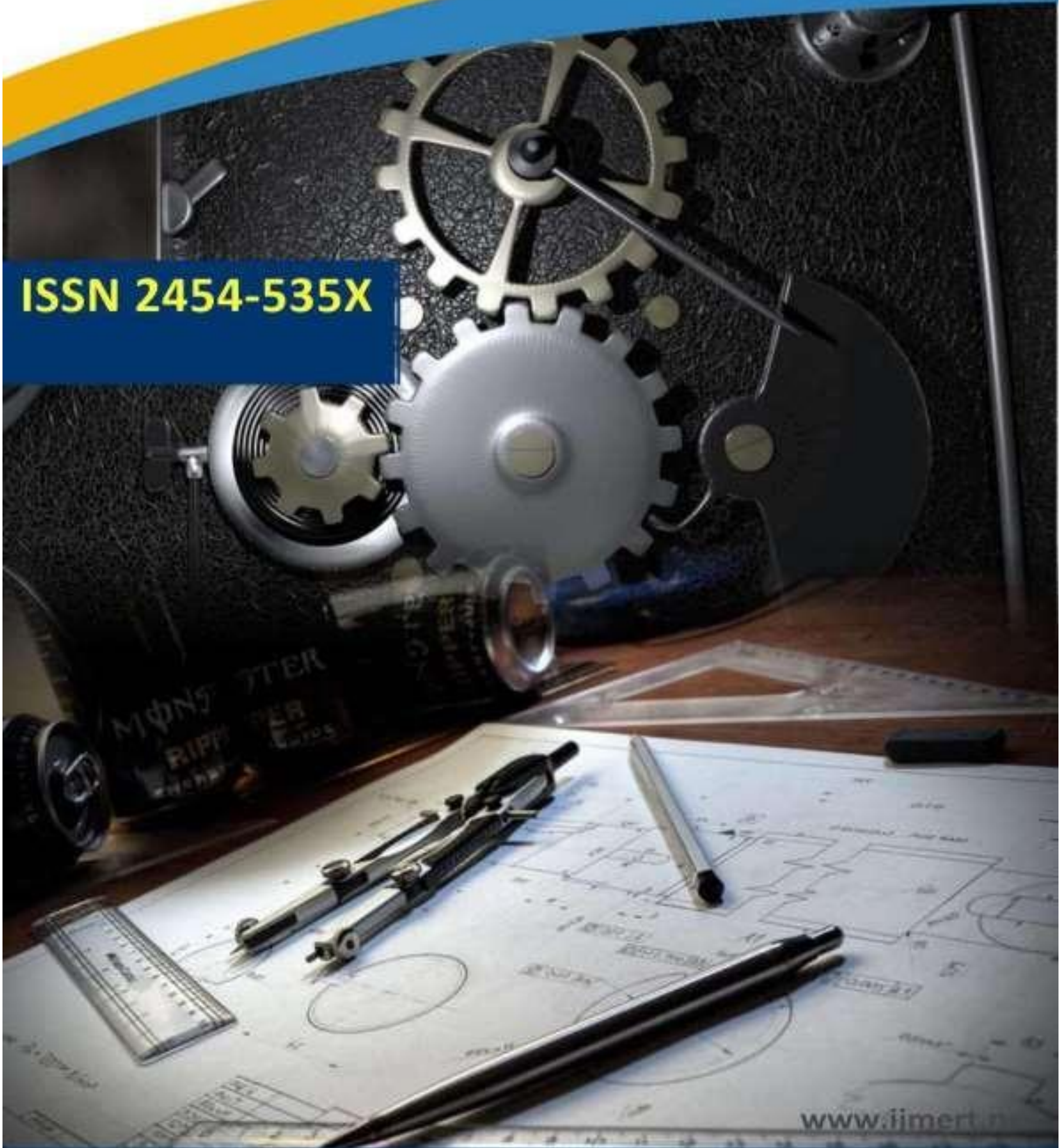
International Journal of
Mechanical Engineering Research and Technology

ISSN 2454-535X



Email ID: info.ijmert@gmail.com or editor@ijmert.net

Int. J. Mech. Eng. Res. & Tech 2017

International Journal of Mechanical Engineering Research and Technology

ISSN 2454 – 535X
www.ijmert.com
Vol. 7 Issue.1 , Jan 2015

Estimation Resistance of an Explorer Submarine

Sagarika[1], Radikha[2], sushma[3], sridevi[3], & Pavani[4]

