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DESIGN AND STRUCTURAL ANALYSIS OF HOVERCRAFT USING CAE TOOLS

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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.*

I- INTRODUCTION

Air-cushion vehicle (ACV) or Ground Effect Machine (GEM) or hovercrafts is a craft capable of travelling over surfaces while supported by a cushion of slow moving, high-pressure air which is ejected against the surface below and contained within a "skirt." Although supported by air, hovercrafts are not considered an aircraft. It is a vehicle supported on a cushion of air, able to traverse many different types of sufficiently smooth terrain – including, in some cases, water. These are machines that slide along while balancing on top of an "air cushion" bubble. This bubble is generated by an air pump (fan) while a flexible "skirt" helps retain the bubble beneath the machine by limiting the air loss. Hovercraft has one or more separate engines - one engine drives the fan on the bottom of the hovercraft, (the impeller) which is responsible for lifting the vehicle by forcing high pressure air under the craft. The air then exits the apparatus through the "skirt", lifting the craft above the area on which the craft resides. One or more additional engines are used to provide thrust in order to propel the craft in the desired direction (these engines

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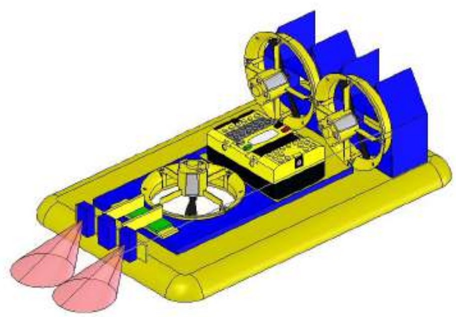
help push the hovercraft). A plethora of different directional utilities exist, but the most popular are thrust vectoring devices (such as rudders or differential thrusts), side thrust devices (such as puff ports or thrusters), and cushion tilt devices (skirt shifts, skirt lifts). Some hovercraft utilize ducting to allow one engine to perform both tasks by directing some of the air to the skirt, the rest of the air passing out of the back to push the craft forward. In preparing to design our own working hovercraft, we attempted to incorporate this one as well as many other proven designs in order to build a successful vehicle.



1.1 Classification of Air Cushion Vehicles (ACV)

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

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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.

Design and Analysis of Hover Bike Model; Now a day's fast and comfort aspects are both important thing and automobile is one of the things that use by human being for fast and comfort transportation but now it is world of innovation and we worked on future of automobile called as hover bike. Hover means to stay in air. In this research literature we thoroughly studied the design parameter required to design a hover bike. The detailed mathematical calculation is carried out for optimum model. The CAD model assembly of bike is design and analyzed by various loading condition for human safety. The obtain results are under factor of safety. This research literature is just a little contribution in field of automobile engineering and for its advancement.

Air Suspended Vehicle for Internal Transportation Purpose; The air cushion vehicle or hovercraft, as it is popularly known is the newest vehicle in today's transport scene. As well as being new, this vehicle is different from other more conventional, terrestrial vehicle in that it requires no surface contact for traction and it is able to move freely over a variety of surface while supported continuously on a self-generated cushion of air. In this study we are using plywood of length 1m and width 0.5m, skirts as same dimensions of plywood, prime mover to develop a model of air suspended vehicle to carry the load of 25kg.

Design and Development of Unmanned Hovercraft; The present study focuses on the development and performance analysis of unmanned hovercraft. The inherent characteristics of hovercraft such as hovering and gliding on diverse surfaces like water and land are intended for pollution control in remote water bodies. The vehicle is designed with bag skirt configuration for ease and smooth functioning on multiple terrains. Computer Aided Design (CAD) model with incorporation of spraying mechanism as a payload is conceptualized. Computational Fluid Dynamic (CFD) analysis at internal flow condition is performed and bag pressure of the skirt is assessed. The prototype model of vehicle to accommodate a payload of 0.8kg is fabricated from suitable lightweight materials and the experiments are conducted to explore the desired operation of hovering and forward thrust systems. The performance studies are made with velocity component in linear direction on land and water surfaces.

