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Design and CFD Analysis of an Indigenous Rescue Vehicle.

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Abstract: *Rescuing distressed swimmers has always been a herculean task with the employment of conventional mechanisms like air tubes, ropes, etc. As a method of improvement, the present work incorporates design and analysis of a motorized rescue, buoy propelled by two high speed motors on the either side of the body. Instead of using a simple U-shaped tube or a mono-hull structure, the adoption of catamaran or di-hull structure increases the stability of the buoy considerably facilitating it to travel through rough water conditions with ease. The catamaran style is well known for its lower drag force, lesser power consumption, high efficiency and maximum stability. CFD analysis is done under static water conditions to prove its efficiency in a simpler way. The buoy works on a remote-control navigation system, where it is navigated to the distressed person using a remote control, once the person grabs the buoy, he is pulled back to the safe region swiftly. By this method the rescuing lead time as well as the effort spent in rescuing can be minimized.*
Keywords: *Catamaran design, CFD Analysis, Hull design, Rescue craft vehicle.*

I. INTRODUCTION

Outcome of extensive survey reveals that there are 3,20,000 deaths annually due to drowning accounting for 7% of over -all deaths worldwide, making it a major public health concern. Rescuing people from swift water currents near the surfs zones and waterfronts is formidable. A person in trouble is often at a far-off distance away from the rescuer and requiring someone to swim to the dis-stressed person or conventional methods like ropes and tubes are deployed, which proves to be laborious. In order to rescue the person quickly, a propeller powered buoy can be adopted in open waters. The main advantage of this buoy is its compact size and less power consumption when compared to a rescue boat. With the use of remote control, the person after grabbing the buoy can be easily pulled back to shore. The buoy is built with multiple rope handles around it in order to make it easy for the person to grab tightly while drowning. The battery and other electronic components are housed at the front and is closed using an air tight lid in order to prevent the water from entering inside the buoy. The device can be re-charged after its function and can be put to use again. By integrating various sensors and other components we can even use the buoy for surveillance purpose, lake mapping, and contamination detection. For future scope the buoy can be made completely autonomous in order reduce human intervention.

The integration of autonomous systems into rescue craft further complicates the design process but offers significant operational advantages. The US Navy's development of remotely operated surface vehicles, including minesweeping boats, demonstrates the potential for autonomous rescue craft that can operate in hazardous environments without risking human life. These developments necessitate sophisticated CFD analyses to optimize hull design for stability, maneuverability, and minimal detectability.

The application of CFD in rescue craft design extends beyond structural considerations to include hydrodynamic performance optimization. CFD simulations facilitate the assessment of flow behavior around hulls, enabling designers to identify and mitigate drag forces that could impair vessel speed and fuel efficiency. The study on biomimetics design optimization for Indonesia's N219 seaplanes, which employs a catamaran configuration, exemplifies how CFD can be used to analyze and reduce drag, thereby enhancing overall vessel performance. Such analyses are crucial for indigenous rescue craft, which must operate efficiently in resource-constrained environments.

In the context of rescue operations, vessel stability and safety are paramount. Many researchers are working on the design of rescue vessels capable of withstanding extreme conditions, with a particular focus on the structural robustness and operational reliability of catamaran-based rescue craft. CFD plays a vital role in simulating extreme sea states and assessing vessel response, which informs design modifications to enhance resilience.

The main objective of the proposed project is the catamaran design, which helps the buoy to stay upright under rough water conditions and also felicitates for stability of the buoy while rescuing a person in water. The catamaran structure also produces less drag force hence the overall performance of the buoy also increases when compared to other hull forms. The CFD analysis is performed for the hull form in order to determine how it would react in the actual environment. The analysis is done in static water conditions and various parameters are examined using the ANSYS software. With the help of the data, the behavior of the buoy can be analyzed and understood under different conditions.