[†]Department of Ship Engineering and Fluid Mechanics, Hanoi University of Science and Technology Hanoi 10000, Vietnam

[‡]Hoa Binh Investment and Development High Technologies Joint Stock Company Hanoi 10000, Vietnam

*Corresponding Author Email: spkj@hust.edu.vn

ABSTRACT:

In Vietnam, research on submarines for exploration has recently begun. People can utilize naval architectural theory, which is based on mathematical calculations, to estimate the resistance of submarines. This approach will need time, and as undersea surfaces are not always uniformly shaped, it is exceedingly challenging to estimate with high accuracy. In this work, the authors discuss the Computational Fluid Dynamics (CFD) method for estimating an explorer submarine's resistance. An explorer submarine with two seats and a displacement of 6.8 tons is subjected to the CFD. The study's findings display the submarine's resistance coefficient in relation to its running speed. Selecting the submarine's primary engine will be made easier for engineers by the assessment of resistance.

INTRODUCTION

Any gadget that can move, dive or rise, or carry out specific tasks in or under water is considered underwater equipment. These devices can be classified into two fields: military underwater equipment and civil underwater equipment, based on their features, designs, and equipment to be used. Military underwater equipment is frequently created and calculated in accordance with tight requirements, utilizing specialized equipment and supplies, due to its unique features for military objectives. On the other hand, compared to military underwater equipment, civil undersea equipment is simpler.

Although they have many distinct features, civil explorer submarines are built using military submarine technology. Civilian explorer submarines operate for shorter periods of time underwater and have a lesser diving range than military submarines.

DESIGN OF THE SUBMARINE

The explorer submarine in this research study is designed for service of survey and research of seabed. Therefore, its operating speed is not so high. The submarine will be designed base on its operating functions.

The depth of Vietnam's inland waters (12 nautical from the sea baseline) does not exceed 150m. Figure 1 shows the map of Vietnam's inland waters.264

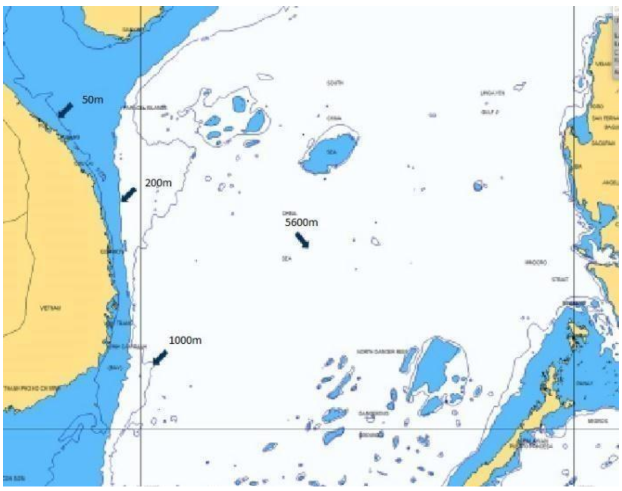


Figure 1. Map of Vietnam's inland waters.

ISSN 2454 – 535X
www.ijmert.com
Vol. 7 Issue.1 , Jan 2015

With a diving depth of 150m, the explorer submarine invortex this project could be survey all points in the territorial sea of Vietnam.

In this project, the explorer submarine is designed with 5 m in the length, 3 m in the breadth and 3 m in the height, the maximum underwater operating speed is 4 nautical mile per hour. The principle parameters of the explorer submarine are shown in Table 1.

Table 1. Principle parameters of the explorer submarine

No	Parameter	Unit	Value
1	Length	m	5
2	Breadth	m	3
3	High	m	3
4	Depth of diving	m	150
5	Maximum operating speed	Nautical mile/h	4
6	Seats	person	2
7	Operated time underwater *(and in maintaining condition)*	hour	8 *(up to 96 h)*
8	Power bank	12V100Ah Battery	45

Figure 2 shows the hull design of the explorer submarine. The main hull of the submarine are including a cylinder with 1.6 m diameter, 2.3 m in length and two of 1.6 diameter semi spheres at front and behind. In which, the front semi sphere is made by acrylic while the behind semi sphere is steel. There are four rising floats in two sides. They are symmetrical. There are four battery power storage pipes at the bottom of the submarine. The submarine uses two symmetrical propellers for main propulsive system.

