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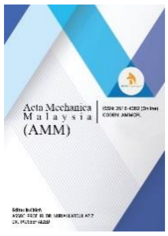

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RESEARCH ARTICLE

COMPUTER FLUID DYNAMIC (CFD) ANALYSIS OF FLOAT AND PROPELLER DESIGN IN ELECTRIC HYBRID WATERBIKE

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ABSTRACT

The water bike consists of an integrated float unit, propeller and frame. Stability on water is the main function of this product. The aerodynamic aspects of the float and propeller (or transmission system) will affect their performance. Specifically for the manufacture of floats and propellers (transmission systems) for water bicycles, CFD analysis is required to inform the performance of these components. The method used in this study is a computer fluid dynamic (CFD) simulation method to analyze the fluid study that occurs when the float and propeller models are applied to the fluid environment. The model that will be used as a simulation object is a parametric 3D model that has been designed according to field conditions. The dimensions of the 3D model of the buoy and propeller system are at the manufacturing design scale. When the buoy speed is 5.5 m/s it is detected that the speed of water flowing around the buoy averages 5.215 m/s with the highest speed of 6.635 m/s in the 1.50 m area and the lowest speed in the 0.22 m area. When the float speed is 5.5 m/s, the pressure that occurs in the surrounding area is detected in the range of 0.117 – 0.118 MPa. The highest pressure of 0.118 MPa occurs in areas 1.50 and 2.30 m with water speeds of 6.635 m/s and 5.739 m/s. The lowest pressure, which is 0.103 Mpa, occurs in an area of 0.22 m with a water speed of 1,100 m/s. When the float speed is 9.7 m/s, the pressure that occurs in the surrounding area is detected in the range of 0.107 – 0.158 MPa. The largest pressure value is in the area of 1.00 m with a value of 0.178 MPa. While the lowest pressure value is in the area of 0.22 m with a pressure value of 0.107 MPa.

KEYWORDS

design, waterbike, float, propeller, CFD

1. Introduction

The water bike consists of an integrated float unit, propeller and frame. Stability on water is the main function of this product. The aerodynamic aspects of the float and propeller (or transmission system) will affect their performance. Bicycles are one of the means of transportation that became the beginning of the emergence of other means of transportation (Grace, 2015). The types of bicycles have developed significantly over time, equipped with innovations in their shapes and features (Anonymous; KajianPustaka.com). Over the last 30 years, many countries have promoted cycling to increase the comfort of life and the sustainability of their transport systems (Buehler, 2022). Lots of emerging models and types of bicycles with various functions. The use of electric bicycles is known to be a solution to keep moving actively, in order to maintain physical and spiritual fitness (Marilyn, 2015). Cycling can not only be done on the mainland. But also on the surface of the water, waterbikes are similar to existing bicycles in general, except that the wheels are removed (Ubaya, 2014). Water bikes are a means of exercising and playing for community activities. In addition, waterbikes can also be used as a means of water recreation at tourist attractions (Hendra, 2016). The results showed that there was a linear correlation between metabolic power and mechanical power when someone made a water bike for sports (Thomas, 2017).

Unesa Lake is located in front of the Lidah Wetan Unesa campus, Surabaya City. This lake is a tourist attraction that can be an option for a vacation with friends or family (Khoiriah, 2021; Idalamat.com). Seeing its potential as a tourist and recreational place, it is necessary to innovate the use of the lake in the field of water transportation, namely by using water bicycles. Seeing its function, water bicycles can be used flexibly, namely as a tourist vehicle on the lake, as a means of water sports, and also as transportation during floods. One of the important components in an electric hybrid water bike is the float and propeller. It is known that there is a correlation between the design of the water bike and the propulsion of the forward ship (Georgiey et al., 2014). One of the important components in an electric hybrid water bike is the load and the propeller. It is known that there is a correlation between the design of the waterbike and the leading boats. Several waterbike designs (amphibious bicycles) have been carried out (Shubham, 2017; Rio, 2020).

The water bike consists of an integrated float unit, propeller and frame. Stability on water is the main function of this product. The aerodynamic aspects of the float and propeller (or transmission system) will affect their performance.

The concept of inventing a hybrid air bike with a portable float as a means of tourism, sports and emergency transportation during floods is very promising in the future. This will answer problems in the tourism and sports health sector as well as disaster emergency management solutions. Specifically for the manufacture of floats and propellers (transmission systems) for water bicycles, CFD analysis is required to inform the performance of these components. an analysis related to the performance

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test of propeller components using CFD has been carried out, it is known that the use of CFD can provide a detailed, effective and efficient analysis (Setya Budi, 2016; Andilolo, 2017; Wibowo, 2017; Simbolon, 2015; Trimulyono, 2015; Trimulyono, 2013).

2. Literature Reviews

One important component of a waterbike is the type of propulsion used. P. Georgiev et al in their research related to the analysis of existing vessels participating in the International Waterbike Regatta, obtained info. Only 10 out of more than 30 participating vessels qualified under the GCI. Of the 10 boats, 5 of them used propellers as the type of propulsion and won the top position. However, it is also necessary to pay attention to the position of the propulsion on the boat, so a CFD analysis is needed on the boat prototype / design.

