Research on Resistance of Some Typical Fishing Vessels in Vietnam

Hoang Cong Liem(✉) and Nguyen Duc Manh

Hanoi University of Science and Technology, Hanoi, Vietnam
liem.hoangcong@hust.edu.vn

Abstract. Vietnam has a coastline of about 3260 km in length with an exclusive economic zone of about 1 million square kilometers. Favorable natural conditions bring advantages to the fishing industry with a catching output of about 3.8 million tons in 2020. Vietnam's fishing fleet is relatively large with about 95,000 vessels, but the large number is small, wooden shell ships with a limited operating range. Number of offshore fishing vessels with the length over 24 m accounts for small number while the expected scale needs to be much larger. In ship design, resistance of ship plays very importance role in designing ship hull form. This research was focused on calculating total resistance of 4 typical fishing vessels. The four vessels which have same displacement volume and velocity were selected. Total resistance of these vessels were obtained from simulation results which was carried out by using Star-CCM+.

Keywords: Ship resistance · Fishing vessel · Computational fluid dynamics

1 Introduction

Vietnam has a coastline of about 3260 km in length with an exclusive economic zone of about 1 million square kilometers. Favorable natural conditions bring advantages to the fishing industry with a catching output of about 3.8 million tons in 2020. Vietnam's fishing fleet is relatively large with about 95,000 vessels, but the large number is small, wooden shell ships with a limited operating range. Ships with the length above 24 m is about 2600 ships (about 2.7% in total). Thus, it can be seen that the number of offshore fishing vessels with the length over 24 m accounts for small number while the expected scale needs to be much larger. Based on that fact, Vietnamese government has No 67 decree to support building new steel fishing vessels. A large number of fishing vessels have been built by applying this decree with the aim of modernizing fleet of fishing vessels.

In design field, ship resistance plays very importance role in designing ship hull shape. Ship resistance will be associated with fuel consumption. Small ship resistance means small fuel consumption, better economic efficiency in operation and less CO2 emissions to the environment. Based on lines plan, fishing vessels have relatively larger resistance in comparation with common cargo ship of the same operating velocity. Therefore, researching and proposing a good lines plan for fishing vessel is always an important task for designers. In the world, studies about resistance of ship are very popular.

A.-T. Le et al. (Eds.): RCTEMME 2021, LNME, pp. 528–541, 2022.
https://doi.org/10.1007/978-981-19-1968-8_44

Researchers can carry out their research by doing experiments, running numerical simulations, or combining of theoretical research and practical research. C.L. Hoang, Y. Toda, Y. Sanada measured total ship resistance of a real ship by carrying out experiment with cement carrier Pacific Seagull [1]. K.S. Min and S.H. Kang proposed a new extrapolation procedure for the prediction of full-scale ship resistance performance and validated proposed procedure by model test results [2]. Some studies that calculate ship resistance by theoretical method can be listed as follow: H.C. Liem et.al used form factor coefficient to calculate resistance of real container ship with specific turning angle based on simulation results of model [3]; M. Bilec and C.D.Obreja used Holtrop-Mennen method to calculate ship resistance and predict power of a fishing vessel [4]. L. Yan et.al optimized Hull form design of twin-skeg fishing vessel for minimum resistance by using computational fluid dynamics calculation and surrogate model [5]. M. A. Ali et al. predicted resistance of two fishing vessels by combining of practical and theoretical research [6]. In order to propose the lines plan with minimum ship resistance, "research on resistance of some typical fishing vessels in Vietnam" will be carried out by using computational fluid dynamics for four models of fishing vessel.

2 Numerical Modeling

2.1 Geometric Model

In this study, models were selected based on the following criteria:

- Widely used for steel fishing vessels
- Displacement volume is about 250 m^3
- Operating velocity is 12 knots.

3D-models were built and adjusted by using Rihno software and Autoship software. The displacement volume of all models was adjusted by geometrical similarity and was set approximately about 250 m^3. Table 1 shows principal particulars of the four models.

