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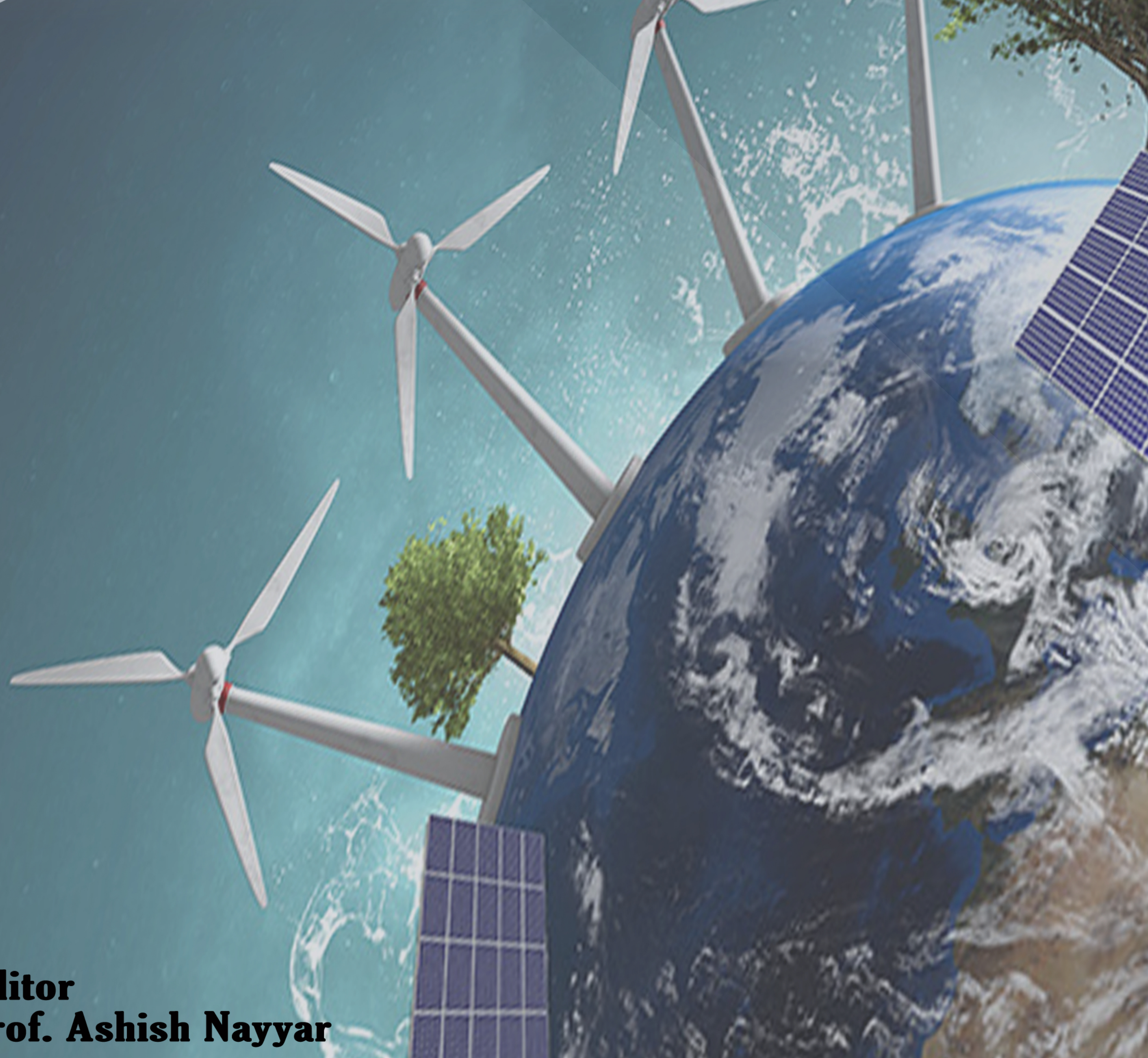

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DESIGN AND SIMULATION OF 3D PRINTED HOVERCRAFT AS A RESUPPLY VEHICLE WITH CFD

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Abstract

A hovercraft or air cushion vehicle (ACV) is a craft, designed to travel over any smooth surface supported by a cushion of slow moving, high-pressure air, ejected downwards against the surface below, and contained within a skirt. This hovercraft is made up of PLA material with the help of 3D printer. This can be operated or powered by turbojet as well as diesel engine also. The hovercraft can travel over mud, muskeg, sand water & ice. It will use two blowers one is used to control the direction and other one is to move the vehicle. The load bearing capacity of hover is 2 kg and the dimension of hovercraft is 35cm15cm*15cm. CFD analysis is done on hovercraft when the hovercraft is in contact with ground. At speed of 30 kmph, the velocity of air on the surface of hovercraft is 0.20 m/sec, which is in safe line.