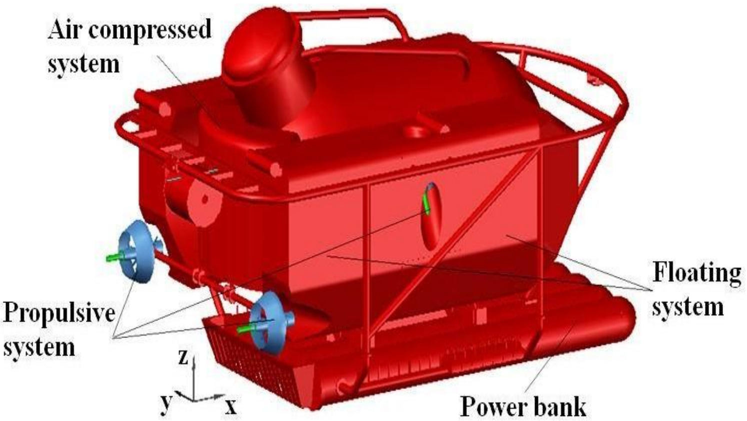


Figure 2. Deign of the explorer submarine.

CFD METHOD FOR THE SUBMARINE

Governing Equations

The system of two phases flow surrounding the submarine is governed by Navier - Stokes equations [1], taking into account k-ε turbulence model.

International Journal of Mechanical Engineering Research and Technology
ISSN 2454 – 535X
www.ijmert.com
Vol. 7 Issue.1 , Jan 2015

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}=0 \quad (1)$$

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}+w\frac{\partial u}{\partial z}=-\frac{1}{\rho}\frac{\partial p}{\partial x}+\frac{1}{\rho}\left(\frac{\partial \tau_{xy}}{\partial y}+\frac{\partial \tau_{xz}}{\partial z}\right)+F_x \quad (2)$$

$$\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}+w\frac{\partial v}{\partial z}=-\frac{1}{\rho}\frac{\partial p}{\partial y}+\frac{1}{\rho}\left(\frac{\partial \tau_{yx}}{\partial x}+\frac{\partial \tau_{yz}}{\partial z}\right)+F_y \quad (3)$$

$$\frac{\partial w}{\partial t}+u\frac{\partial w}{\partial x}+v\frac{\partial w}{\partial y}+w\frac{\partial w}{\partial z}=-\frac{1}{\rho}\frac{\partial p}{\partial z}+\frac{1}{\rho}\left(\frac{\partial \tau_{zx}}{\partial x}+\frac{\partial \tau_{zy}}{\partial y}\right)+F_z \quad (4)$$

where, u, v and w are components of velocity vector, ρ is density of environment, p is static pressure, τ is shear stress tensor, F_x, F_y, F_z are components of gravitational body force.

Turbulent Model

In this study, k-ε turbulence model is used. The k-ε turbulence model is the most common model used in computationalfluid dynamics to simulate turbulent flows. It is a model with two equations which represent turbulence by means of two transport equations. The k-ε model was first used to improve the mixing-length model, as well as to find an alternative to algebraically prescribing turbulent length scales in moderate to high complexity flows. The first transported variable determines the energy in the turbulence is called turbulent kinetic energy, k-ε. The second transported variable is the turbulent dissipation, ε, which determines the rate of dissipation of the turbulent kinetic energy [3-4].

Domain and Boundary Conditions

Computational domain for CFD simulation in this study is showing in Figure 3. It is a cylinder with 52 m in length and 26 m of diameter. The submarine is located on central line of the cylinder and at 25 m far from the inlet of the flows.

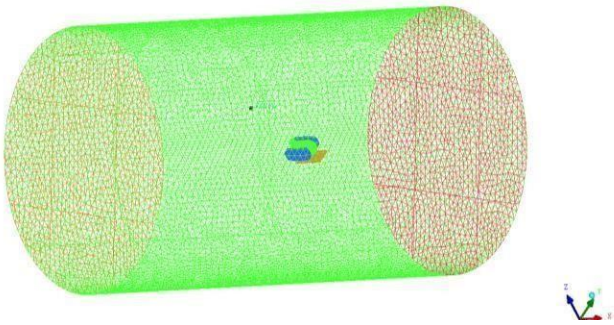


Figure 3. Domain in CFD of the explorer submarine.