Many studies related to the design of waterbikes have been carried out, one of which is Shubham Awasthi in designing his amphibious waterbike which is designed to be used on land or water. However, this design is patent (bicycle body with integrated float), so when used on land it will increase the burden on the body. Another waterbike design was carried out by Muhammad Eri Rio et al in his design using a propeller drive and using a modified bicycle frame. Design and simulation using maxsuft software and the design of this waterbike will later be used in Marina beach tourism.

The use of CFD to analyze the thrust and torque of the b-series type propeller on a 150m midget submarine by Setyabudi et al, obtained information that using the CFD application is able to obtain results from all propeller models, namely flow shape, thrust value and pressure value. in variations of 400 RPM, 450 RPM and 500 RPM. The optimum propeller model is the B – 7 Series in Model 2 (27.70 & 0.59) 400 RPM rotation with an average pressure value of 66.34 Pa, and turbulent flow with an average speed of 15.56 m/s s.

Andilolo et al in their research related to the analysis of Kaplan Series propellers with reduced diameter to 0.975R, 0.95R, 0.925R, 0.90R and the addition of end plates on propeller tips with 4 length variations, namely 150 mm, 100 mm, 75 mm, 50 mm and using rake angles of 00 and 150, for optimum propeller variations using CFD applications. Based on this analysis, the optimum propeller model is obtained by reducing the diameter by 2.5% with a rake angle of 150 and adding an end plate with a length of 75 mm with a thrust value of 122163 N, an average pressure of 37202.5 Pa, and an efficiency value of 55. 47% with optimal propeller rotation of 275 RPM.

Research related to the use of CFD applications was then carried out by Wibowo et al regarding the Analysis of Thrust Optimum Values of Propellers B4-70, Ka4-70 and Au4-59 on Tugboat Port Package-Ii 2x1850hp With Variations in Rake Angle. From the results of model analysis using the CFD application, it is known that the highest thrust value is produced on the Propeller Ka4 70 Series model with a rake angle of 60 with a value of 337206 N. The lowest torque value is produced on the Propeller B4 70 Series model with a rake angle of 120 with a value of 40068.80 Nm , and get the highest efficiency value obtained on the propeller model B4 70 rake angle 150 which is equal to 0.61694956.

3. Research Method

The method used in this study is a computer fluid dynamic (CFD) simulation method to analyze the fluid study that occurs when the float and propeller models are applied to the fluid environment. The model that will be used as a simulation object is a parametric 3D model that has been designed according to field conditions. The dimensions of the 3D model of the buoy and propeller system are at the manufacturing design scale. The following is a form of both designs.