Keywords: **Air Cushion Vehicle, Hovercraft, CFD**

INTRODUCTION

The basic principle of the hovercraft is that moving an object from the ground using air, then it requires less force to move the object. Because the object does not have any contact with the ground, then the surface tension will get reduced. So it is easy to move the object. The friction is also reduced in case of smoother surface. If the surface contains rocks or any other obstacles, then it may cause slow down the vehicle, or even damage occurs in the air cushion vehicle [1]. Hovercraft is used in various fields like for rescue operations, transportation, as resupply vehicle etc. [2-3]. Fig.1 shows a hovercraft with basic components.

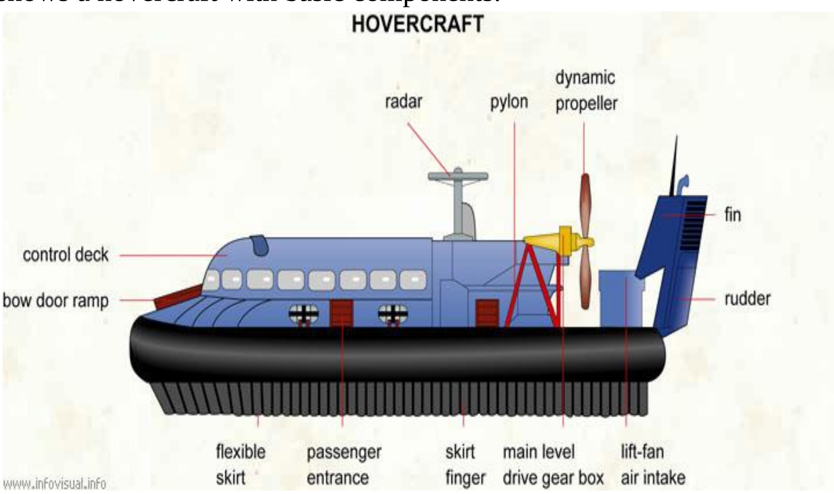

Fig. 1 Hovercraft (main components)

The design and development of amphibious vehicle are becoming a trend around the world due to its various applications like surveillance, patrolling, monitoring, payload delivery, photography, data collections and many hazardous jobs [4]. These vehicles are well known for its speed characteristic by which it could travel in water and land in high speed. The reason behind this characteristic is the hovercraft technology [5].
The objective of this research work is to design, manufacture (using additive manufacturing) and simulate a prototype of hovercraft to carry food, water and power when any natural disaster like flood, tsunami occur. Also remove the diesel and petrol engine from the hovercraft and make is a battery-operated vehicle, which can be operated by safe distance.