Table 1. Principal particulars of models

Name	Model No. 1	Model No. 2	Model No. 3	Model No. 4
Loa (m)	29.14	29.74	28.40	25.40
Lpp (m)	27.06	26.84	25.60	22.61
B (m)	6.916	7.24	8.64	7.32
D (m)	2.963	3.77	3.73	3.20
d (m)	2.386	2.607	2.781	2.337
Cb	0.489	0.450	0.414	0.597
V (m^3)	248.53	249.54	249.60	249.31

Where,

Loa: Length over all of ship,
Lpp: Length between perpendiculars of ship,
B: Ship breadth,
D: Ship depth,
d: Ship draft,
Cb: Block coefficient.
V: volume of displacement.

As shown in Table 1, model No.1 has the smallest displacement volume with 248.53 m^3 while model No. 3 has the biggest displacement volume with 249.60 m^3. The difference in displacement volume between two models is less than 0.5%.

Lines plan of model No. 1 to model No. 4 are shown from Fig. 1 to Fig. 4, respectively. Model No. 1 and No. 2 have round bilge, however, bilge radius of model No. 2 is much larger than model No. 1. Model No. 2 has V - shaped sections while model No 1 has both V and U- shaped sections. Model No. 3 has three chine hull and shallow V- shaped form in the bottom. Model No. 4 is multichine hull with U- shaped sections.