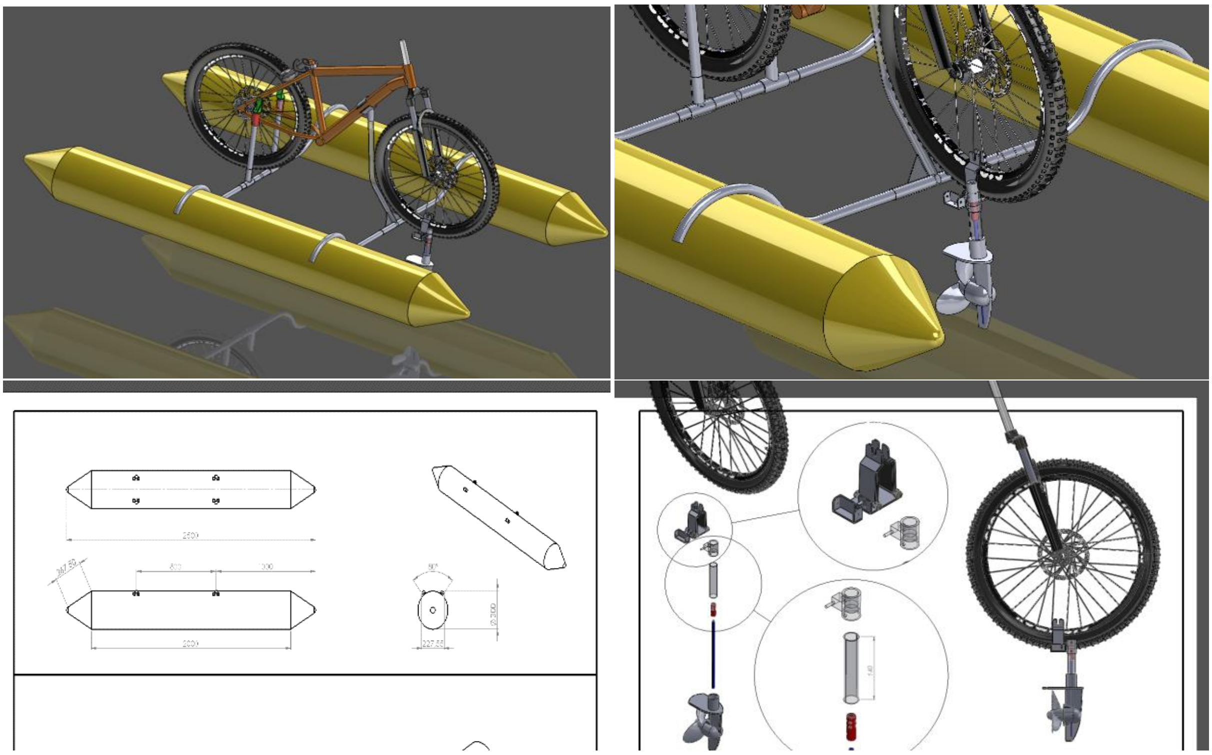

Figure 1: 3D model of a float and propeller system electric hybrid waterbike

The computer fluid dynamic (CFD) simulation process begins with: 1) determining the model that will be used as the object of the simulation, 2) determining the scenario conditions experienced by the buoys and propellers. In this case testing was carried out at a speed of 5.5m/s and 9.7m/s with a time constant. 3) The flow of water when hit by a float and propeller system is laminar and turbulent. 4) The value of gravity is also entered at 9.81 m/s2. 5) The material for the waterbike buoy is PVC Vinyl and the propeller system is iron.

4. Findings and Discussion

4.1 Test Results of CFD Building with Speed Of 5.5 M/S

In Figure 2 it can be seen the results of the CFD test, the relationship between the velocity of the float and the fluid in the virtual computer water domain. The total length of the buoy is 2.5 m and the virtual water domain on the computer is 3 m long. When the buoy speed is 5.5 m/s it is detected that the speed of water flowing around the buoy averages 5.215 m/s with the highest speed of 6.635 m/s in the 1.50 m area and the lowest speed in the 0.22 m area.

In table 1 it can be seen that the magnitude of the water velocity fluctuates in the area of 0.04 – 0.22 m from 5,392 m/s to 1,100 m/s. Furthermore, in the area 0.39 – 3.00 the average velocity of water is 5.473 m/s. Next is the relationship between the speed of the buoy against the pressure that occurs in the surrounding area. When the float speed is 5.5 m/s, the pressure that occurs in the surrounding area is detected in the range of 0.117 – 0.118 MPa.

From table 1 it is known that the highest pressure of 0.118 MPa occurs in areas 1.50 and 2.30 m with water speeds of 6.635 m/s and 5.739 m/s. The lowest pressure, which is 0.103 Mpa, occurs in an area of 0.22 m with a water speed of 1,100 m/s.

In Figure 3 it can be seen the results of the CFD test for the length of the turbulent flow and the energy it generates. The length of the turbulent flow in the area of 0.22 m is 0.011 m long with a turbulent flow energy of 0.355 J/kg. Turbulent flow energy in the area of 0.04 – 0.50 m has a fairly high value with a turbulent flow length of 0.002 – 0.011m.

Table 2 shows that the energy of tubulent flow in the area of 0.04 – 0.50 m is 0.009 J/kg, 0.154 J/kg, 0.355 J/kg and 0.012 J/kg, respectively. Then in the area of 0.39 – 3.00 m the length of the turbulent flow and the energy is relatively constant, namely 0.001 m and 0.003 J/kg.