LITERATURE REVIEW

The first mention in the historical record of the concepts behind surface-effect vehicles that used the term hovering was by Swedish scientist Emanuel Swedenborg in 1716. The shipbuilder Sir John Isaac Thorneycroft patented an early design for an air cushion ship or hovercraft in the 1870s, but suitable, powerful, engines were not available until the 20th century [6]. In 1915, Dagobert Müller von Thomamühl built the world's first "air cushion" boat (Luftkissengleitboot). Hovercraft uses aerostatic principle through which it can travel effectively over the water surface by reducing the water drag. Hovercraft can be classified into Air Cushion Vehicle (ACV) and Surface Effect Ship (SES)[7], out of which ACV is highly recommended due to its shallow draft and amphibious characteristics. In a series of high-speed watercraft, ACV's are excellent in terms of less wave drag and speed. The bag and finger skirts are recognized as the most efficient skirt types for modern ACV's [8] due to its superior air cushion characteristics. Though it travels over the water surface, (without making contact with water), it doesn't create any harm to aquatic beings. It makes less pressure on the earth surface as compared to the pressure created by human footprints [9]. Due to this significant behaviour, hovercraft are considered as an ideal platform for environmental monitoring in coastal regions [10].
Frictionless movement and fast transportation are admired nature about the hovercraft. Few researchers focused on design and development of hovercraft. Amiruddin et al. [11] constructed a hovercraft with an aluminium base for a single person to travel. Schleigh [12] fabricated a hovercraft model and controlled its operation to track a line. Gera et al. [13] designed and fabricated an industry application hovercraft which runs on pressure lines from industries. Hein and Liaw [14] developed a one-seater hovercraft, consequently he investigated hovering and propulsion system of the vehicle [15]. The literature studies of hovercraft design are not addressed the design challenges of unmanned amphibious vehicles. Most of the small size hovercraft designs [16-17] are made for hobby purpose only which is not up to the level of performing experiments in water bodies. This paved the way to develop a highly reliable small size hovercraft platform for conducting various experiments on land for environmental monitoring. In this paper, the authors focus on major design drivers of hovercraft and validate the design through simulating the conditions using Computational Fluid Dynamic (CFD) platform and also the performance of the vehicle is tested.

DESIGN METHODOLOGY AND HOVERCRAFT COMPONENT DESIGNS

a. Design Methodology

Concept Phase – In this phase, the basic concept of the hovercraft was finalized. The design was finalized after studying the literature review and other competitors in the market.
Design Phase (Mechanical) –The SOLIDWORKS software is used to design the different components and final assembly of hovercraft.

Design Phase (Electrical) – The electrical design completed manually according to standard formulas used in industries to determining the running capacity of a hovercraft vehicle.

Simulation Phase – The simulation work is completed on ANSYS software.

Fabrication Phase –Different components are generated through 3D printing technology with PLA material. Other parts like motors and electrical equipment's are purchased directly. The battery pack was lithium-polymer battery of 2500 mAh.

Testing Phase – We have run the fabricated hovercraft in real world conditions. The hovercraft is properly working on land as well as on water. However, due to size constrain we face some problems which limits our vehicle to work properly in water surface.

b. **Hovercraft Components Design**

Chassis : It is the base of the hovercraft. All the other components are mounted on it. Its weight is around 102 gm.

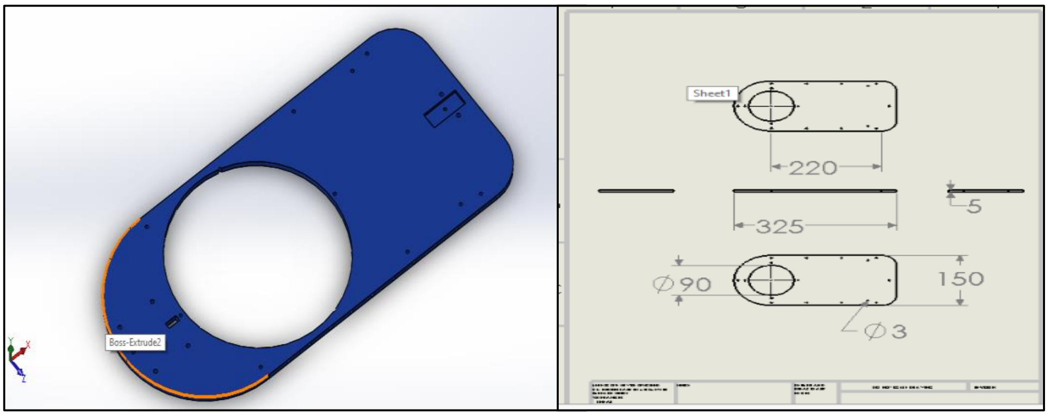

Fig. 2 : Chassis (model view with dimensions)

(a) *Back Case :* It is used to mount the propeller and motor for thrust. Its weight is around 140 gm.

