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DESIGN AND STRUCTURAL ANALYSIS OF HOVERCRAFT USING ANSYS SOFTWARE

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Abstract: *A hovercraft is a special type of vehicle that moves on a cushion of air. The lifting motion is controlled by a fan or fans so that an air gap can be formed. Such separation between the bottom of the hovercraft and the ground provides a motion platform, on which the friction force between the hovercraft and the ground reduces to a very small amount. For this research project, there are two basic requirements. The first requirement is to design and analysis of a physical model of a hovercraft. The second requirement is to control the motion of the constructed hovercraft by the method, such as following a track, which consists of straight lines and curves. These systems are done by modeling software's like CatiaV5, and analysis is done by Ansys software. By utilizing the high air pressure to lift the cargo, the presence of an air gap enables it to move the heavy cargo with much less force. Specifications of a product are detailed in terms of the product size, speed range, weight and power consumption. The first design kit was for a hovercraft model with one lifting fan and one propelling fan. The second design kit was for a hovercraft model with one lifting fan and two propelling fans. We need to design these two hovercraft models, as shown below. The lifting fan is placed in the central location of the hovercraft to provide the force required to lift the hovercraft and form an air gap between the hovercraft and the ground. The two propelling fans are located at the rear part of the hovercraft to generate the thrust action, which pushes the hovercraft forward. Even though the program worked well, there were some errors that were identified after testing. One problem was that the additional components that were added for the program were too heavy for the lift fan, resulting in increased performance.*

I- INTRODUCTION

A hovercraft, also known as an air-cushion vehicle or ACV, is a craft capable of travelling over land, water, mud or ice and other surfaces both at speed and when stationary. Hovercrafts are hybrid vessels operated by a pilot as an aircraft rather than a captain as a marine vessel. The first practical design for hovercraft derived from a British invention in the 1950s to 1960s. They are now used throughout the world as specialized transports in disaster relief, coastguard, military and survey applications as well as for sport or passenger service. Very large versions have been used to transport hundreds of people and vehicles across the English Channel whilst others have military applications used to transport tanks, soldiers and large equipment in hostile environments and terrain.

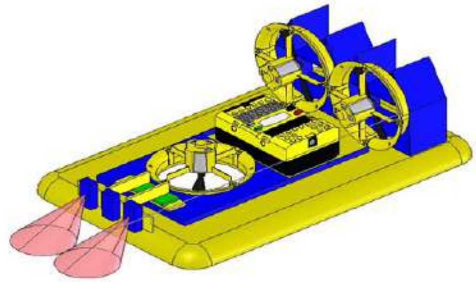

Fig: Hovercrafts

Fluid cushioned vehicles which are suspended a slight distance above an underlying ground or water surface by pressurized fluid flow output beneath such vehicles are known as an air-cushion vehicle, also known as a ground effect machine (GEM) or a Hovercraft. These devices are also known as surface effect machines, ground effect vehicles and airborne surface vehicles. One type having a flexible or partially flexible skirt to contain lifting air, which leaks out under the skirt and can be controlled to some extent for balance and steering. Usually the propulsion and directional control are obtained by separate means, such as propellers and rudders, on top of the vehicle.

The other basic type has rigid side walls surrounding an air chamber, the walls being immersed in or in sliding contact with the supporting surface to minimize air leakage. The supporting air can be used for propulsion, since the energy is well contained, but additional propulsion means is often used.

II - LITERATURE REVIEW

90design & Air Flow Simulation of Small-Scale Working Model of Hovercraft; Hovercraft is an air cushion vehicle which moves on the land, ice, water and several other surfaces on which other vehicle cannot travel like in mud. The main focus is on applying the basic principles, laws and equations like continuity, energy, momentum for simulating the model. The simulation of the model is done to optimize the lift of hovercraft by optimize flow pattern and by finding dimensions and other parameters like pressure, velocity, discharge for particular weight. This paper is prepared regarding to work of simulation and design of small-scale working model of hovercraft. Before the actual simulation basic theory is studied various methodologies and basics regarding to software as well as for project concern are studied. The result obtained from simulation is studied and optimum flow pattern for particular weight is selected in order to design the actual model. The results obtained by simulation are compared with the result obtained from the experimental model of hovercraft. This paper is regarding to work of simulation and comparison with theoretically calculated values.