Boundary conditions in the CFD of the submarine are: submarine and cylinder are standing and set as walls, water flow is pumped from inlet with a range of velocities from 0.5 m/s (or 0.97 nautical miles per hour) to 5.5 m/s (or 10.69 nautical miles per hour), temperature is set at 300ºK. The inlet is set with velocity and the out let is set with pressure, the density of water is 998.2 kg/m^3, the viscosity of water is 1.003 x 10^{-3} kg/(ms) [5-7].

RESULT AND DISCUSSION

International Journal of Mechanical Engineering Research and Technology

ISSN 2454 – 535X
www.ijmert.com
Vol. 7 Issue.1 , Jan 2015

In this study, the resistance of the submarine is estimated with four directions of movement of the submarine: forward, backward in horizontal direction, diving and rising in vertical direction as up and down. After carrying CFD method for estimation the resistance of the explorer submarine, the result is shown in following figures.

Figure 4 shows the contour of dynamic pressure of the explorer submarine. This picture is taken from the CFD of the submarine when it runs forward with speed of 4.88 m/s at the depth of 10 m from the water surface. In this figure, the color column in the left displays the high and low of the pressure. The blue color is the lower pressure and the red color is the higher pressure. It shows that the high pressure of the submarine is at the top of its cylinder door, with red color.

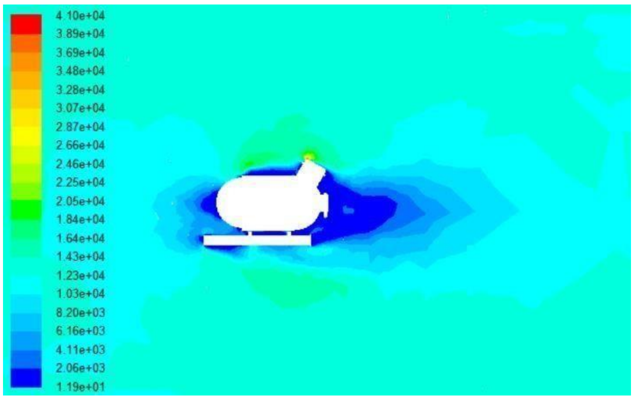


Figure 4. Contour of dynamic pressure of the explorer submarine with speed of 4.88 m/s, forward at 10 m depth.

Figure 5 shows the contour of dynamic pressure of the explorer submarine taken from the CFD of the submarine when it runs backward with speed of 4.88 m/s at the depth of 10 m from the water surface. In this figure, the color column in the left displays the high and low of the pressure. The blue color is the lower pressure and the red color is the higher pressure. This figure also shows that the high pressure of the submarine when it moves backward is at the top of its cylinder door.

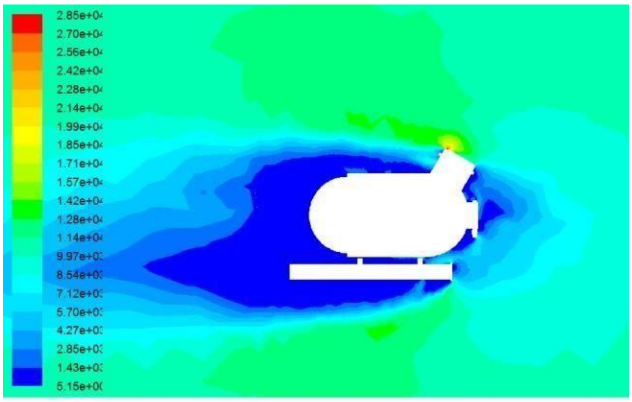


Figure 5. Contour of dynamic pressure of the explorer submarine with speed of 4.5 m/s, backward at 10 m depth.

Figure 6 and 7 show the contour of water velocity around the explorer submarine. Figure 6 is taken from the CFD of the submarine when it dives with speed of 4.5 m/s at the depth of 10 m from the water surface. Figure 7 is taken from the CFD of the submarine when it rises with speed of 4.5 m/s at the depth of 10 m from the water surface.