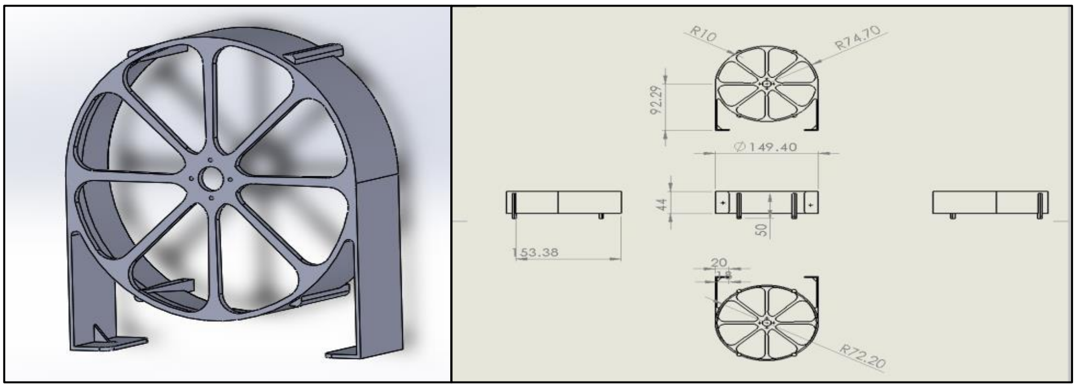

Fig. 3 : Back Case (model view with dimensions)

(b) *Holder :* It is used to hold and supply the material at rescue operation. It is of around 70 gm.

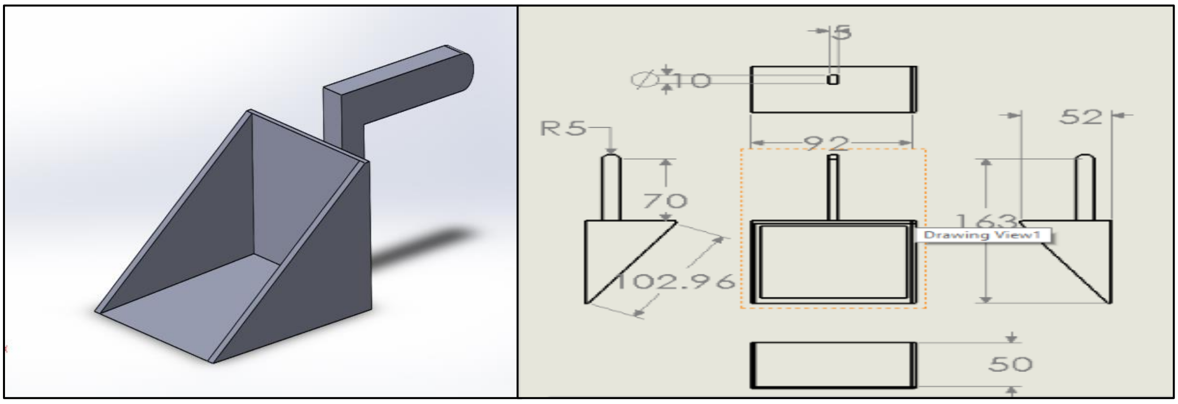

Fig. 4 : Holder (model view with dimensions)

(c) *Clamp :* It is used to hold the servomotor, which is used for movement of the holder. Its weight is 22 gm.

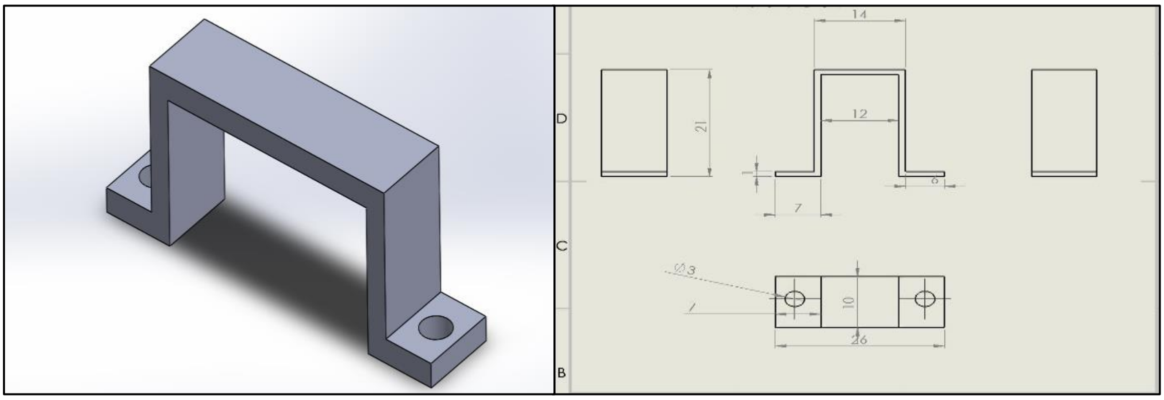

Fig. 5 : Clamp (model view with dimensions)

(d) *Connecting Shaft :* It is of 5 gm weight and used to give direction to the wings.