II. DESIGN OF THE RESCUE VEHICLE

In order to rescue drowning people in a more efficient way and eliminate the disadvantages of the conventional rescue
methods, the buoy is designed using catamaran hull structure. The basic catamaran design of a boat consists of di-hull structure separated by a deck parallel to the water surface. Similar criterion is used in the designing of the rescue buoy, which also comprises of di-hull structure separated by an intermediate housing, which can also be utilized for accommodating electronic equipment and other components. The displacement of the hull is reduced by eliminating the excess weight on the body. Usage of finer bows with sharper angles, pierce the water away steadily, thereby offering lesser resistance.

The optimum length to width ratio of a catamaran should be greater than 50%. The ratio of present design is 80% which ensures more stability, this eventually facilitates the proper functioning of the craft under rough water conditions. Higher dead rise angle requires lesser power and produces comparatively minimal drag force. A dead rise angle of 72° is provided for increasing the advantages of the present work. Figure 1 shows the schematic representation of the proposed design of rescue buoy. Table 1 gives the design specifications of the rescue buoy. The 3D model of the rescue buoy is shown in figure 2 & 3.

2D DRAFT DESIGN

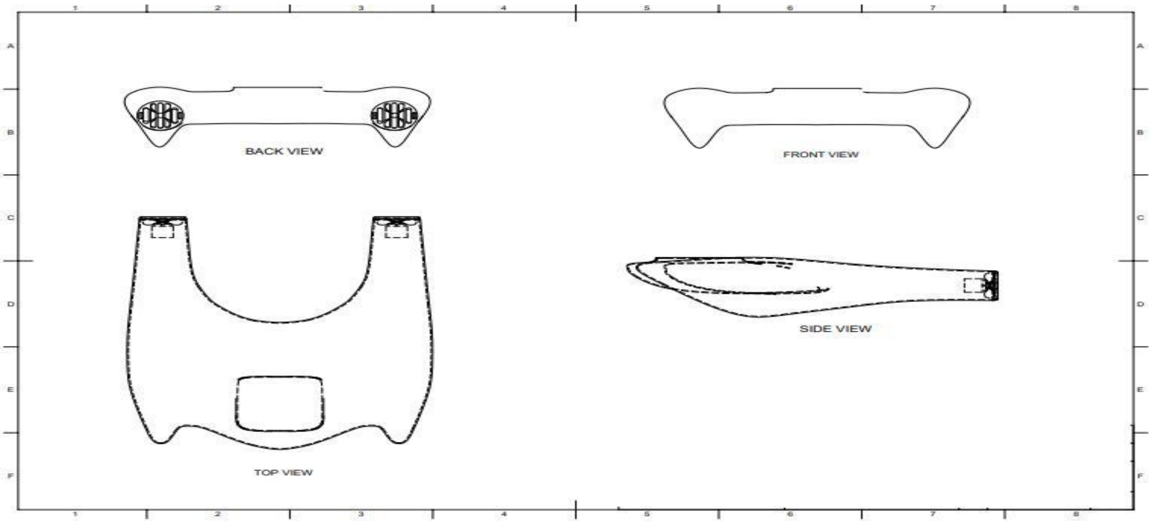

Fig. 1: Schematic Representation

Table 1: Design specifications of proposed rescue buoy

Length	1130mm
Width	860mm
Height	270mm
Hull depth	125mm
Housing depth	145mm
Hull angle	36°
Dead Rise angle	72°
Propeller pitch Angle	25°