CFD Analysis of a Round Shaped Air Cushion Vehicle with Flexible Skirt Segments at 90°; Air cushion vehicles represent an interesting research area, mainly from their application point of view. But, at the same time, represents the reason of the scarcity of published results. Based on a series of initial simulations carried out by authors, who analyzed lift forces for a round-shaped air cushion vehicle where the segments of the flexible skirt were inclined at

90˚, it was decided to carry out more complex studies regarding this configuration, presented in a seriesof articles. This complex study consists in performing static CFD simulations, in which values for different constructive elements are modified in order to analyzetheir influence on lift force. In this first article, the imposed fixed parameters are: angle of inclination of the segments of the flexible skirt and height of the segments, respectively. The main constructive variable parameters are: air clearance heightand length between the edge of the bag to cushion feed orifice and inner wall ofthe flexible skirt segments. The simulations were carried out in ANSYS Fluent

software, where velocity contours, streamlines and velocity profiles from the exit under the flexible skirt were analyzed and through Curve Fitting Toolbox application found in MATLAB program, the equations were established thatdescribe lift force variation.

A Study of a Skirtless Hovercraft Design; Three proposed skirt-less hovercraft designs were analyzed via computational fluid dynamics to ascertain their lift generation capabilities. The three designs were adaptations from William Walter's hybrid-craft primer and his patent for a fan driven lift generation device. Each design featured Coanda nozzles, or nozzles that utilize the Coanda effect, to redirect air flow to aid in the generation of an air curtain around a central air flow. The designs also utilized a Coanda wing as a lifting body to aid in lift generation. Each design was set at a height above ground of one foot and a radius of two feet. The craft was assumed to be axisymmetric around a central axis for a perfectly circular craft, much like a flying saucer. The craft can be divided into several parts, the core, the nozzles, the plenum chamber (for designs 2 and 3), and the wing. Flow is generated from rotor blades situated one foot above the top of the core of the craft. The nozzles are located at the edges of the craft below the wing. In designs two and three the plenum chamber is the region between the core and the wing. For each design three cases were performed where t was increased for each case. This resulted in a total of nine cases, three cases for three designs. For each case the ratio of nozzle thickness to the radius of the curved plate, t/R, was set to 0.344 and t was increased while R was calculated to maintain the ratio. The computational fluid dynamics (CFD) analysis captured the pressure data and the lift forces were calculated using a pressure differential analysis. Analysis proved that the hybricraft designs could produce positive lift. While the first design did not produce positive lift, the second and third designs managed to generate enough lift to support a craft of a maximum of 52810.24 kg. The max amount of lift produced was 5388.8 N, while the minimum positive lift generated was 3642.9 N.

III - PRINCIPLE OF HOVERCRAFT MODEL

Laws of Motion Are Used In Hovercrafts

A hovercraft is a versatile boat that you can ride up to the shore. Riding on a hovercraft is like gliding along on a cushion of air. Hovercrafts are also known as air-cushion vehicles. Air currents underneath the base of the hovercraft allow it to travel on land or water. Low-pressurized air is ejected downward against the surface below, whether land or sea, causing the boat to float on the air. Newton's three laws of motion further explain how hovercrafts operate.

Newton's First Law: This law is also referred to as "the law of inertia." It states, "An object at rest will remain at rest unless acted on by an external force. An object in motion continues in motion with the same speed and in the same direction unless acted upon by an external force." Simply stated, objects tend to maintain their position or direction unless another force or object interferes. Friction is tension between two objects that are touching. A hovercraft in motion will eventually come to rest because of friction and Newton's First Law. Once the hovercraft is no longer powered and comes to a stop, it will simply float on the water.