Design And Fabrication Of A Model Radio Controlled -Air Cushion Vehicle Utilize A Combined Single Trust And Lift System With A Body Shape Of Box Made Out Of Thermocol And With A Skirt Made Out Of Plastic; This project is based upon the design study [Plan something for a specific role, purpose or effect] which means create the design for; create or execute in an artistic or highly skilled manner. Main Objective of this project work to be carried out is to design a Radio controlled -Air cushion vehicle [RC-ACV]. More importantly main objection function is to implementing new ideas and concepts to make design safer, cost effective, to find alternative materials to make design lighter in weight, make design more aerodynamically and importantly more

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environmentally friendly. For the proper visualization of design, the model we also aim to make use of a Mechanical Cad software's 2D like Auto Cad & 3D like Pro/E or Solid works.

Design and Analysis of Winged Hovercraft; A flying hovercraft and ground effect vehicle design. The flat double-wing design for small, medium, and large cargo or military transport vehicles allows travel from very slow to medium to high speeds over water or land. The highly elongated, flat wing of very low aspect ratio provides a vehicle that is capable of traveling in ground effect flight at a safe distance above the water. Primarily a high-speed (150-200 kts), over-water, ground-effect, vehicle that is augmented with hovercraft capabilities for acceleration to flight speed, deceleration, and slow to moderate speed (0-75 kts.) operations. The vehicle design is adaptable from one-man units to large, ocean-going high-speed cargo ships of 400 feet and over, with carrying capacities over five million pounds. A vehicle of this design is 250% more\ efficient than modern aircraft, 15 times faster than cargo ships, and capable of going into true flight to overfly land masses for ocean-to-ocean and inland lake or river access. The design can be adapted to a multitude of fast, military, over-water vehicles of any size capable of travel over any terrain.

III – PRINCIPLE OF HOVERCRAFT MODEL

3.1 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.

3.2 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 dragon 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.

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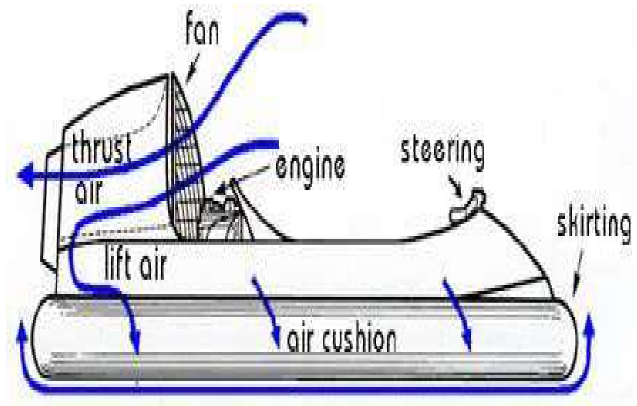

On the way apportion of air from the lift fan is used to inflate the skirt and rest is ducted down under the craft to fill area enclosed by the skirt.

IV – DESIGN METHODLOGY OF HOVERCRAFT MODEL

4.1 Introduction to CATIA

CATIA (Computer Aided Three-dimensional Interactive Application) is a multi-platform CAD/CAM/CAE commercial software suite developed by the French company Dassault Systems. Written in the C++ programming language, CATIA is the cornerstone of the Dassault Systems product lifecycle management software suite. CATIA competes in the high-end CAD/CAM/CAE market with Cero Elements/Pro and NX (Unigraphics).

CATIA can be applied to a wide variety of industries, from aerospace and defense, automotive, and industrial equipment, to high tech, shipbuilding, consumer goods, plant design, consumer packaged goods, life sciences, architecture and construction, process power and petroleum, and services. CATIA V4, CATIA V5, Pro/ENGINEER, NX (formerly Unigraphics), and Solid Works are the dominant systems.