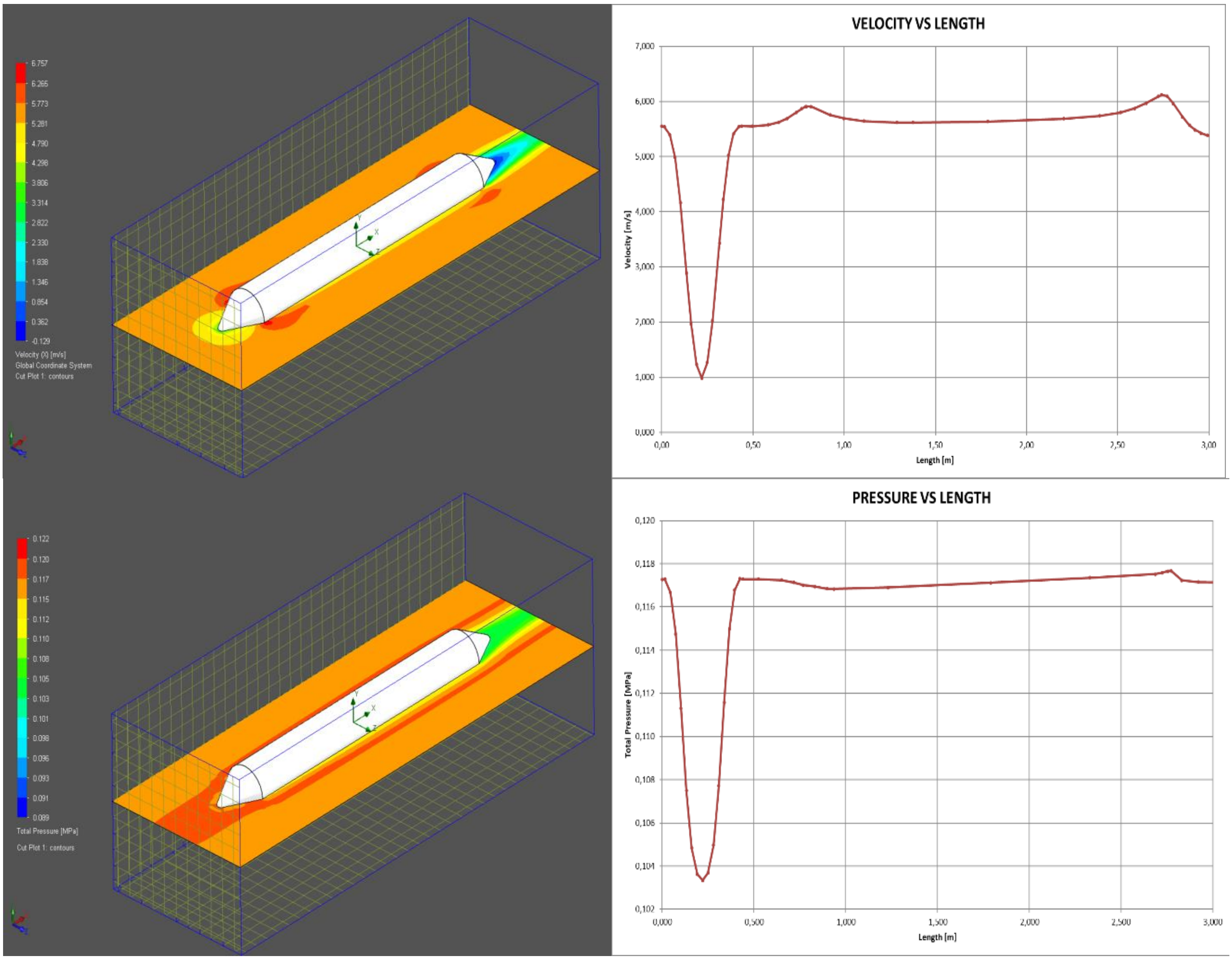

Figure 2. Effect of speed on water pressure (test scenario 1)

Table 1: Relationship Between Water Velocity and Pressure Generated

Length of Water Domain (m)	Velocity of water (m/s)	Pressure(MPa)
0.04	5,392	0.117
0.10	4.158	0.110
0.22	1,100	0.103
0.39	5,413	0.117
0.50	5,548	0.117
0.80	5,904	0.117
1.00	5,689	0.117
1.30	5,616	0.117
1.50	6,635	0.118
1.80	5,200	0.117
2.00	5,435	0.117
2.30	5,739	0.118
2.50	5,799	0.118
3.00	5,385	0.117