International Journal of Mechanical Engineering Research and Technology
ISSN 2454 – 535X
www.ijmert.com
Vol. 7 Issue.1 , Jan 2015

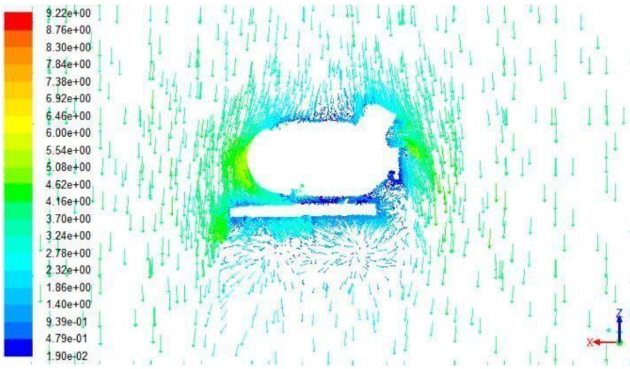


Figure 7. Contour of water velocity around the explorer submarine with speed of 3.5 m/s, rising at 10 m depth.

In those figures, the color column in the left displays the high and low of the water velocity magnitudes. The blue color is the lower water velocity and the red color is the higher water velocity. Those figures show that when the submarine diving and rising, the water flows around in bottom and top of its hull have vortex.

Table 2 and Table 3 show the result of resistant coefficient of the explorer submarine with different its speed of movement when it moves forward and backward directions.

Table 2. Resistant coefficient of explorer submarine when it moves forward.

v	0.51	2.32	3.34	3.86	4.89
C_x	1.91	0.85	0.75	0.70	0.75

Table 3. Resistant coefficient of explorer submarine when it moves backward.

v	1.50	2.50	3.50	4.50
C_x	1.12	1.02	0.94	0.88

Figure 8 and Figure 9 show the resistant coefficient of the explorer submarine when it moves forward and backward directions.

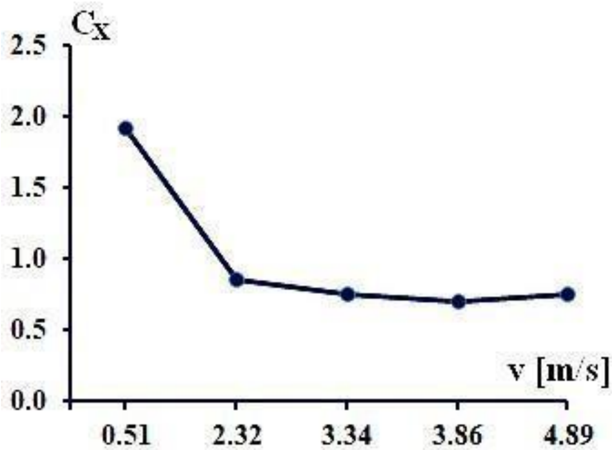


Figure 8. Resistant coefficient of explorer submarine when it moves forward.

International Journal of Mechanical Engineering Research and Technology
ISSN 2454 – 535X
www.ijmert.com
Vol. 7 Issue.1 , Jan 2015

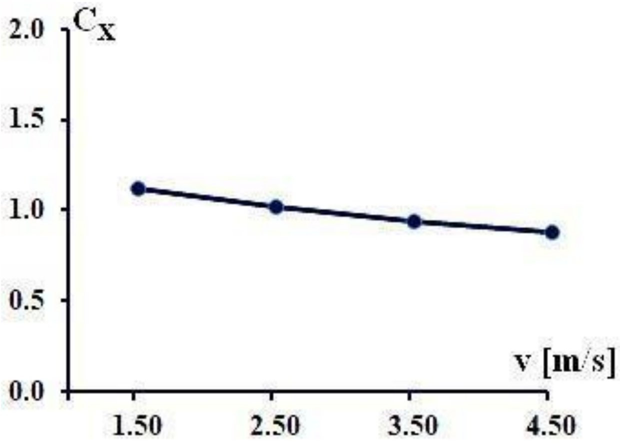


Figure 9. Resistant coefficient of explorer submarine when it moves backward.

Table 4 and Table 5 show the result of resistant coefficient of the explorer submarine with different its speed of movement when it dives and rises in vertical direction.

Table 4. Resistant coefficient of explorer submarine when diving.

v	2.50	3.50	4.50	5.50
C_z	4.49	2.55	1.86	1.56

Table 5. Resistant coefficient of explorer submarine when rising.

v	2.50	3.50	4.50	5.50
C_z	8.85	2.62	0.91	0.20

Figure 10 and Figure 11 show the resistant coefficient of the explorer submarine when it dives and rises in vertical direction.