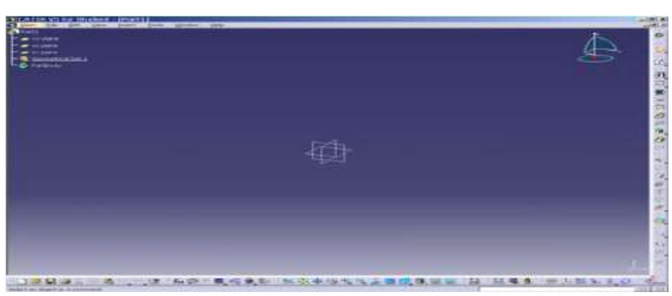

Fig: Home Page of CatiaV5

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4.4 Modeling of Hovercraft Model in CATIA V5

This **HOVERCRAFT MODEL** is designed using CATIA V5 software.

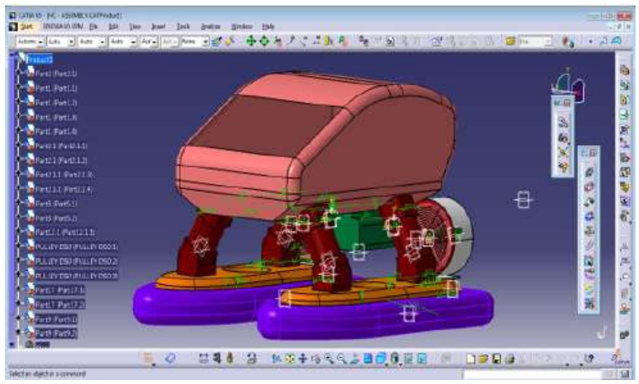

Fig: Model design of Hovercraft in CATIA-V5

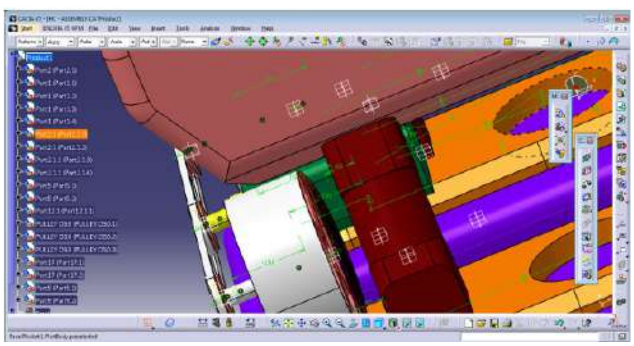

Fig: Model arrangement of hovercraft mechanism in CATIA-V5

V – ANALYSIS OF HOVERCRAFT MODEL

5.1 Procedure for FE Analysis Using ANSYS:

The analysis of the Skirt, Air cushion, cabin, blower fan, pulleys, v-belt 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.

5.2 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

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Browse" and choose the file saved from CATIAV5R20 > Click ok to import the file

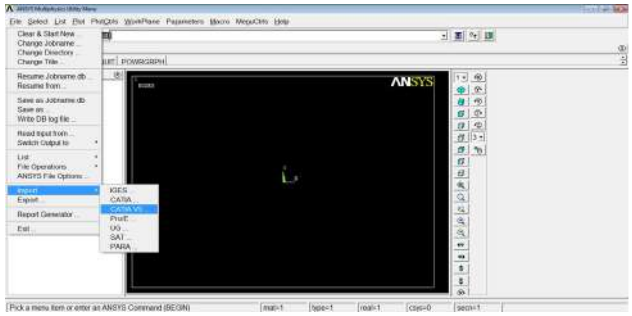

Fig: Import panel in Ansys.

Meshing:

Mesh generation is the practice of generating a polygonal or polyhedral mesh that approximates a geometric domain. The term "grid generation" is often used interchangeably. Typical uses are for rendering to a computer screen as finite element analysis or computational fluid dynamics. The input model form can vary greatly but common sources are CAD, NURBS, B-rep and STL (file format), found in mathematics, computer science, and engineering.