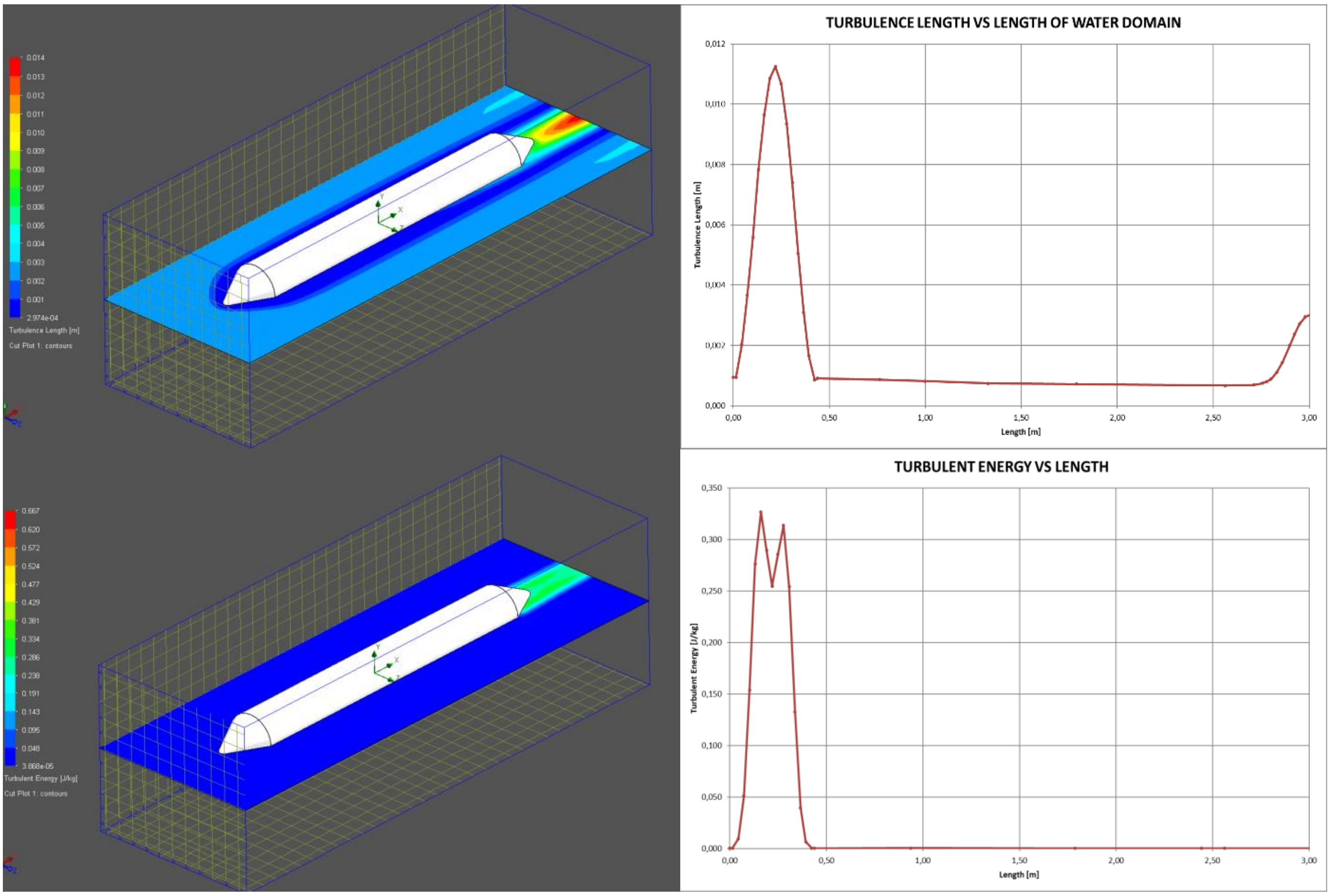

Figure 3: Effect of Turbulent Flow Energy on the Length of the Turbulent Flow of Water (test scenario 1)

Table 2: The Relationship Between the Length of the Turbulent Flow of Water and the Energy of the Turbulent Flow

Length of Water Domain (m)	Turbulent flow length(m)	Turbulent flow energy (J/kg)
0.04	0.002	0.009
0.10	0.006	0.154
0.22	0.011	0.355
0.39	0.002	0.012
0.50	0.002	0.012
0.80	0.001	0.003
1.00	0.001	0.003
1.30	0.001	0.003
1.50	0.001	0.003
1.80	0.001	0.003
2.00	0.001	0.003
2.30	0.001	0.003
2.50	0.001	0.003
3.00	0.003	0.002

4.2 Test Results of CFD Building with Speed of 9.7m/S

In Figure 4 it can be seen the results of the CFD test, the relationship between the velocity of the float and the fluid in the virtual computer water domain. The total length of the buoy is 2.5 m and the virtual water domain on the computer is 3 m long. When the float speed is 9.7 m/s, the speed of water flowing around the float is detected, the average is 8,949 m/s with a maximum speed of 10,176 m/s in the 0.80 m area and 10,052 m/s in the 2.50 m area. In table 3 it is known that in the area of 1.00 – 2.30 m the water velocity is between 9.714 – 9.943 m/s.

Next is the relationship between the speed of the buoy against the pressure that occurs in the surrounding area. When the float speed is 9.7 m/s, the pressure that occurs in the surrounding area is detected in the range of 0.107 – 0.158 MPa. The largest pressure value is in the area of 1.00 m with a value of 0.178 MPa. While the lowest pressure value is in the area of 0.22 m with a pressure value of 0.107 MPa.

The results of the CFD test, the length of the turbulent flow and the energy it generates are related to one another. The length of the turbulent flow in the area of 0.22 m is 0.010 m long with a turbulent flow energy of 0.726 J/kg. Turbulent flow energy in the area of 0.04 – 0.50 m has a fairly high value with a turbulent flow length of 0.001 – 0.010 m. Table 4 shows that the energy of tubulent flow in the area of 0.04 – 0.50 m is 0.015J/kg, 0.374 J/kg, 0.726 J/kg and 0.016 J/kg, respectively. Then in the area of 0.39 – 3.00 m the length of the turbulent flow and the energy is relatively constant, namely 0.001 m and 0.002 J/kg.