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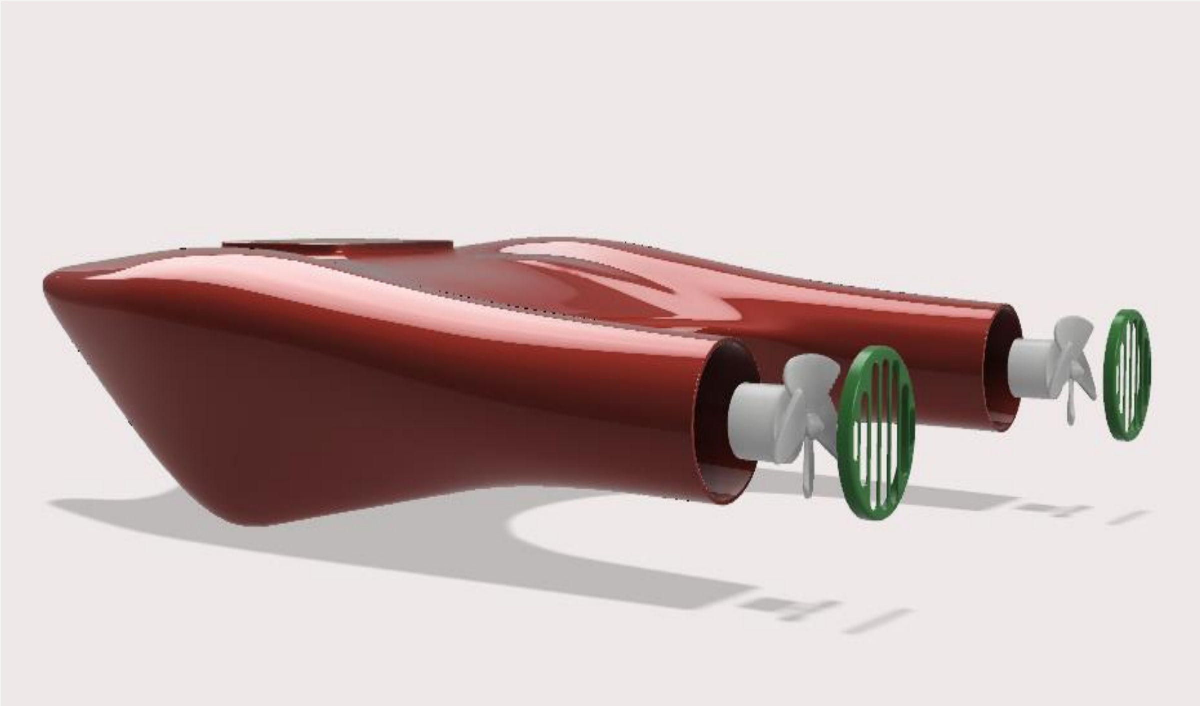
Propeller casing diameter	120mm
Design volume	6.306×106 mm3
Total mass	6.365 kg



3D DESIGN

Fig. 2: Exploded view of rescue buoy.