VI – DISCUSSION ON ANALYSYS RESULT

6.1 Results of Displacement analysis:

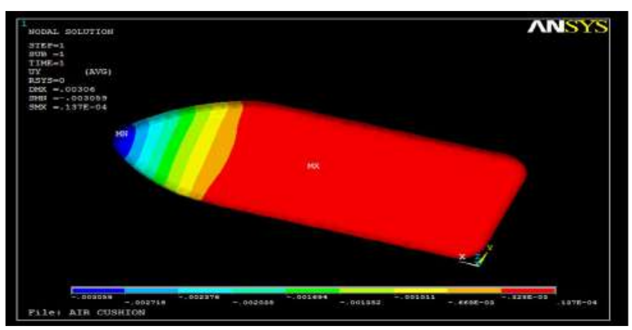

Fig: Displacement of Air cushion

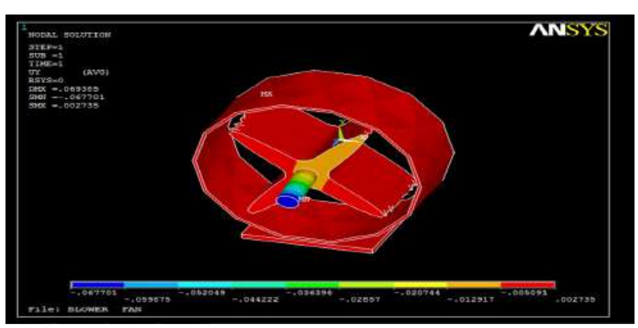

Fig: Displacement of Blower Fan

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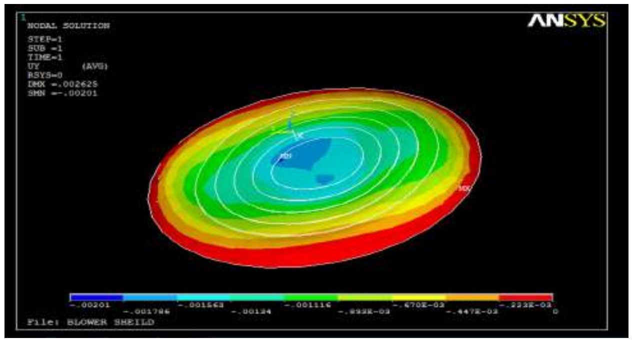