Newton's Second Law: According to Newton's second law of motion, "Acceleration is produced when a force acts on a mass. The greater the mass [of the object being accelerated], the greater the amount of force needed [to accelerate the object]." Newton's second law explains the force that accelerates the hovercraft. Some hovercrafts, such as homemade ones, can be steered simply by shifting your weight inside the vehicle. Leaning to the left will push more air to the right side. This will move the hovercraft toward the left. Leaning forward will add velocity by blowing air out the back of the vehicle.

Newton's Third Law: Newton coined, "For every action, there is an equal and opposite reaction." This means that actions are interrelated. Further, actions and reactions occur in pairs. This law is true whether the forces are in equilibrium, moving, stationary or accelerating. For instance, the opposite of push is pull, and the opposite of up is down. Newton's Third Law explains the forces of lift and thrust in a hovercraft. The hovercraft is lifted off the ground by its air cushion -- the difference in air pressure above and below the hovercraft -- causing a lifting force. The fan of the hovercraft pushes air behind the vehicle, which propels it forward.

The Hovercraft Principle

The principle of working of a Hovercraft is to lift the craft by a cushion of air to propel it using propellers. The idea of supporting the vehicle on a cushion of air developed from the idea to increase the speed of boat by feeding air beneath them. The air beneath the hull would lubricate the surface and reduce the water drag on boat and so increasing its speed through water. The air sucked in through a port by large lifting fans which are fitted to the primary structure of the craft. They are powered by gas turbine or diesel engine. The air is pushed to the underside of the craft.

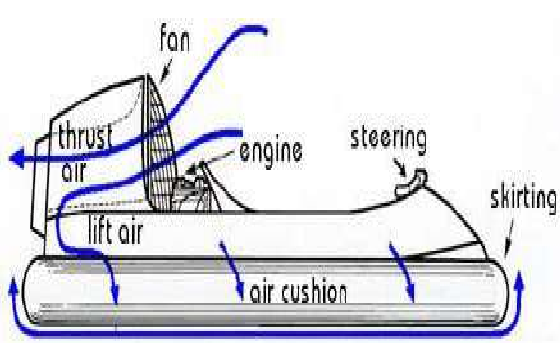

Fig: Hovercraft Principle

On the way apportion of air from the lift fan is used to inflate the skirt and rest is ducted down under the craft to fill area enclosed by the skirt.

Designing a Hovercraft

When designing a hovercraft it is important to have a clear set of client needs and target specifications to refer to throughout the design process. The client needs are used to evaluate preliminary design concepts to select the most feasible for each functional component of the hovercraft, while the target specifications are used to further refine the selected design components.

- Safe For Use Indoors In The Presence Of Spectators
- Light Weight
- Cost Effective
- Easy To Manufacture
- Should Move In A Straight Line
- Should Move Fast
- Portable
- Aesthetically Pleasing (Fit And Finish)

IV - DESIGN METHODLOGY OF HOVERCRAFT MODEL

Modeling of Hovercraft Model in CATIA V5

This Hovercraft Model is designed using CATIA V5 software. This software used in automobile, aerospace, consumer goods, heavy engineering etc. it is very powerful software for designing complicated 3d models, applications of CATIA Version 5 like part design, assembly design.

The same CATIA V5 R20 3d model and 2d drawing model is shown below for reference. Dimensions are taken from. The design of 3d model is done in CATIA V5 software, and then to do test we are using below mentioned software's.