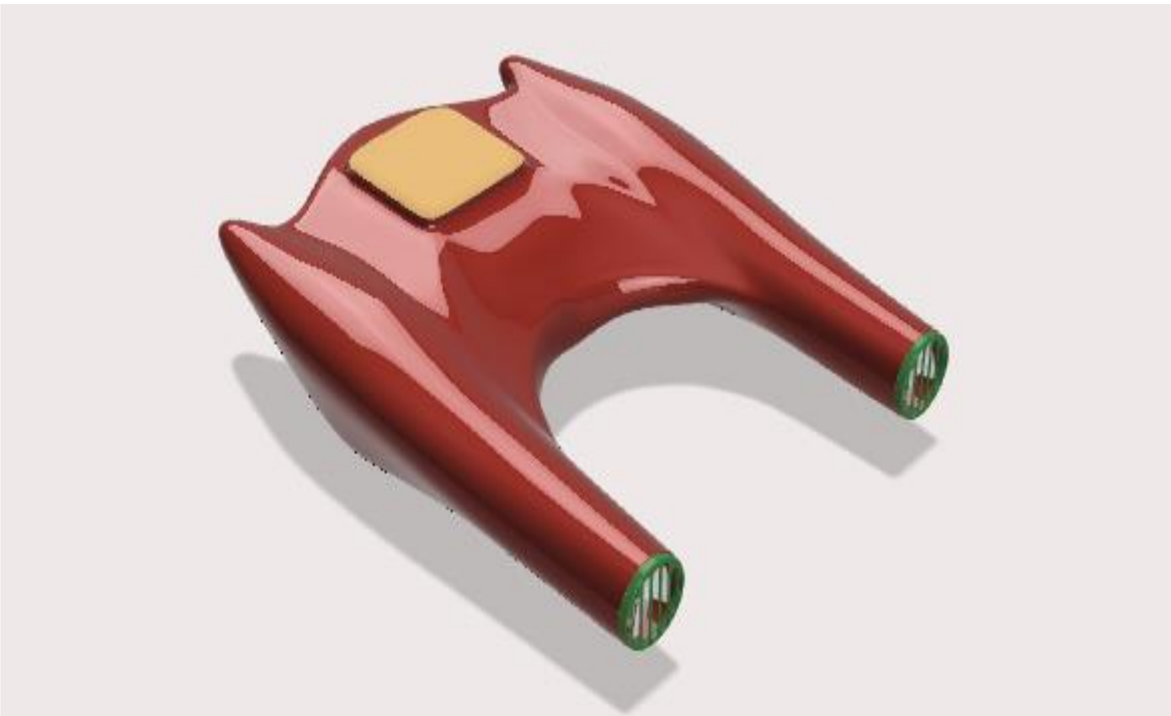


Fig. 3: Assembled view of rescue buoy

To pull a 50kg load a thrust force of 1kg is required by the craft vehicle. This requirement holds good for still water conditions. Hence, under rough water
conditions we consider an optimum value of 2kg thrust force to be produced to propel the buoy.

P=0.65hp
Pitch angle ϕ= tan-1(P/2πr),
Radius r= 60mm.
P= 173.4 mm.
P/D = 1.45

The optimum range of the pitch diameter ratio is in the range 0.8 to 1.8. The effective power (PE) is calculated to be 75W.

In order to evaluate for the floatability of the rescue craft vehicle, we need to calculate the buoyancy force (B) and the force of gravity (G) pushing it downwards.

Buoyancy is the upward thrust force exerted by the fluid against the weight of the immersed body. The magnitude of the buoyancy force depends on the submerged volume of the body. In general, an object having lesser density than the fluid tends to float.

Buoyancy force B = V *D*g = 65.593 N

where,

V- volume of the body
D- density of the fluid (in this case water)
g- acceleration due to gravity

Force of gravity, G = (Total mass of object) * (9.81 m/s2).

G = 62.448 N

If the force of buoyancy is greater than the force of gravity, the object is bound to float. Since, the above conditions are satisfied, it is evident that the buoy would float.

III. CFD ANALYSIS

Initially the design is imported into Ansys workbench and an enclosure is created around the model to represent the working medium and the respective boundary conditions are allotted. The entire model is split up into two symmetrical parts for the ease of analyzing. In the Fig. 4, the blue region represents the inlet face and the red region represents the outlet face. The enclosure is divided into two parts to represent water and air mediums. Meshing is done to produce results of higher accuracy. Later the velocity conditions are specified and the required results are obtained.