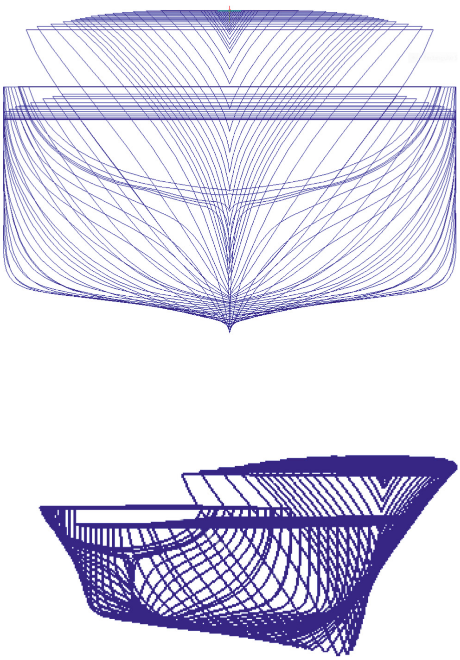


Fig. 1. Lines plan of model No. 1

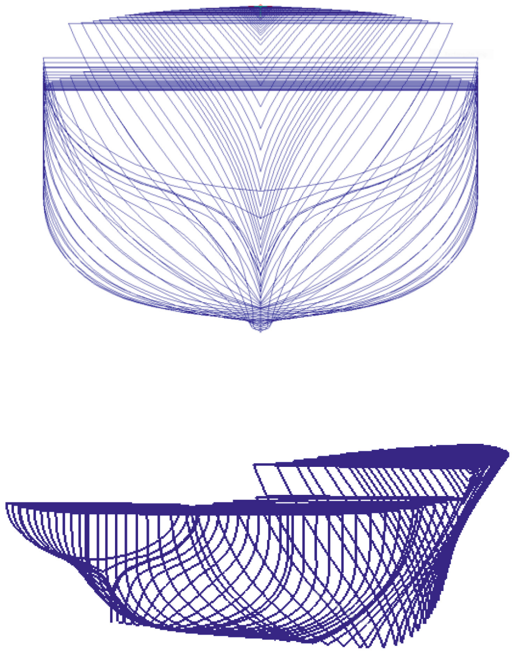


Fig. 2. Lines plan of model No. 2

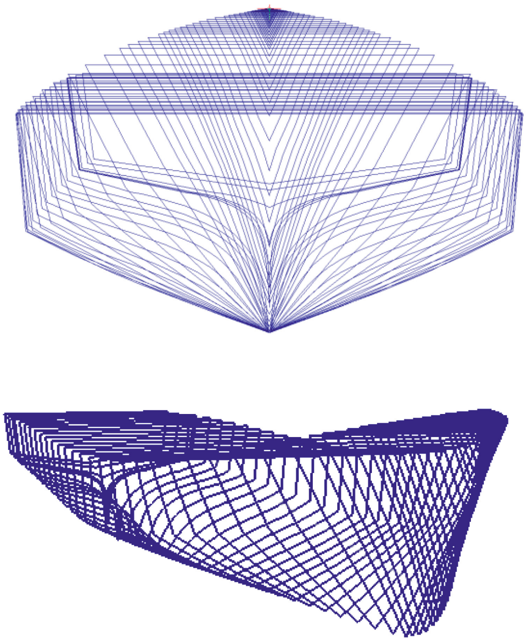


Fig. 3. Lines plan of model No. 3

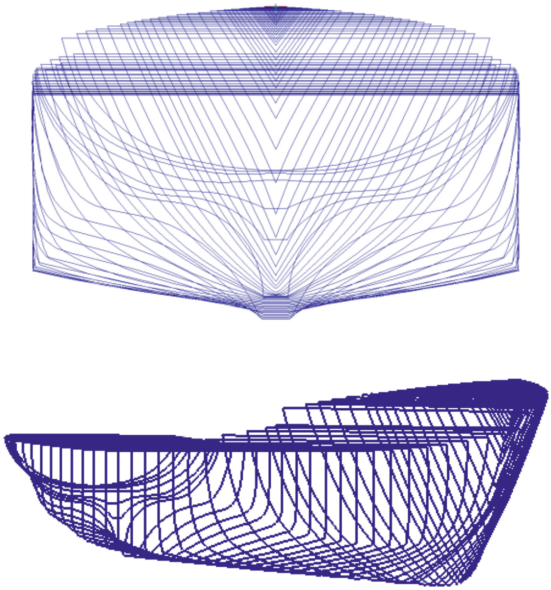


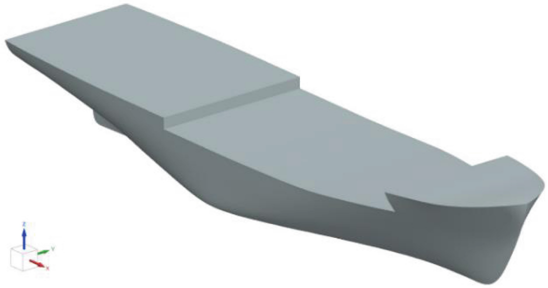
Fig. 4. Lines plan of model No. 4

As mentioned before, the four models were built by using Rihno software. Figure 5 shows hull form of fishing vessels in 3D of model No. 1 to No. 4, respectively.

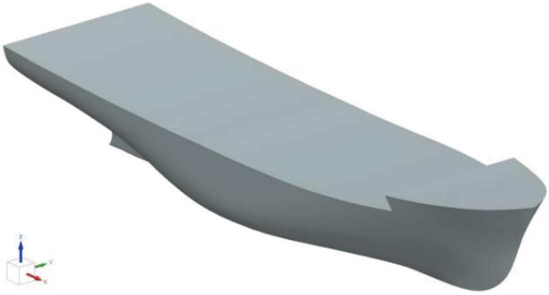
2.2 Computational Domain

The simulation was carried out using Star CCM+. The four models were selected for simulation. The simulation was carried out with real ship dimentions. The setting of the computational domain was as follow: longitudinal distance: -120 m $< x <$ 70 m; transversal distance -60 m $< y <$ 60 m; vertical distance -50 m $< z <$ 31 m. Figure 6 shows the computational domain for simulation. Overset region was created in computational domain to simulate ship motions. Overset region has box shape with dimensions in x, y, z direction equal to the length, breadth, and depth of ship plus 5 m. The advantage of overset region is to allow relative movements between diffrent parts.