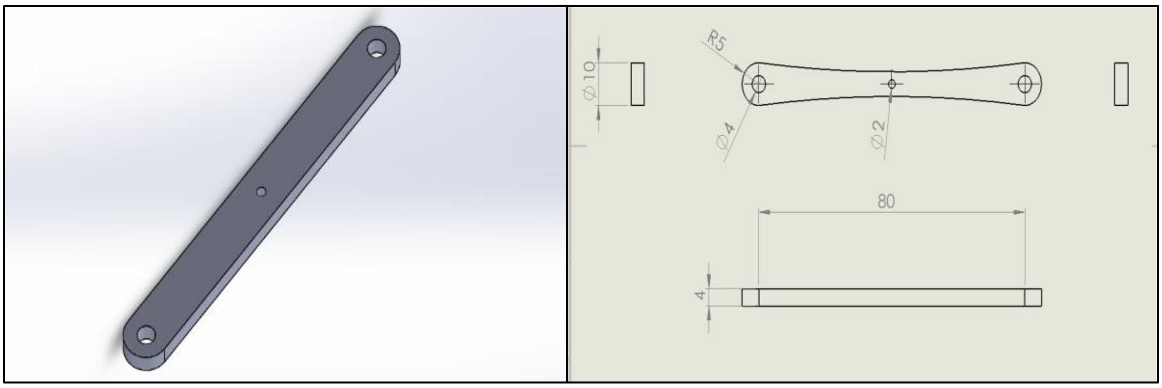

Fig. 6 : Connecting Shaft (model view with dimensions)

(e) *Wings :* It is used to change the direction of the hovercraft

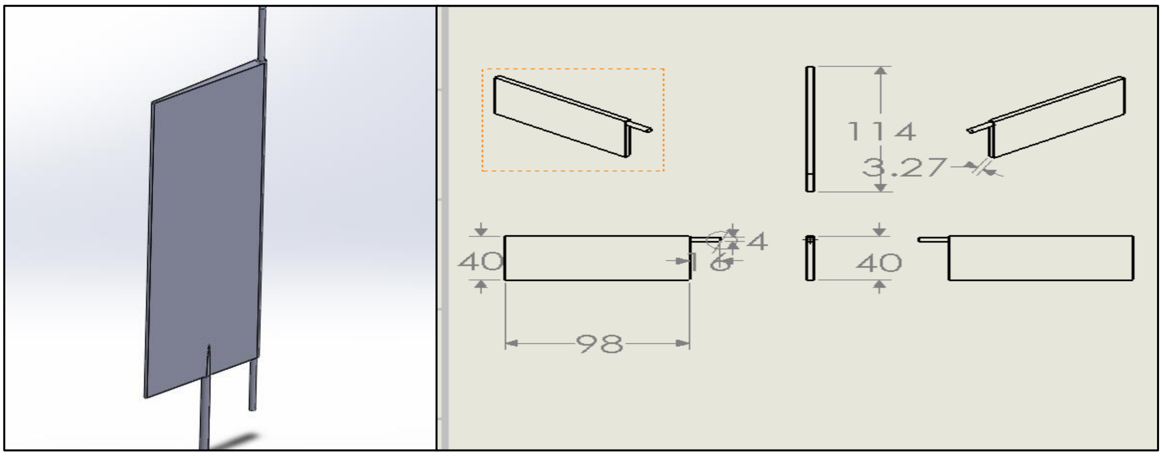

Fig. 7 : Wings (model view with dimensions)

FABRICATION, ASSEMBLY, SIMULATION AND DESIGN CALCULATIONS

4.1 **Fabrication and Assembly -** After all the components are designed and manufactured by the use of 3D printing technology the fabrication of the components is done in various stages such as fabrication of chassis with the cushion, mounting of propeller on the back case and front case, installing all the electrical equipment's on the various places of the hovercraft.