Fig: Displacement of Blower Shield

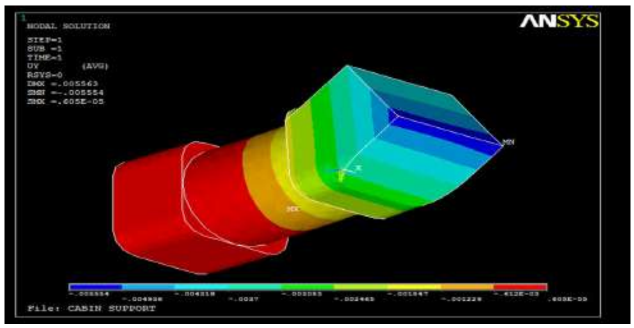

Fig: Displacement of Cabin support

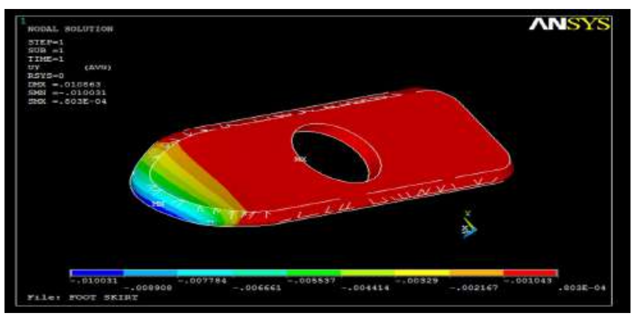

Fig: Displacement of Foot skirt

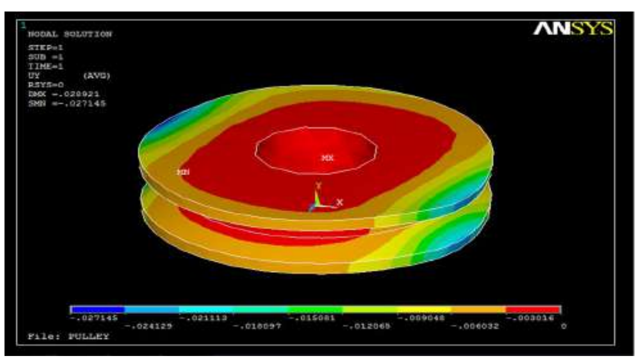

Fig: Displacement of Pulley

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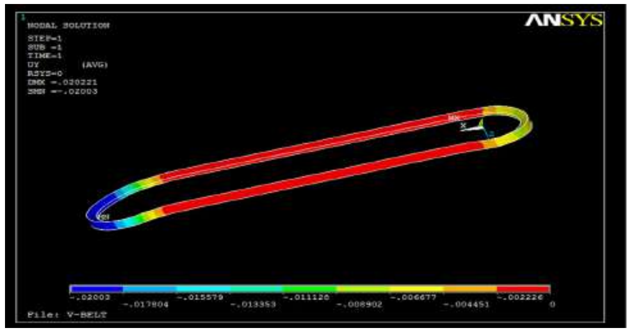

Fig: Displacement of V-Belt

6.2 Results of Stress analysis:

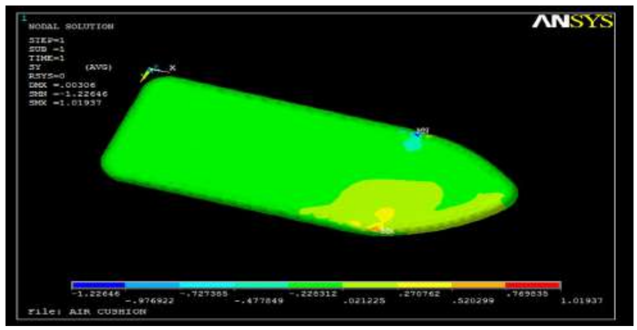

Fig: Stress Analysis of Air cushion

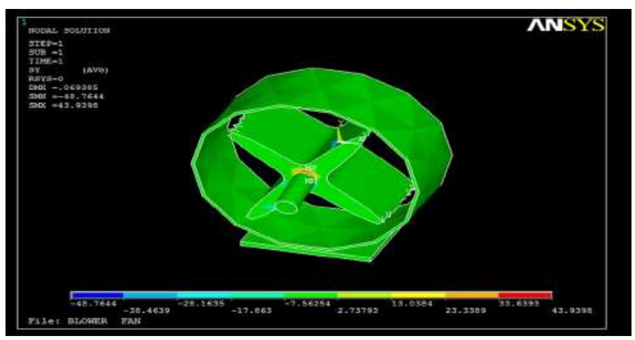

Fig: Stress Analysis of Blower Fan

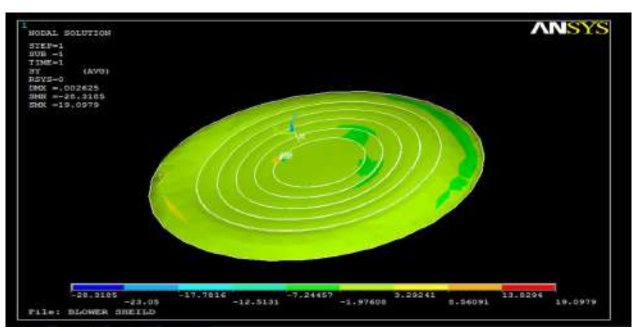

Fig: Stress Analysis of Blower Shield

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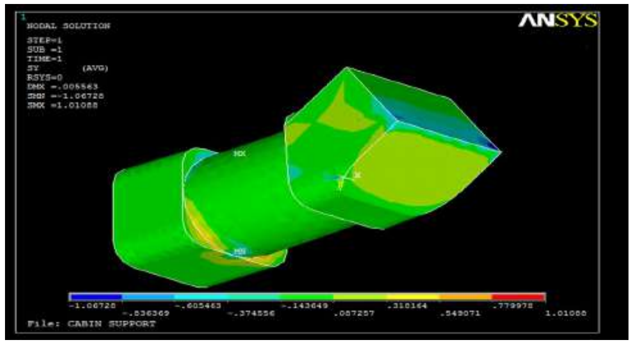