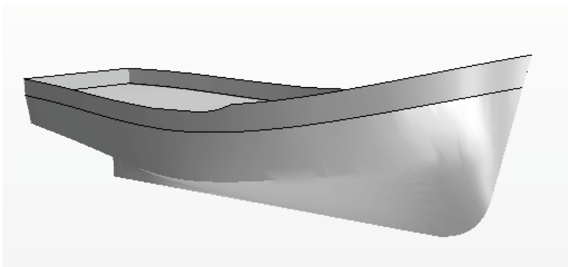
The mesh was generated by using the automated mesh process offered by Star-CCM+. Table 2 shows the total number of cells for simulation cases.



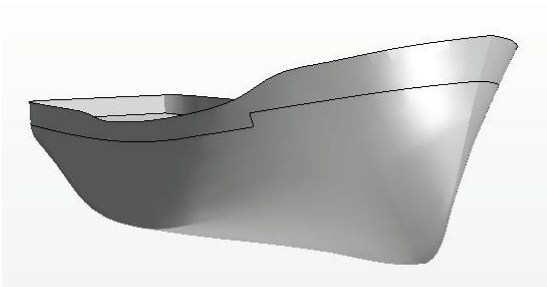
a. Model No.1



b. Model No.2



c. Model No.3



d. Model No.4

Fig. 5. Ship hull

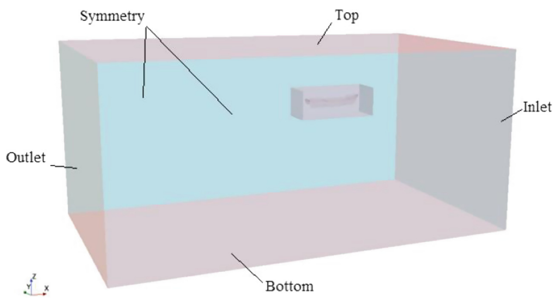


Fig. 6. Computational domain

Table 2. Total number of cells

	Model No. 1	Model No. 2	Model No. 3	Model No. 4
Simulation domain	624,505	633,407	677,684	912,449
Overset	996,542	1,025,313	1,031,833	666,875
Total	1,621,047	1,658,720	1,709,517	1,579,324

Figure 7a, 7b, 7c, 7d shows The inner trimmed volume mesh which is displayed on the two planar sections and volume mesh on body surface of model No. 1 to No. 4, respectively.

2.3 Boundary Condition

The boundary condition using in simulation was velocity inlet, pressure outlet. The inlet, top and bottom of the tank were set to a velocity inlet. The velocity at the inlet was 12 knots (6.17 m/s) which was equivalent to velocity of the ship. The tank bottom was set to a pressure outlet. The tank side was set to symmetry plane. K-ε turbulence model was used throughout the simulation.