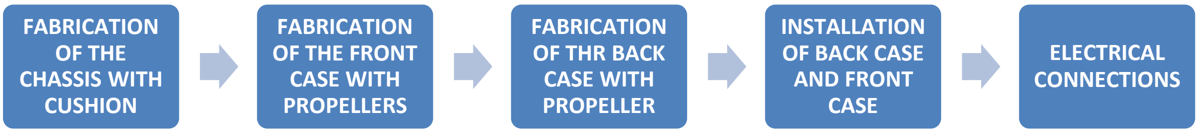

Fig. 8 : Hovercraft fabrication steps

Fig. 9 : Assembled Hovercraft

Table 1 List of the electrical components used in the hovercraft

Name Of Component	Quantity	Specification
BLDC Motor	**2**	Type: BLDC motor of 1400 kV. Operated with the 12 V capacity battery, Max RPM or the propellers are 1400x12 = 16800 rpm
Servo Motor	2	-
Power Distribution Board	1	-

Battery (Li-Po)	1	Removable 12 V battery pack, Charge time: 3 hours to full charge by a programmable charger' Assist range: 400m per charge
Jumper Wires	17	-
Transmitter	1	Model CT6B
Receiver	1	Model CT6B
Electronic Speed Control	2	-

4.2 Simulation and Design Calculations

The individual components and the assembly of the hovercraft designed in SOLIDWORKS was imported in ANSYS for analysis. The steps followed for FEA of the model are given below in flow chart.

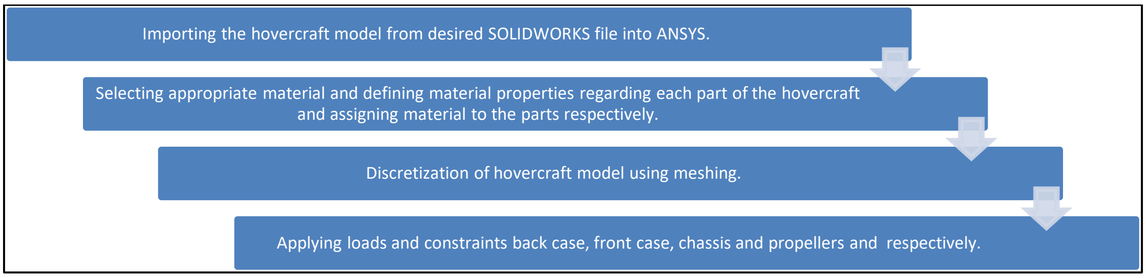

Fig. 10 : Steps in FEA

This CFD analysis shows that how an air particle pass on the front case, red color show the maximum velocity of air at that point of contact the velocity is 40 m/sec, when inlet velocity is 15 m/sec.

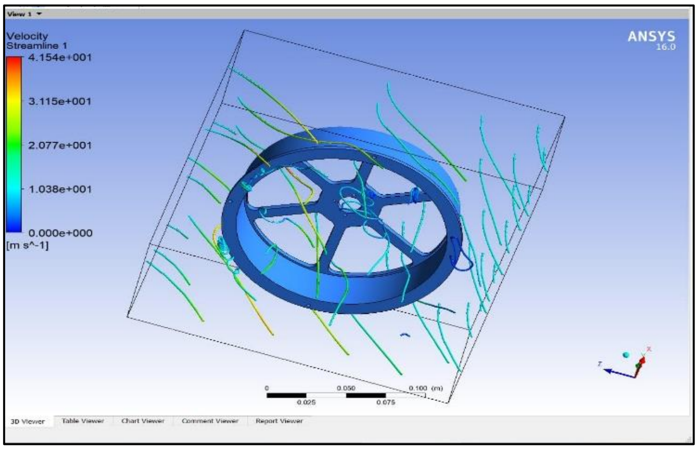

Fig. 11 : Front case simulation for counter air pressure by the chassis

In Structural analysis, we calculate the direction deformation of the back case, when we applied 150N force on X direction we found that deformation is only 5mm.