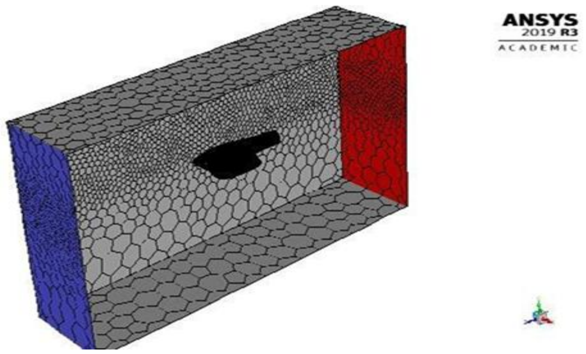


Fig. 4: Meshing and representation of boundary conditions

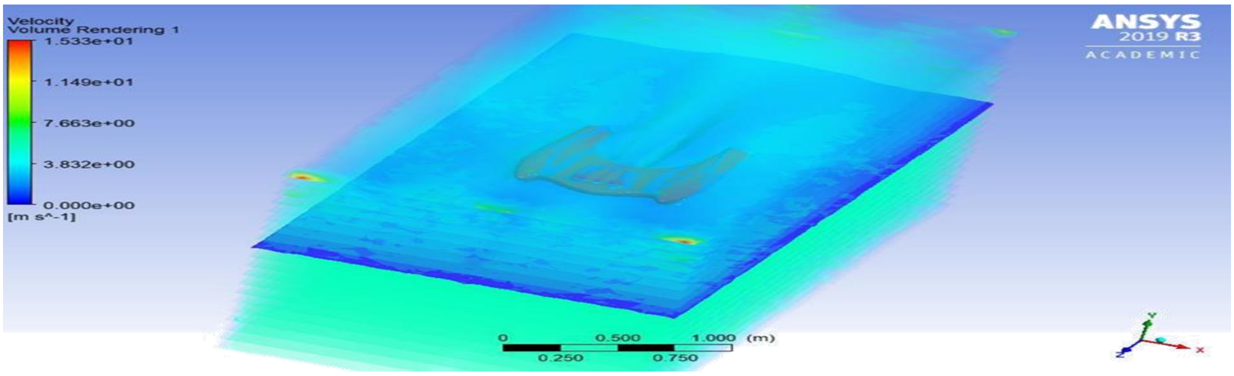


Fig. 5: Volume rendering

Figure 5 shows the volume rendering for visualizing the data of the 3-Dimensional model. This rendering is obtained under velocity contour results.

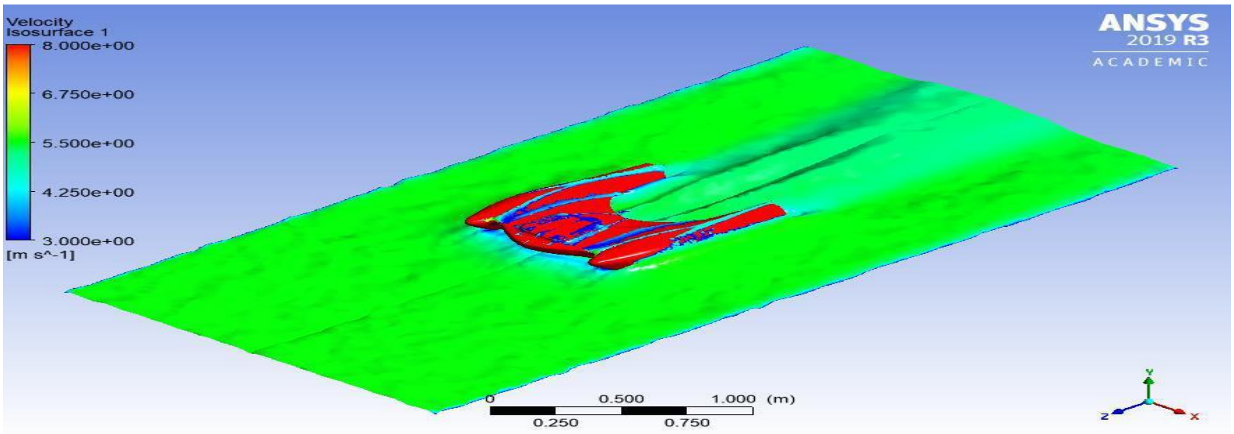


Fig. 6: Surface velocity representation

It can be seen in figure 6 that the optimum surface velocity lies at 5.6m/s.