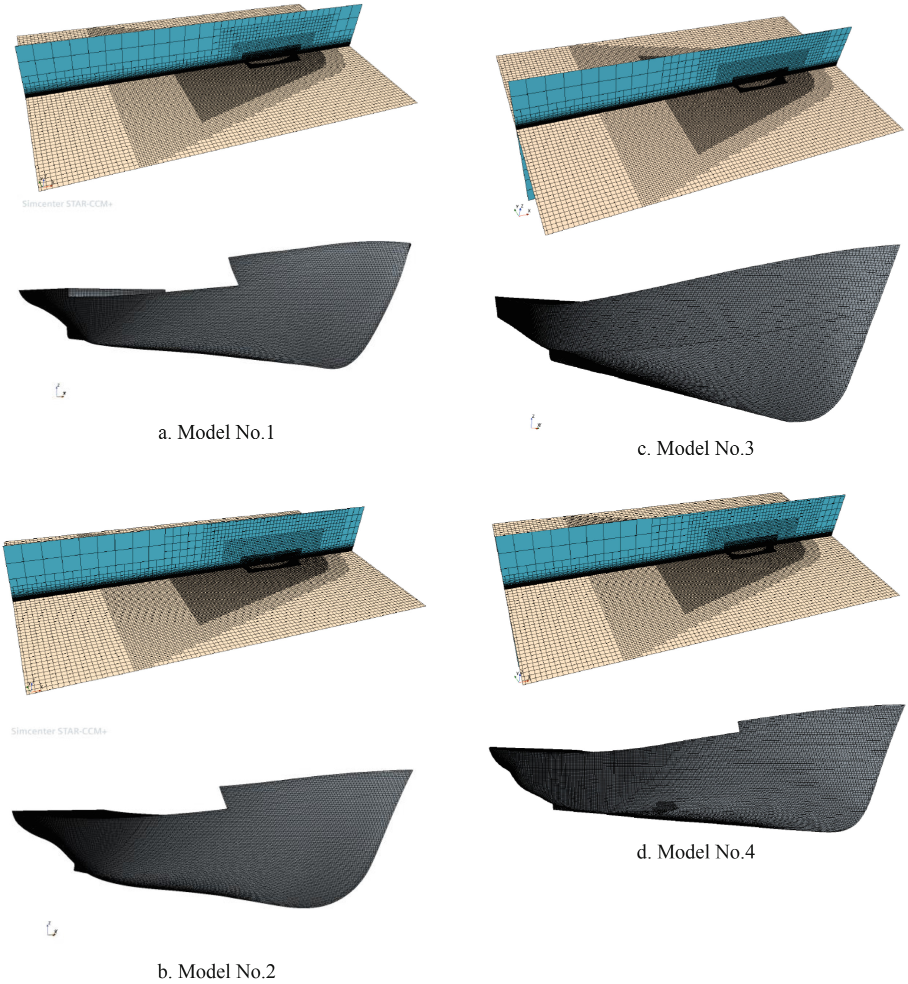
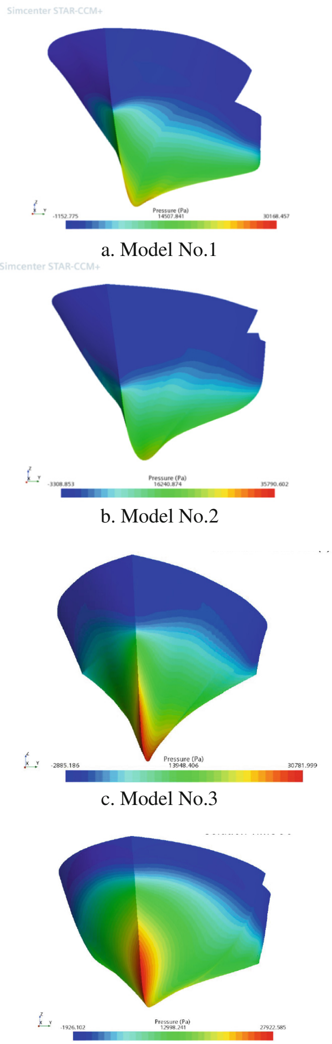


Fig. 7. Hull mesh

3 Results

3.1 Simulation Results

Figure 8 and Fig. 9 show the distribution of pressure around the ship hull with the view from the top, the side of the model, respectively. Figure 10 shows wave pattern around the ship hull.



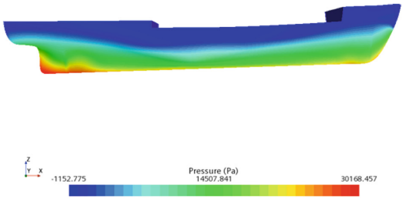
a. Model No.1

b. Model No.2

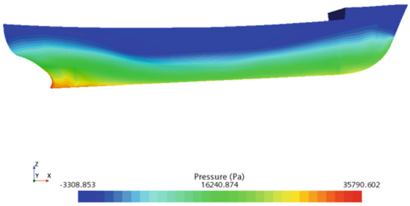
c. Model No.3

d. Model No.4

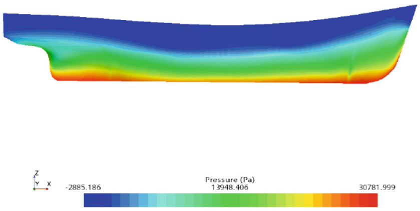
Fig. 8. Pressure distribution (front view)



