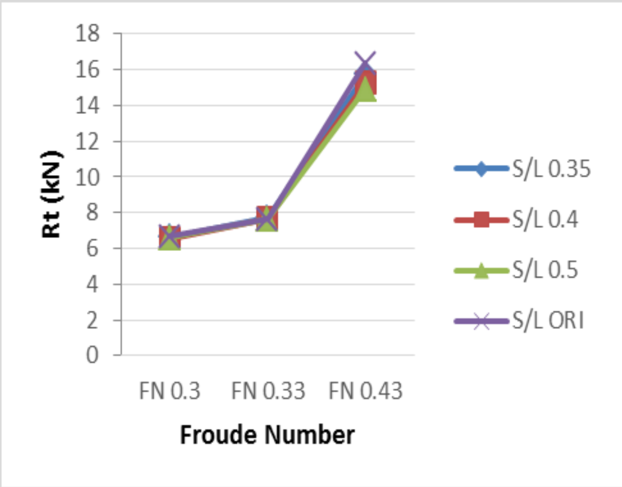

Fig. 20. Total resistance result on Symmetrical Hard Chine.

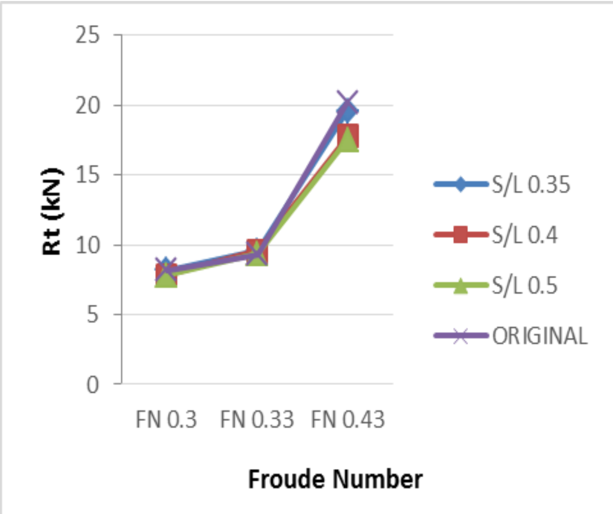

Fig. 21. Total resistance result on Asymmetrical Outer Hard Hard Chine.

Based on the results in Table 3 – Table 5 of the three variations of the merge shape and variations of the S / L form, all of them tends to be the same. These results indicate the magnitude types of resistance obtained through CFD simulations, are very influential on changes in S / L. Based on the purpose of this study, the results of this simulation can be said to be successful. Previous studies have performed obstacle calculations. The results of the resistance analysis show that the smaller the clearance (S / L) and the faster the speed the greater the resistance will be [11]. And the greater the distance of the gastric separator (S / L), the smaller the drag caused by the average [12].

B. Wave Elevation

Generally there are four components of the wave on the ship, namely: the bow wave system, the bow shoulder wave system, the stern shoulder wave system and the stern wave system [13]. Fig 22 is the result of a simulation on "wave pattern" for variations in the catamaran hull with (S / L = 0.35 - 0.5) at 0.43 Froude numbers.