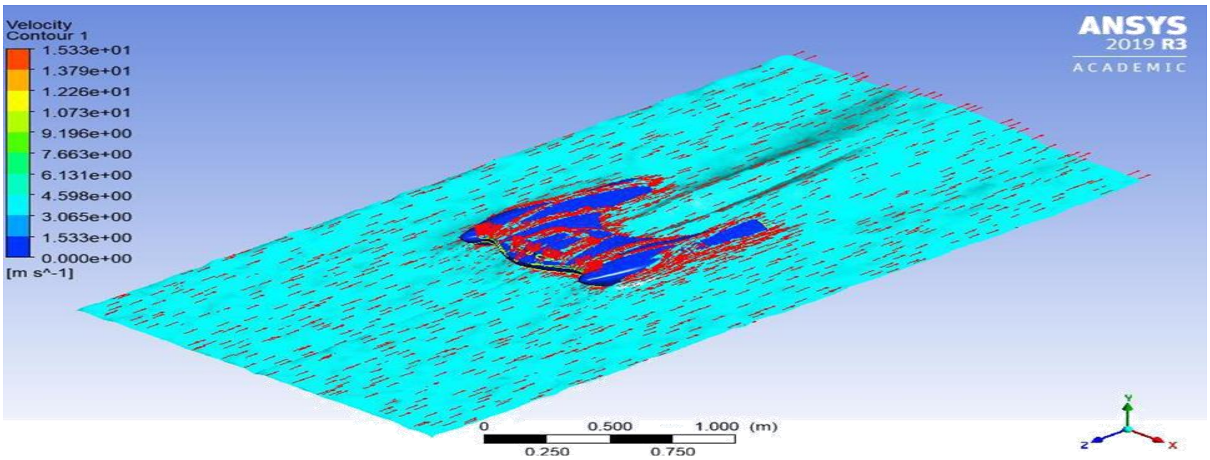


Fig. 6: Surface velocity representation

It can be seen in figure 6 that the optimum surface velocity lies at 5.6m/s.

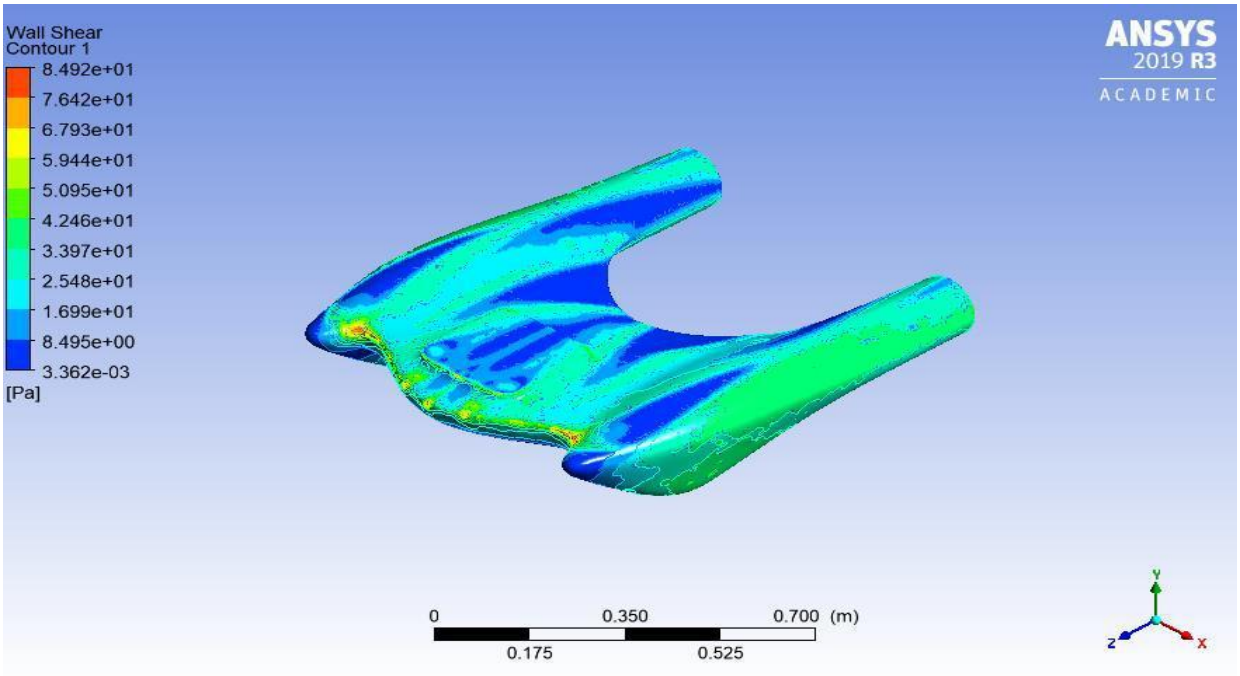


Fig. 8: Shear force across the walls of the buoy

Figure 8 represents the shear force induced on walls of buoy and can be seen that the shear force is directly proportional to velocity and drag force.