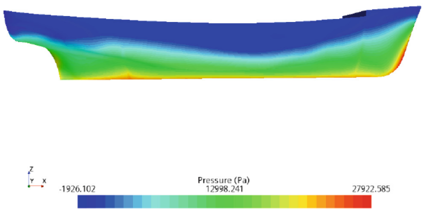
a. Model No.1



b. Model No.2

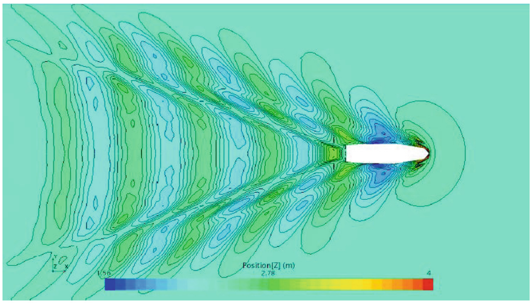


c. Model No.3

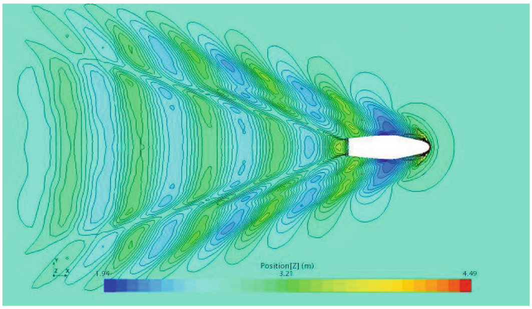


d. Model No.4

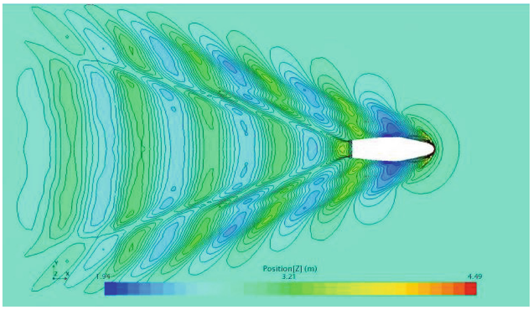
Fig. 9. Pressure distribution (side view)



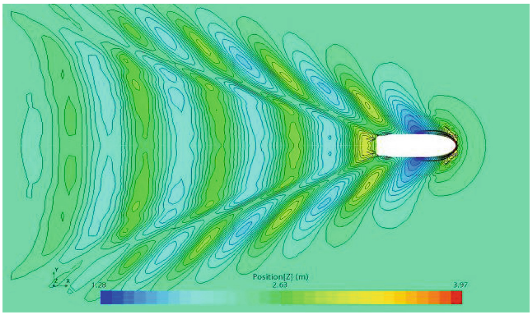
a. Model No.1



b. Model No.2



c. Model No.3



d. Model No.4

Fig. 10. Wave pattern around the ship hull

Table 3. Total resistance

Name	Model No. 1	Model No. 2	Model No. 3	Model No. 4
R (KN)	36.7	46.5	48.5	60.4

Table 3 shows the total resistance of the four models. Where, R is total resistance. It can be seen from the table, total resistance of model No. 1 is smallest with 36.7 KN while total resistance of model No. 4 is biggest with 60.4 KN.

3.2 Validation Study

In order to validate the result, total resistance of the first model was calculated by using Maxsurf software. Table 4 shows the total resistance of Model No. 1 which was calculated using Maxsurf software. As shown in Table 4, total resistance of Model No. 1 is 35 KN at the ship velocity of 12 knots. The difference between calculated result and simulation result is 1.7 KN (about 4.6%). It can be said that the simulation result agrees quite well with the calculated result.