Fig: Stress Analysis of Cabin support

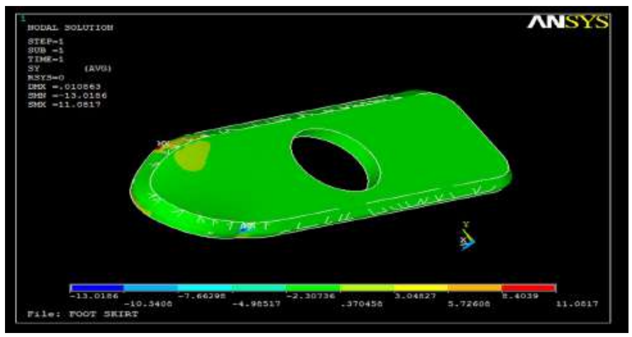

Fig: Stress Analysis of Foot skirt

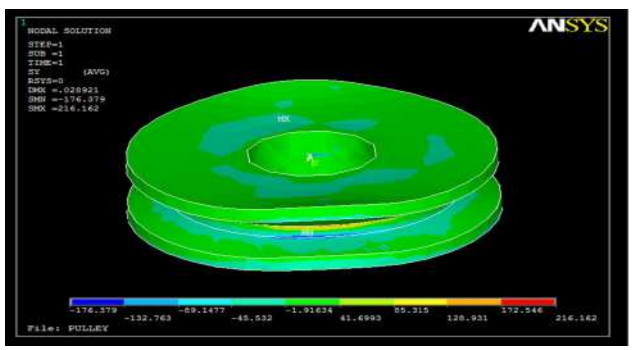

Fig: Stress Analysis of Pulley

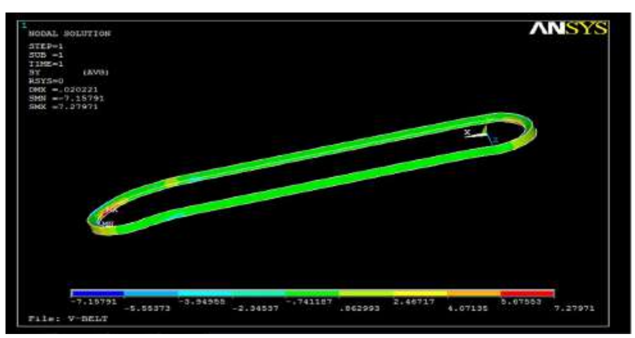

Fig: Stress Analysis of V-Belt

6.3 Results of Strain analysis:

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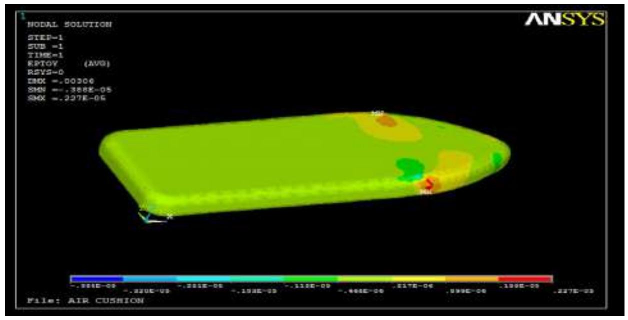