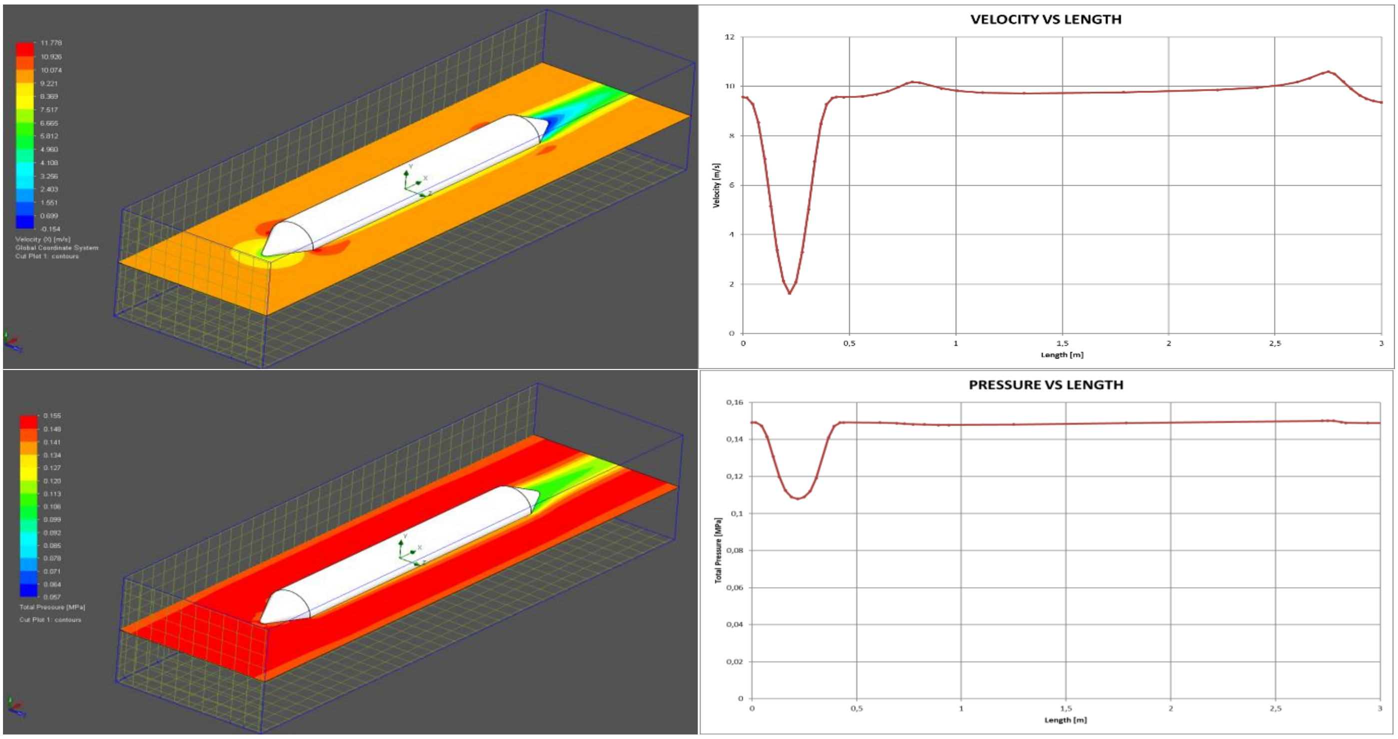

Figure 4. Effect of speed on water pressure (test scenario 2)

Table 3: Relationship Between Water Velocity and Pressure Generated		
Length of Water Domain (m)	Velocity of water (m/s)	Pressure (MPa)
0.04	9,289	0.147
0.10	7,058	0.131
0.22	1620	0.107
0.39	9,269	0.147
0.50	9,594	0.150
0.80	10.176	0.158
1.00	9,815	0.178
1.30	9,714	0.148
1.50	9,763	0.148
1.80	9,790	0.150
2.00	9,854	0.150
2.30	9,943	0.152
2.50	10052	0.155
3.00	9,353	0.147