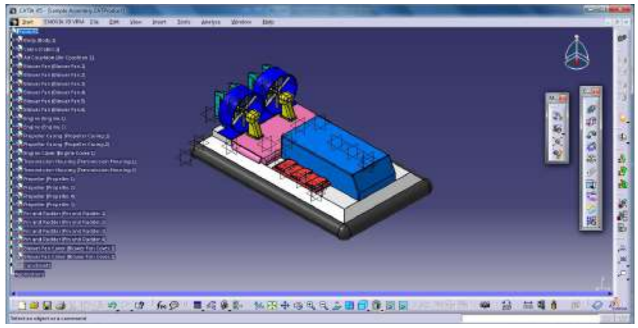

Fig: Model design of Hovercraft in CATIA-V5

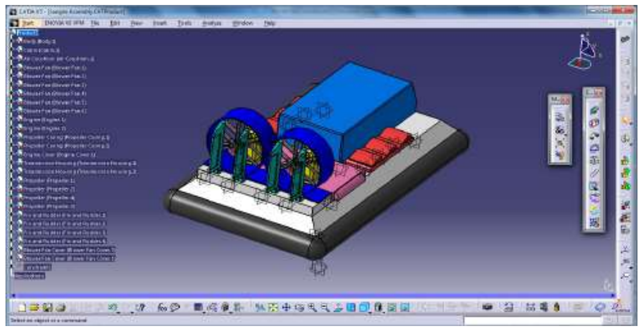

Fig: Model arrangement of hovercraft mechanism in CATIA-V5

V - ANALYSIS OF HOVERCRAFT MODEL

Procedure for FE Analysis Using ANSYS:

The analysis of the hovercraft components is done using ANSYS. For compete assembly is not required, motor and attached system is to carried out by applying moments at the rotation location along which axis we need to mention. Fixing location is bottom legs of assembly of the craft.

Preprocessor

In this stage the following steps were executed:

- **Import file in ANSYS window**

  File Menu > Import> STEP > Click ok for the popped up dialog box > Click Browse" and choose the file saved from CATIAV5R20 > Click ok to import the file

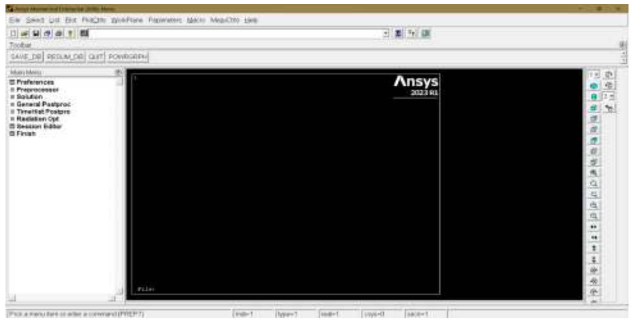

Fig: Import panel in Ansys.

VI - DISCUSSION ON ANALYSYS RESULT

Results of Displacement analysis:

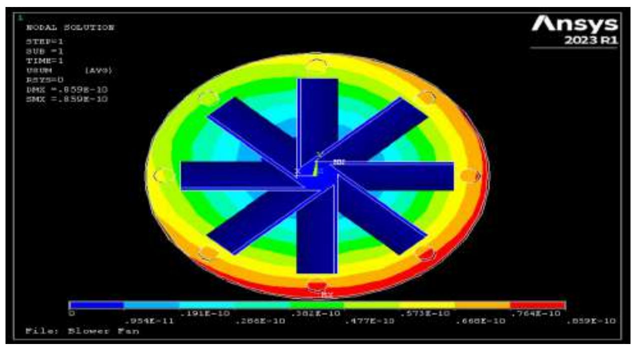

Fig: Displacement of Blower Fan

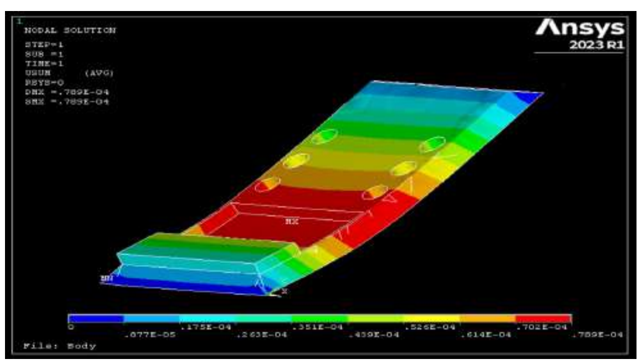

Fig: Displacement of Body

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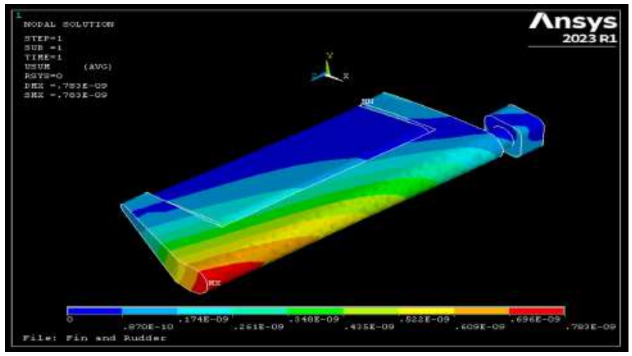

Fig: Displacement of Fin and Rudder

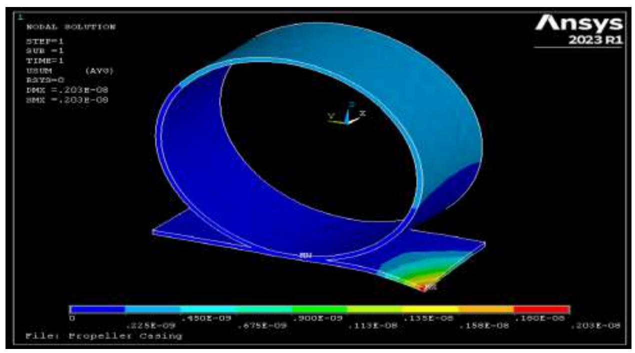

Fig: Displacement of Propeller Casing

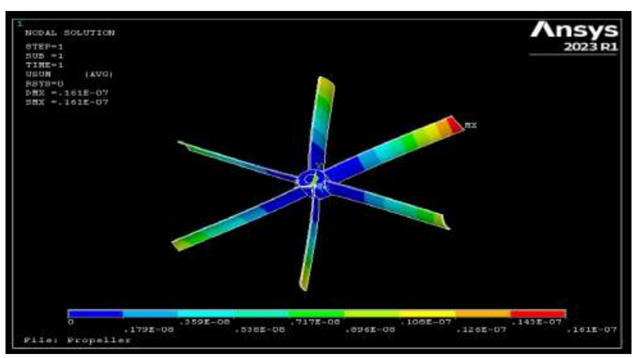

Fig: Displacement of Propeller

VII - CONCLSION

A highly nonlinear model for the dynamic behavior of Hovercraft is considered. A parametric study to investigate the influence of the control parameters on the dynamic response is conducted. The control parameters that influence the transient response are found to be dimensionless equation is developed to predict the settling time of the response. Based on the developed equation, the Optimum values of the control parameters of the ACV are obtained.

As shown in above figures the displacements of the components is meshed and solved using Ansys and displacement is very less. This is showing us that clearly each component in assembly is having minor displacement.

S.No	Component	Max. Displacement (in mm)
01	Air cushion	67.436
02	Blower Fan Cover	0.320E-06
03	Blower Fan	0.859E-10
04	Body	0.789E-04
05	Cabin	0.212E-08
06	Engine Cover	0.208E-07
07	Fin and Rudder	0.783E-09
08	Propeller Casing	0.203E-08
09	Propeller	0.161E-07

The final result positive manner .There is no problem while in Final assembly design; without failure. For proving that above analysis is carried out for applying displacements at structural force analysis. Clearly there is no shortage of ACV development in the future. As the technology is taking off in various forms, for example, combined with Maglev technology for high speed mass transit networks, the air cushion is well on its way to clear the path for future vehicle transport.

Although new hovercraft and ACV vehicles are low in noise, a problem that plagued earlier developments most engines used are still gasoline-based. It seems only a matter time before the first hover bikes and hover cars will appear on our streets. Hover buses anyone? What we need to tackle now is the power source of our current vehicles. Gasoline-based motors need to be a thing of the past quickly if we are to have any clean air in our cities. Electric motors and the newly developed fuel cells are the way forward; forget about the outdated combustion engine! TO BE ON ROAD…

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