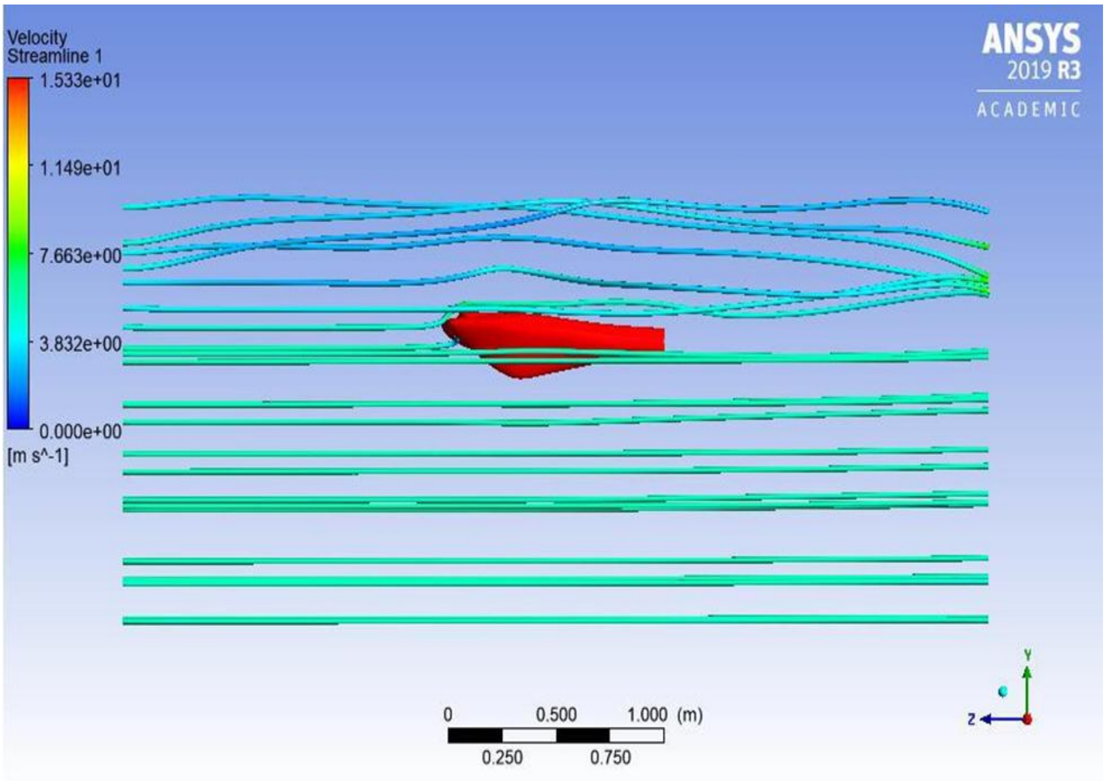


Fig. 9: Streamline velocity representation

Figure 9 depicts the streamline flow velocity in medium. Streamlines are the curves which are instantaneously tangent to the velocity vector of the flow indicating the direction in which each element of the fluid travels at any point of time. Figure 10 shows the velocity comparison across multiple axes.