Table 4. Total resistance of model No. 1

Speed (kn)	Froude No. LWL	Froud No. Vol.	Holtrop resist. (kN)
10.8	0.341	0.707	19.1
10.9	0.344	0.713	20.1
11	0.347	0.720	21.0
11.1	0.350	0.727	22.1
11.2	0.354	0.733	23.2
11.3	0.357	0.740	24.4
11.4	0.360	0.746	25.7
11.5	0.363	0.753	27.1
11.6	0.366	0.759	28.5
11.7	0.369	0.766	30.0
11.8	0.373	0.772	31.6
11.9	0.376	0.779	33.2
12	0.379	0.785	35.0
12.1	0.382	0.792	36.8

Table 5. Main parameters for analyzing result

Name	Model No. 1	Model No. 2	Model No. 3	Model No. 4
Loa (m)	29.135	29.74	28.4	25.4
Lpp (m)	27.067	26.84	25.6	22.61
B (m)	6.961	7.24	8.64	7.32
D (m)	2.963	3.77	3.73	3.2
d (m)	2.386	2.607	2.781	2.337
v (m/s)	6.17	6.17	6.17	6.17
V (m^3)	248.53	249.54	249.6	249.31
ω (m^2)	220.83	216.17	237.87	206.33
Re	139169491	138002333	131626666	116253083
C_F	0.001987	0.001989	0.002002	0.002038
Cb	0.489	0.45	0.414	0.597
Fn	0.3788	0.3804	0.3896	0.4145
Sc	0.03630	0.03585	0.03418	0.03023
R (KN)	36.7	46.5	48.5	60.4

3.3 Result Analysis

The resistance of a ship at a given speed is the fluid force acting on the ship in such a way as to oppose its motion. The total resistance can be split into brief components such as: frictional resistance, viscous pressure resistance and wavemaking resistance. In order to have better understanding about the difference of total resistance of the four models, all parameters such as: principal dimensions, Froude number, Reynold number, wetted surface, slenderness coefficient and total resistance are put in the same table (Table 5).

Where, ω is wetted surface, Fn is Froude number and R is total resistance, Re is Reynold number, Sc is slenderness coefficient. Sc can be calculated by using Eq. 1 [7]:

$$Sc = \frac{L}{V^{\frac{1}{3}}} (1)$$

C_F is frictional coefficient, Cf can be calculated using Eq. 2 [8]:

$$C_F = \frac{0.075}{(lgRe - 2)^2} \qquad (2)$$

The total resistance of ship denpends on the size of the ship, the form of the hull and the speed of the ship. In this research, velocity of models are the same. The difference of displacement volume is small and can be neglected. We now focuse on the form of the hull to explain the difference in total resistance results of the four models. As shown in Table 5, frictional coefficient of the four models are nearly the same. Therefore, the difference in frictional resistance of these models depend on the difference in wetted surfaces of the four models. The wetted surface of model No. 3 is biggest with 237.87 m^2 while the wetted surface of model No. 4 is smallest with 206.33 m^2. Wetted surface of model No. 4 is smaller than model No. 3 about 31.54 m^2 or about 13%. It means that the difference of frictional resistance of model No. 3 and No. 4 is about 13%. This number will be smaller when the comparation is made between model No. 1 and No. 2 with model No. 4.

Friction resitance of model No. 4 is smallest, however total resistance of model No. 4 is biggest of the four models. Total resistance of model No. 1 is smallest of the four models with 36.7 KN. The main difference now will be accounted for vicous pressure resistance and wavemaking resistance. It is hard to clarify the reason and to calculte exactly brief components of resistance of the four models. However, as shown in Table 5, viscous pressure resistance and wavemaking resistance tend to increase with the increase of Fround number and with the decrease of Slenderness coefficient.

4 Conclusion

In this research, total resistance of 4 typical fishing vesssels were studied by using computational fluid dynamics. The simulation were carried out by using Star-CCM+. Model No. 1 with round bilge, V-shaped form at forebody and U-shaped form at afterbody has smallest total resistance of the four models. Viscous pressure resistance and wavemaking resistance tend to increase with the increase of Fround number and with the decrease of Slenderness coefficient.

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