Fig: Strain Analysis of Air cushion

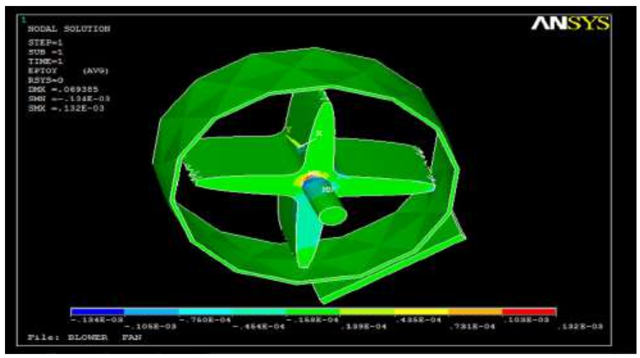

Fig: Strain Analysis of Blower Fan

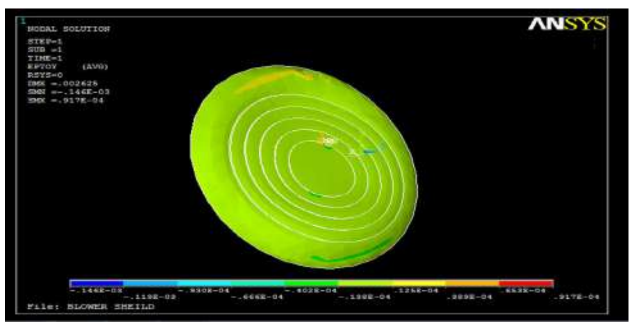

Fig: Strain Analysis of Blower Shield

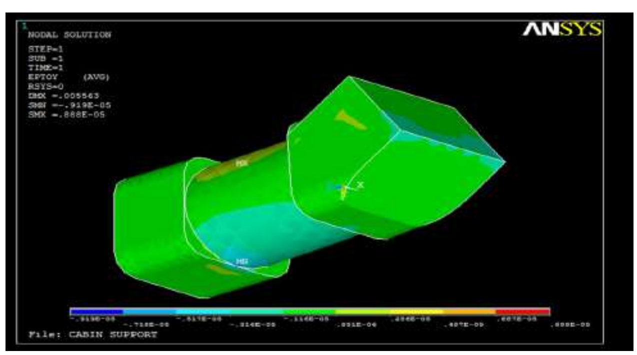

Fig: Strain Analysis of Cabin support

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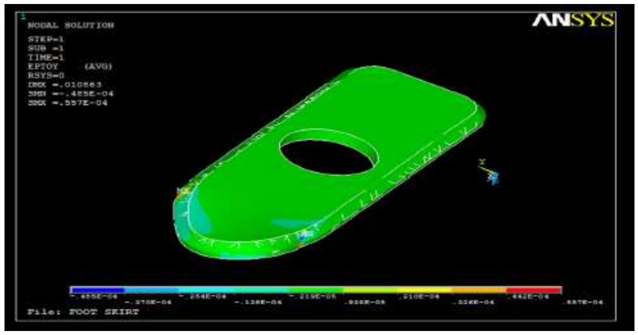

Fig: Strain Analysis of Foot skirt

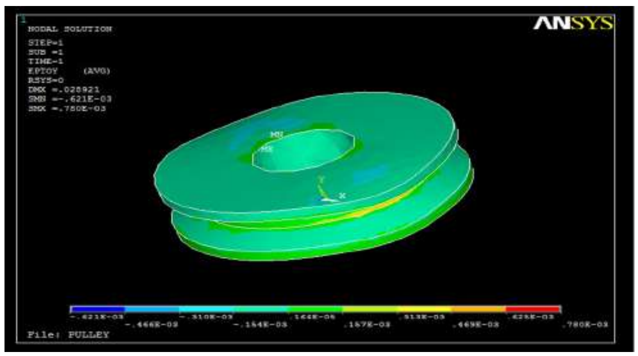

Fig: Strain Analysis of Pulley

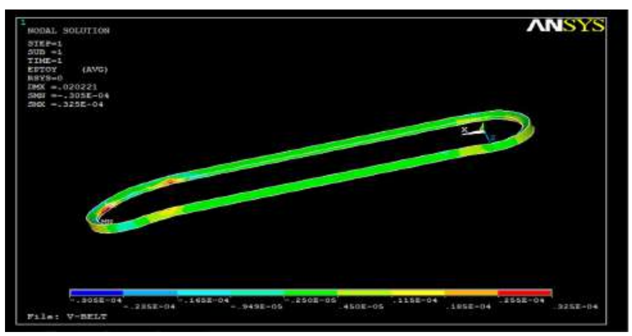

Fig: Strain Analysis of V-Belt

VII – CONCLSION

A highly nonlinear model for the dynamic behavior of ACV 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 gear assembly is having minor displacement. Stress is at the fixing location (Minimum Stress which is acceptable), stress value is 0.00306 MPa. The value which is very less compared to yield value of given materials; this is below the yield point. 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 and rotational 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. Consider that if the hovercraft does so well on difficult earth terrain, such as swamps, deserts, mud flats as well as rivers and even Open Ocean, what it would do for exploration of the planets in our solar system with a variety of hostile atmospheres and surfaces. 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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