This image shows the overall deformation of back case when @150N gravity force applied on it. The maximum deformation is only 2mm which is in under limit.

Fig. 12 : (a) Direction deformation of the back case by propeller and (b) total deformation of back case

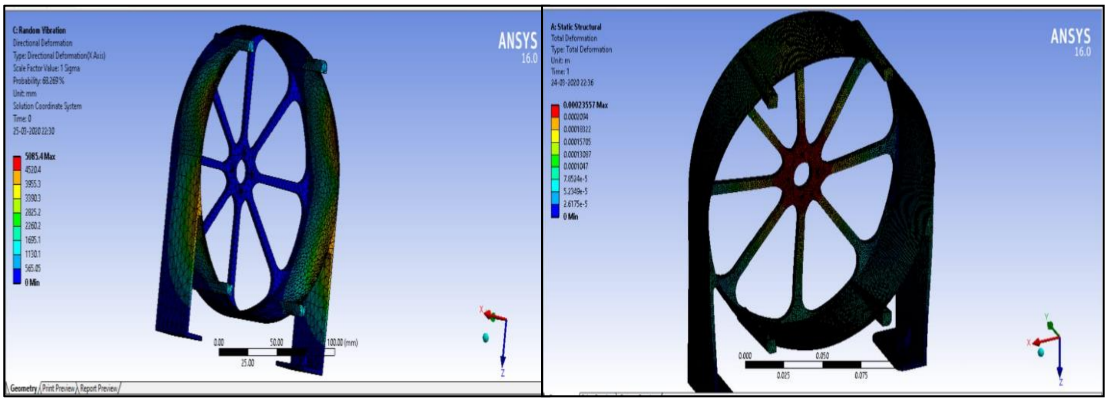

Fig. 12(a) shows the contour velocity of front case which means velocity of air at the edges of object is 17 m/sec which is shown in red color. Fig. 12(b) shows the density of front case which means maximum density is at the center which is shown in red color.

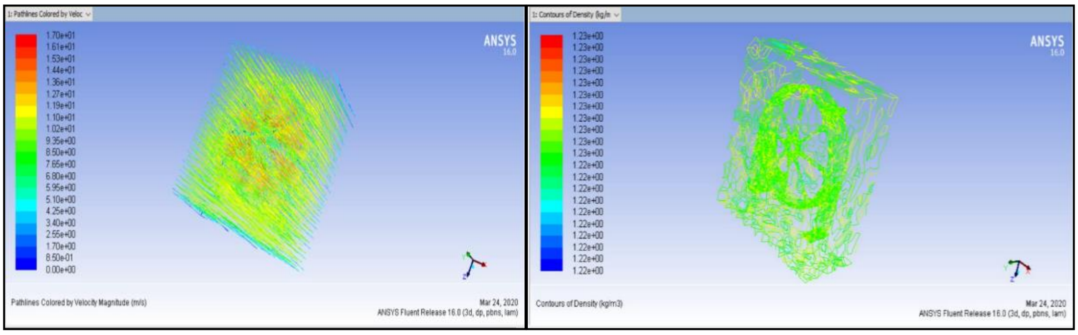

Fig. 13 : Counter velocity of front case and counter density of front case

Hovercraft Design Calculations :

Maximum take-off wt. (W) = m x g

= 0.8 x 9.81= 7.848 N

Length of Hovercraft (L) = 0.32 m (As per requirement)

Width of Hovercraft (W) = 0.32/2 = 0.16 m

Cushion area = L x W

= 0.32 x 0.16 = 0.0512 m^2

Cushion pressure (Pc) = W/AC

= 7.848/0.0512 N / m^2 = 153.28 N/m2

Air escape velocity = (2 PC / Density of air) ½

= (2 x 153.28/1.22) ½ = 15.85 m/s

The different performance parameters like maximum take-off weight, cushion pressure are, air escape velocity etc. calculated and compare with the simulation data. The design parameters found to in safe range.

CONCLUSION

This report has discussed all the aspects of the hovercraft supply vehicle in details. It can be concluded that the design of the hovercraft as per the initial specifications is successfully carried out.