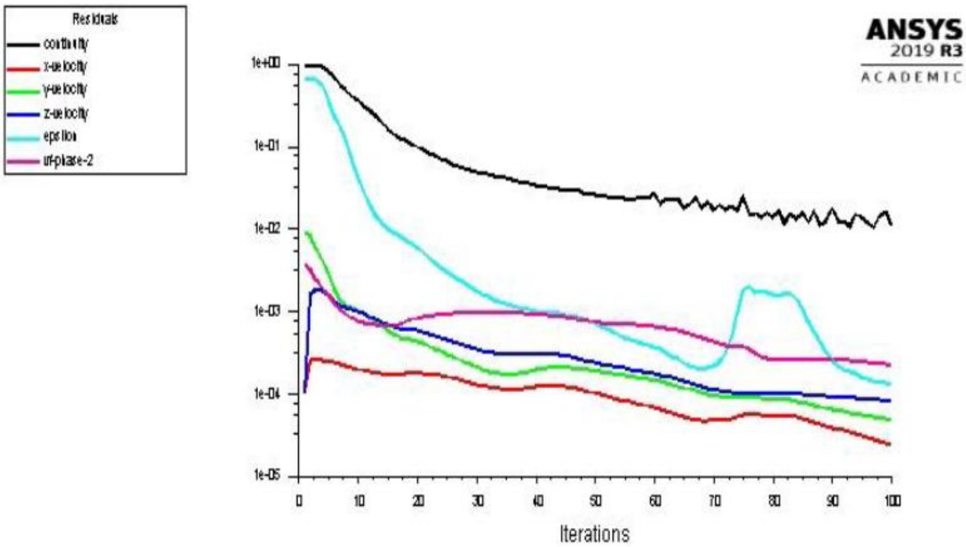


Fig. 10: Velocity representation along different axes

IV. CONCLUSION

The present work efficiently solves the problems concerned with rescuing people from drowning. It overcomes the drawbacks observed in conventional methods used in rescue operations. The newly implemented design structure is robust, fast and easily deployable. The catamaran design reduces the drag force and also increases the stability of the buoy. The analysis results show the efficient working of the design in rough water conditions.

The application of the proposed buoy is not limited to rescuing people but can also be employed for surveying monitoring and other purposes also.

REFERENCES

1. Dzan, Wei-Yuan, Shin-Yow Chang, and Keng-Chih Hsu. "Designing and building of a catamaran and its stability analysis." 2013 Second International Conference on Robot, Vision and Signal Processing. IEEE, 2013.
2. Nursal, Ridwan Saputra, et al. "Investigation on resistance effects through towing test and CFD analysis on catamaran boat hull form." ARPN J Eng Appl Sci 12.4 (2017): 1334-1343.
3. Prastowo, Hari, Agoes Santoso, and Andre Arya. "Analysis and Optimation Hydrofoil Supported Catamaran (HYSUCAT) Size 25 Meter based on CFD Method." International Journal of Marine Engineering Innovation and Research 1.1 (2016).
4. Hoppe, K. G. "Recent applications of hydrofoil-supported-catamarans." Fast Ferry International 36 (2001).
5. Bari, Ghazi S., and Konstantin I. Matveev. "Hydrodynamic modeling of planing catamarans with symmetric hulls." Ocean Engineering 115 (2016): 60-66.
6. Insel M. An investigation into the resistance components of high-speed displacement catamarans (Doctoral dissertation, University of Southampton).
7. Panan, Land. "The principle of shipbuilding-ships dynamics." Taipei: Five south books companies (1999).
8. Mulligan, Anthony C., and Robert W. Lautrup. "Remote controlled motorized rescue buoy." U.S. Patent No. 8,882,555. 11 Nov. 2014.
9. Iqbal, Muhammad. "Traditional catamaran hull form configurations that reduce total resistance." International Journal of Technology 8.1 (2017).Rashid, Mahbub & Roy, Rupal & Ahsan, Md Manjurul & Siddique, Zahed. "Design and Development of an Autonomous Surface Vehicle for Water Quality Monitoring". Preprint , January 2022 doi:10.48550/arXiv.2201.10685.
10. Putra, Ebenhaezer Candela Kristiawan, Suryanto, Muhammad Ramadhani, Suryanto, Suryanto, Adiputra, Ristiyanto, Prabowo, Aditya Rio, Puryantini, Navik, Carvalho, Hermes, Jurkovič, Martin and Imanullah, Fahmi. "Technological developments of amphibious aircraft designs: Research milestone and current achievement" Curved and Layered Structures, vol. 12, no. 1, 2025, pp. 20250026. https://doi.org/10.1515/cls-2025-0026.
11. Matthews, Nigel, Keith F. Joiner, and Warren F. Smith. 2024. "Stability Assessment of a Catamaran Using Sea Trials" Journal of Marine Science and Engineering 12, no. 8: 1436. https://doi.org/10.3390/jmse12081436.
12. Karlson, Graydon L. "Designing the best catamaran." Mathematical and computer modelling 17.4-5 (1993): 179-186.