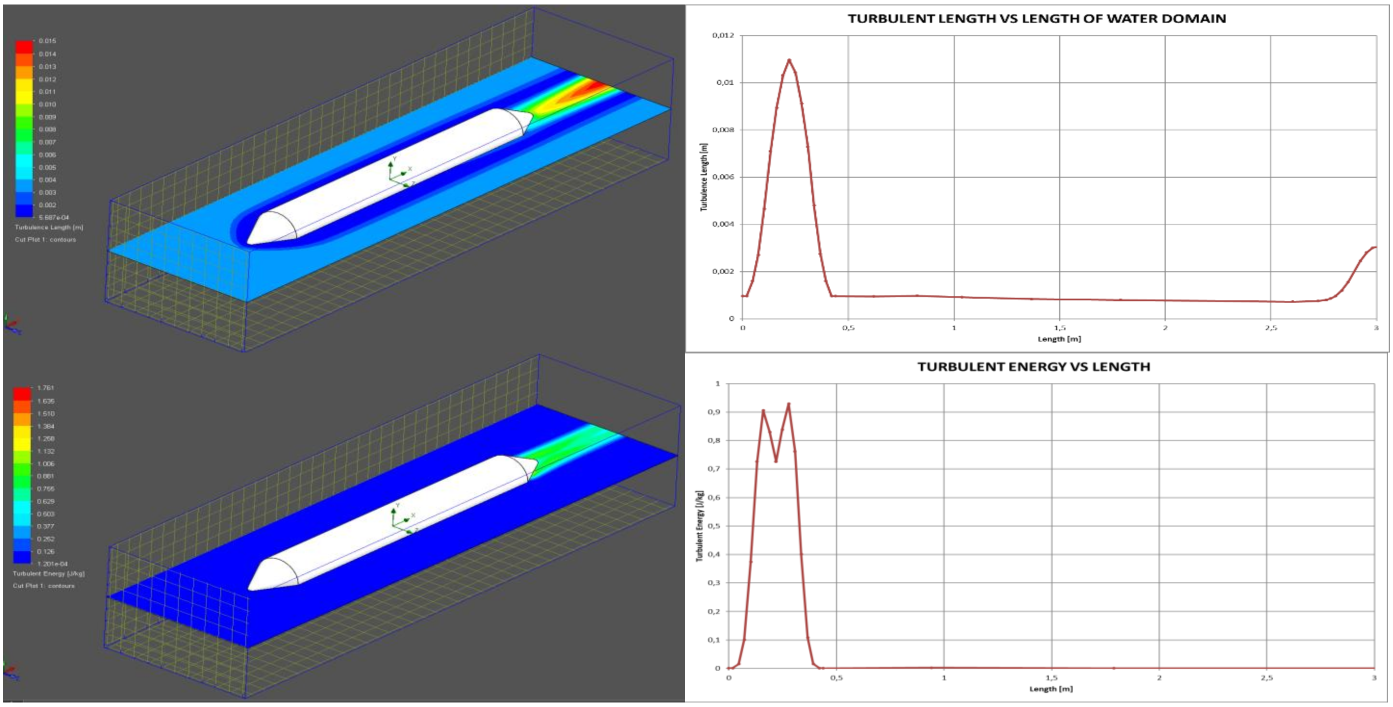

Figure 5: Effect of turbulent flow energy on the length of turbulent water flow (test scenario 2)

Table 4: The Relationship Between the Length of the Turbulent Flow of Water and the Energy of the Turbulent Flow		
Length of Water Domain (m)	Turbulent flow length(m)	Turbulent flow energy (J/kg)
0.04	0.001	0.015
0.10	0.004	0.374
0.22	0.010	0.726
0.39	0.002	0.016
0.50	0.001	0.016
0.80	0.001	0.002
1.00	0.001	0.001
1.30	0.001	0.002
1.50	0.001	0.001
1.80	0.001	0.002
2.00	0.001	0.002
2.30	0.001	0.002
2.50	0.001	0.002
3.00	0.003	0.001

4.4 Propeller Transmission System CFD Test Results with Speed Of 5.5m/s

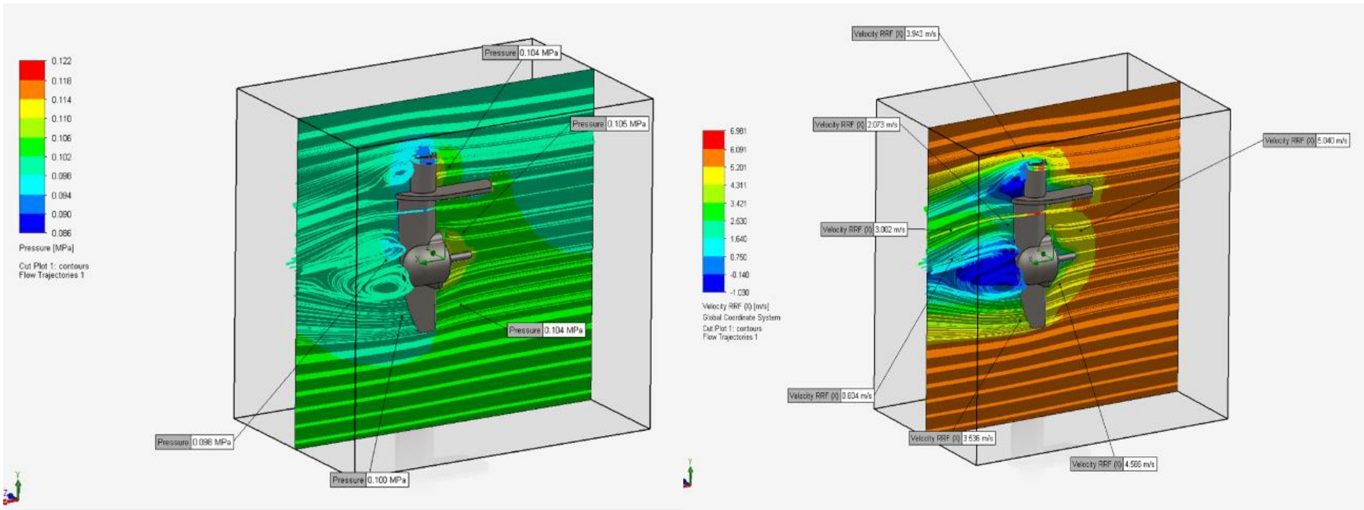

Figure 6: Test CFD propeller transmission system

From the test results of the propeller transmission system with a speed of 5.5 m/s, the following results are obtained:

- Velocity test : 5.5m/s (25km/h)
- Velocity 1 detected : 3.536 m/s
- Velocity 2 detected : 0.604 m/s
- Velocity 3 detected : 3,002 m/s
- Velocity 4 detected : 3,943 m/s
- Velocity 5 detected : 4,566 m/s

With a water pressure of:

- Velocity test : 5.5m/s (25km/h)
- Resistance pressure 1 : 0.098 MPa
- Resistance pressure 2 : 0.100 MPa
- Resistance pressure 3 : 0.104 MPa
- Resistance pressure 4 : 0.104 MPa
- Resistance pressure 5 : 0.105 MPa

5. Conclusion

When the buoy speed is 5.5 m/s it is detected that the speed of water flowing around the buoy averages 5.215 m/s with the highest speed of 6.635 m/s in the 1.50 m area and the lowest speed in the 0.22 m area. When the float speed is 5.5 m/s, the pressure that occurs in the surrounding area is detected in the range of 0.117 – 0.118 MPa. The highest pressure of 0.118 MPa occurs in areas 1.50 and 2.30 m with water speeds of 6.635 m/s and 5.739 m/s. The lowest pressure, which is 0.103 Mpa, occurs in an area of 0.22 m with a water speed of 1,100 m/s.