While performing it on practical ground, it is found that the velocity of hovercraft is 3m/sec. with payload and without payload velocity of hover is 4m/sec. In simulation, we calculate stress, deformation on individual scale on which normal stress is not more than 7.57e6 MPa which is in permissible range on 3 sigma scale. The deformation on 1 sigma scale at 150N force is only 5.0mm which also in limits. The CFD analysis shows that aerodynamics of hovercraft is perfect for 100 iterations @7m/s air velocity so we can say all the simulation are perfect and in permissible range.

REFERENCES

[1] J. J. Helferty and S. J. Chen (2013), Hovercraft – A Project Based Approach To Introduction to Engineering.S. B. Pillapakkam,

[2] Amyot, J.R. (Ed.). (2013). Hovercraft technology, economics and applications (Vol. 11). Elsevier.

[3] Pope, G.G. (1976). An evaluation of a light hovercraft as a spraying platform and survey craft in the UK and Botswana. PANS, 22(1), 132-136.

[4] Yan, R.J., Pang, S., Sun, H.B., & Pang, Y.J. (2010). Development and missions of unmanned surface vehicle. Journal of Marine Science and Application, 9(4), 451-457.

[5] Saad, K.A.M., Murugan, K., & Ramli, M.A.H. (2018). The development of hovercraft design with a horizontal propulsion system. In Engineering Applications for New Materials and Technologies (pp. 91- 103). Springer, Cham.

[6] Moran, D.D., "Cushion Pressure Properties of a High Length-to-Beam Ratio Surface Effect Ship," NSRDC Report SPD-600-01, 1975.

[7] Yun, L., & Bliault, A. (2000). Theory and design of air cushion craft. Elsevier.

[8] Chung, J., & Jung, T.C. (2004). Optimization of an air cushion vehicle bag and finger skirt using genetic algorithms. Aerospace Science and Technology, 8(3), 219-229.

[9] Hovercraft.org. hovercraft-environment. Retrieved from www.hovercraft.org: http://www.hovercraft.org/hovercraft-environment/

[10] Lamberson, J., & Nelson, W. (2002). Environmental monitoring and assessment program national coastal assessment field operations: west coast field sampling methods-Intertidal 2002. US Environmental Protection Agency, Newport.

[11] Amiruddin, A.K., Sapuan, S.M., & Jaafar, A.A. (2011). Development of a hovercraft prototype with an aluminium hull base. International Journal of Physical Sciences, 6(17), 4185-4194.

[12] Schleigh, J. (2006). Construction of a hovercraft model and control of its motion (Doctoral dissertation). University of Maryland, USA.

[13] Gera, P., Sarkar, S., Jha, R., Raj, R., Bardhan, R., & Gupta, S. (2009, January). Design, fabrication and industrial application of a miniature hovercraft. In ASME 2009 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference (pp. 665-674).

[14] Hein, S.M., & Liaw, H.C. (2013). Design and development of a compact hovercraft vehicle. IEEE/ASME International Conference on Advanced Intelligent Mechatronics, (pp. 1516-1521). Wollongong, Australia.

[15] Anguah, K., & Szapiro, N. (2009). Design and construction of a passenger hovercraft. E90 final report.

[16] Okafor, B.E. (2013). Development of a hovercraft prototype. International Journal of Engineering and Technology, 3(3), 276-281.

[17] Noor, S.M., Syam, K., Jaafar, A.A., Sharif, M.M., Ghazali, M.R., Ibrahim, W.I., & Atan, M.F. (2016, February). Development of a working hovercraft model. In IOP Conference Series: Materials Science and Engineering (Vol. 114, No. 1, p. 012150). IOP Publishing.

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Renewable energy and sustainable development are the key technologies to offer solutions to the ever-increasing environmental pollutions and depleting conventional fuel reserves. With an aim to discuss the state of art technologies pertaining to the renewable energy domain, RTU (ATU) TEQIP III Sponsored 3rd International Conference on New and Renewable Energy Resources for Sustainable Future (ICONRER-2021) was organized by the Department of Mechanical Engineering, Swami Keshvanand Institute of Technology, Management and Gramothan, Jaipur in collaboration with Rajasthan Technical University and Department of Mechanical Engineering, Assiut University, Assiut (Egypt) from February 11 to 13, 2021. ICONRER is a series of the conference started in 2017 and it was 3rd event of that series.

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