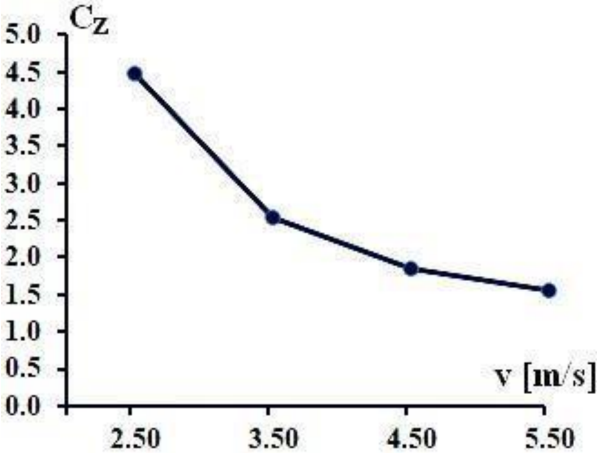


Figure 10. Resistant coefficient of explorer submarine when it dives.

International Journal of Mechanical Engineering Research and Technology
ISSN 2454 – 535X
www.ijmert.com
Vol. 7 Issue.1 , Jan 2015

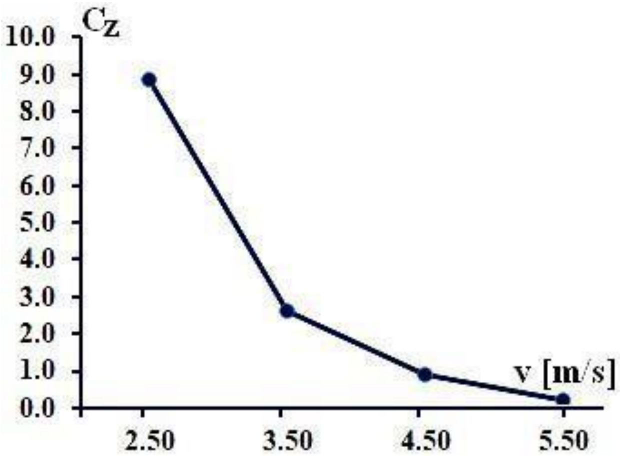


Figure 11. Resistant coefficient of explorer submarine when it rises.

CONCLUSIONS

It is very important for resistant estimation of submarines because it will help engineers to select the suitable main engines forthe submarines.

Resistant estimation of a submarine is very complicated if we calculation base on naval architecture theory with mathematics.However, with CFD method, resistant estimation is more simply.

In this study, resistant estimation of a submarine had conducted with four moving directions of the submarine. They are including forward, backward in horizontal direction, dive and rise in vertical direction of movements.

The result of CFD estimation shows that when the explorer submarine moves in horizontal direction, the resistant coefficientin backward movement is higher than in forward movement. When the submarine moves in vertical direction, the resistant coefficient in rising movement is higher than in diving movement. The cause of this phenomenon is coming from the hull shape of the submarine.

ACKNOWLEDGEMENT

This research study is funded by the grant numbered DTDL.CN-41/18 from Ministry of Science and Technology.

REFERENCES

[1] S. Sathishkumar, M. Kannan. “Design And Fatigue Analysis Of Multi Cylinder Engine And Its Structural Components”, *Acta Mechanica Malaysia*, vol. 1, no. 1, pp. 10-14, 2018.

[2] Nakayama, Y., Boucher, R., “Introduction to fluid mechanics”. Butterworth-Heinemann, 2000.

[3] D. Xu. “Research On Brand Construction And Development Of Agricultural Products In Guizhou, *Engineering HeritageJournal*, vol. 2, no. 2, pp. 19-24, 2018.

[4] Phan, A. T., Vu, D. Q., “Estimation of Car Air Resistance by CFD Method”. *Vietnam Journal of Mechanics*, vol.36, no.3,pp.235-244, 2014.

[5] R.S. Mor, S.K. Jaiswal, S.Singh, A. Bhardwaj. “Minimizing the Uncertainty in Business Operations through Demand Forecasting: A Structural-literature-review”, *Advances In Industrial Engineering And Management*, vol. 7, no. 2, pp. 4654, 2018.

[6] Phan, A.T., “A Study on Hovercraft Resistance Using Numerical Modeling”. *Applied Mechanics and Materials*, Vol. 842, pp. 186-190, 2016.

[7] A.M. Khattak, M. Younas, G. Ali Khan, MUR. S.N. Muhammad Safeer. “P-Separation Axioms In Supra Soft TopologicalSpace, *Matrix Science Mathematic*, vol. 3, no. 1, pp. 7-10, 2019.