When the float speed is 9.7 m/s, the pressure that occurs in the surrounding area is detected in the range of 0.107 – 0.158 MPa. The largest pressure value is in the area of 1.00 m with a value of 0.178 MPa. While the lowest pressure value is in the area of 0.22 m with a pressure value of 0.107 MPa. Furthermore, in the propeller transmission system, if it is at a speed of 4.56 m/s it will have a pressure of 0.105 MPa.

6. Limitation & Further Research

In this CFD test case, we will not discuss the impact of erosion due to speed, pressure and water turbulence on the buoys and propellers of the electric hybrid waterbike. The CFD test is more focused on the influence of the water fluid velocity on pressure and the amount of flow and turbulent energy produced.

References

Andilolo, Y R. et al. 2017. Case Study of Kaplan Series Propeller Performance Due to Diameter Reduction and End Plate Addition with CFD Method. Journal of Marine Engineering - Vol. 5.

Anonymous, https://www.merdeka.com /jatim/tipe-type-sepeda-and-characteristics-which- need-to-know-this-selengkapnya -kln.html

Buehler R et al. 2022. Chapter Seven - A global overview of cycling trends. Advances in Transport Policy and Planning. Vol. 10, Pp. 137-158.

Georgiev P., Genkov S., Denev J. & Saidov G. 2014. Classification and analysis of vessels used in the International Waterbike Regatta. Marine Technology and Engineering. Taylor & Francis Group, London, UK. Pp.261-268.

Grace, Rohmat. 2015. Mountain Bikes Miscellaneous Mountain Bikes. Bandung: One Nusa

Hendra S. 2016. Design and Build a Water Bike (Waterbike) as a Water Recreation Vehicle in Batam City. Integration Journal, Vol. 8(1), April 2016, Pp. 74-79. p-ISSN: 2085-3858

Khoiriah. N.A. 2021. Asyiknya Nongkrong di Danau Kampus UNESA (Universitas Negeri Surabaya). Pesona Indonesia. https://pesona-indonesia.id/asyiknya-nongkrong-di-danau-unesa-190 . Mei 15, 2021.

Marilyn J. 2015. Extending life on the bike: Electric bike use by older Australians. Journal of Transport & Health. Australians – Science Direct. Vol. 2(2), Pp. 276-283.

Objek Wisata Danau Unesa Lidah - Surabaya, Jawa Timur. https://idalamat.com/alamat/ 274709/ danau-unesa-lidah-surabaya- jawa-timur

Rio, 2020. ME Designs a Water Bike for Bengkalis Beach Marina Sand Field Tourism. National Seminar on Industry and Technology (SNIT), Bengkalis State Polytechnic. November 2020, Pp. 305–37.

Sepeda (Sejarah, Bagian, Prinsip Kerja, Jenis-jenis dan Manfaat). Agustus 06, 2020. KajianPustaka.com. https://www.kajianpustaka.com/2020/08/sepeda.html

Setya Budi, PB et al. 2016. Analysis of Thrust and Torque Values of B-Series Propellers on a 150m Midget Submarine With Variations of Skew Angle and Blade Area Ratio (Ae/Ao) Using the CFD Method. SHIP, Vol. 13.

Shubham A. 2017. Design & Fabrication of Amphibious Bicycle. International Journal of Applied Engineering Research.

Simbolon, H. et al. 2015. Analysis of B-Series and Kaplan Series Maximum Thrust Propeller Values on Tugboat Ari 400 Hp With Variations in Diameter, Number of Leaves, Rake Angle Using CFD. Journal of Marine Engineering - Vol. 3(4).

Thomas F. 2017. Development and testing of a novel arm Cranking powered watercraft. Frontiers in physiology.

Trimulyono, A. et al. 2013. The Effect of Using an Energy Saving Device on the B4 55 Propeller With the CFD Method. SHIP- Vol. 10(3).

Trimulyono, A. et al. 2015. Efficiency Analysis of B-Series and Kaplan Propellers on Tugboat Ari 400 Hp With Variations in Number of Leaf, Rake Angle Using CFD. SHIP, Vol. 12(2).

Ubaya. 2014. Ubaya Students Make Tandem Water Bikes, Manufam Tandem Water Bikes (Manuvers Family). http://www.ubaya.ac.id/ubaya/news_detail/954/Ubaya-Bikin-Sepeda-Air-Tandem.html

Wibowo, GP, et al. 2017. Optimum Thrust Value Analysis of B4-70, Ka4-70 and Au4-59 Propellers on Tugboat Port Paket-II 2x1850hp With Variation of Rake Angle Using CFD. Journal of Marine Engineering - Vol. 5.