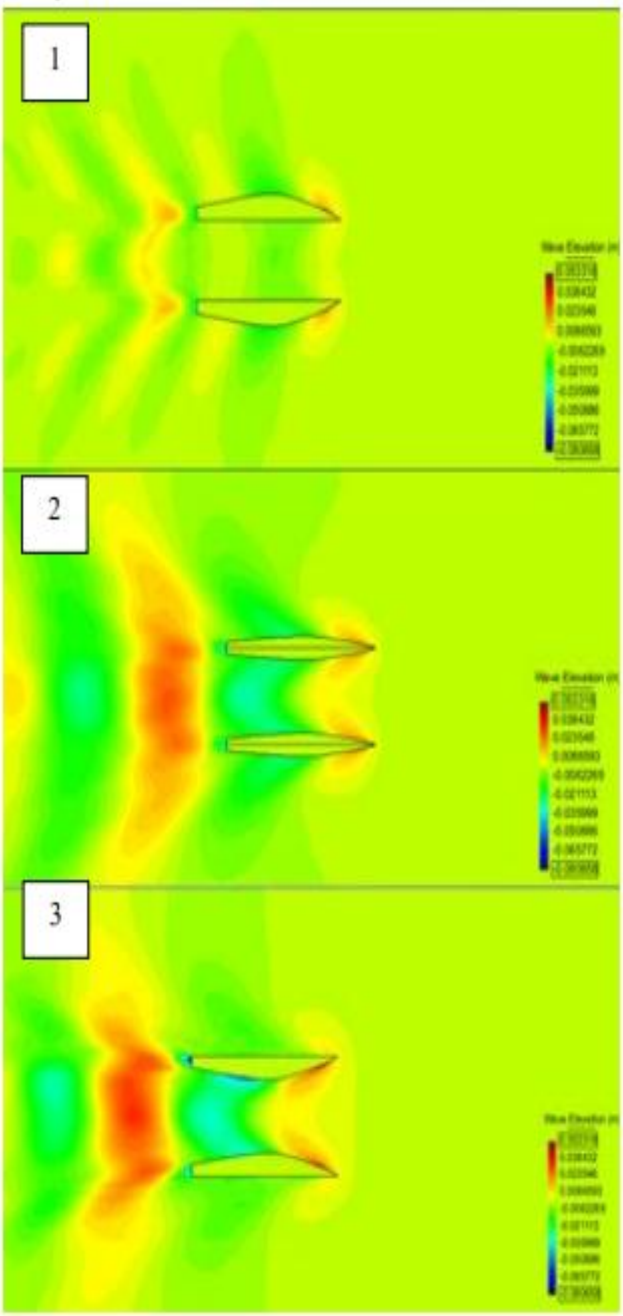

Fig. 22. Wave elevation on Straight asymmetrical Round Bilge, symmetrical Hard Chine, Asymmetrical Outer Hard Hard Chine S/L 0.35 Fr. 0.43

It can see based on Fig 23 if it's linked to table 5, the differences caused by types of hull is very clear. In model 1 (Asymmetrical Round Straight Round Bilge) there is s pressure on the shoulder of the bow where the point of the waves meet is on the bow. But the blue waves are only on the stern so that the value of the resistance produced is greater, whereas in the second model (Hard Chine Symmetrical), it has a pressure on the bow and there is a low wave pressure in the center of the ship. While the third model (Asymmetrical Outer Straight Hard Chine) reflects a pressure on the shoulder of the inner bow. Both of these models have a meeting point of the wave slightly backward, so that the total resistance value in the yield is relatively small [14}, [15].

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The meeting point of the pressure will hamper the flow of the vessel because catamaran has a flow on the inside; between the hulls. Which is different from a monohull vessel where the flow of water is on the outside. So the resistance of the catamaran is located between the hull distance on the inside. Previous studies have concluded that the results of these simulations show changes in wave pressure and elevation in the distance between the hulls. Changes in pattern (characteristics) of waves are also influenced by changes in the distance between the hulls (S / L). This is caused by the disturbance of flow velocity and the pressure around the hull increases, especially in the inner area [16].

IV. CONCLUSION

It can be concluded from the CFD simulation results above we can find the most optimal catamaran hull design if a catamaran ship is designed with Hard Chine Symmetrical hull with a variation of S / L 0.5. Judging from the resistance characteristics, this model has a wave resistance value of 9.87 kN, a viscous resistance of 5.04 kN, and a total resistance value of 14.92 kN. Where there is a reduction of the wave resistance of 12.1%, viscous resistance of 1.5%, and a total resistance of 8.779% from the original model. Another advantage of this type of catamaran for the Purseseine Boat is the use of a fairly wide deck for the laying of fishing gear, efficient use of fuel due to reduced ship resistance.

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AUTHORS PROFILE

Kiryanto was born in 1960, at Bojonegoro, East Java, Indonesia. He received master degree of mechanical in Sepuluh Nopember Institute of Technology, Surabaya, East Java, Indonesia. Currently, he works at the Department of Naval Architecture, Faculty of Engineering, Diponegoro University. His research interests are mechanical and fishing boat design.

Dr. Mohd Ridwan was born in 1971, at Padang, West Sumatera, Indonesia. He received doctor degree of science of ocean in Diponegoro University, Semarang, Central Java, Indonesia. Currently, he works at the Department of Naval Architecture, Faculty of Engineering, Diponegoro University. His research interests are fishing boat and sea transportation.

Berlian Arswendo Adietya was born in 1985, at Semarang, Central Java, Indonesia. He received master degree of ship production and material in Sepuluh Nopember Institute of Technology, Surabaya, East Java, Indonesia. Currently, he works at the Department of Naval Architecture, Faculty of Engineering, Diponegoro University. His research interests are ship production and ship design.

Dr Eng Deddy Chrismianto was born in 1973, at Surabaya City, East Java, Indonesia. He received doctor degree of naval architecture and marine systems engineering in Pukyong National University, Busan, South Korea. Currently, he works at the Department of Naval Architecture, Faculty of Engineering, Diponegoro University. His research interests are ship design and computer aided design.

Anggita Rahmadhani Ayuningtiyas is currently an Undergraduate Student at Department of Naval Architecture, Faculty of Engineering, Diponegoro University, Indonesia. His current research interest, ship design and computer aided design.

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