Structural and Modal Analysis on A Frame Less Chassis Construction of Heavy Vehicle for Variable Loads

K. P. Sirisha, R. Lalith Narayana, A. Gopichand, Ch. Srinivas, G. Ram Balaji

(M.Tech, Department of Mechanical Engineering, ASRCE, Tanuku-534211,
Associate professor, Department of Mechanical Engineering, ASRCE, Tanuku-534211,
Associate professor, Department of Mechanical Engineering, SCET, Narsapur-534275,
Associate professor, Department of Mechanical Engineering, ASRCE, Tanuku-534211,
M. Tech, Department of Mechanical Engineering, SCET, Narsapur-534275)

ABSTRACT

This project mainly dealt with modelling of the frame less chassis and the analysis over that. The modelling of the component was done by using the advanced modelling software CATIA V5. The analysis was done by using one of the most important numerical methods is FEA and the software used is ANSYS 14.0. By using the features of this CATIA V5 software CHASSIS was modelled. The modelling of the individual parts will be done in the part module and the assembly of the individual parts was done in the assembly module by using bottom up method. In the analysis, the behaviour of the chassis will be shown in 6 mode shapes by using modal analysis. The static structural analysis was done at different load conditions and results will be tabulated and graphs were plot.

Keywords **-** Get mass far away from neutral axis, Thin wall tube in theory best, Wall buckling is an issue, must be resolved with something, Doors and Windows a problem.

I. INTRODUCTION

The automotive chassis is tasked with holding all the components together while driving, and transferring vertical and lateral loads, caused by accelerations, on the chassis through the suspension and two the wheels. Most engineering students will have an understanding of forces and torques long before they read this. It is suggested that the reader has a good understanding of the concepts of axial forces, shear forces, bending, torsion, angular and normal deflections, and finally mass moment of inertia. The key to good chassis design is that the further mass is away from the neutral axis the more rigid it will be. This one sentence is the basis of automotive chassis design. Some people stress full triangulation and material choice but once you are into these specifics some critical understanding is missed. People familiar with space frames may be thinking that full triangulation is the key to a good space frame. While this will make the design better it can still benefit from this more general design principles. The design section of the book will talk more about these items in relation to the types of chassis but the first part is the theory.

The perfect chassis is a large diameter thin walled tube. In order to understand this you should have a solid grasp of statics and deflection. The Automotive chassis has two main goals. Hold the weight of the components To rigidly fix the suspension components together when moving the first item is an easy design solution and is also the basis of the original chassis designs that were taken from horse drawn carriages. One of the most effective shapes for supporting point loads fixed at two ends is an I-Beam, a box tube, or a C-Beam. One beam on either side so that a floor could be attached and even the smallest of I or C beams can hold tremendous weight. Truck frames still use this construction as it is an easy and effective method of supporting heavy loads. It didn’t take long to find out that once these carriage chassis’s has been adapted and speeds increase they would no longer be sufficient to couple suspension components. It was a long time before body on chassis was eliminated in everyday vehicles and happened because of desire to reduce cost and weight in production cars. Long before that the space frame was born to fix the problems associated with this type of frame for higher performance vehicles. Space frames did not lend itself to mass production and stayed only in race cars and high performance sports cars.

Space frames gave way to the monocoque chassis as large flat surfaces had more mass consistently further away from the neutral axis. Race cars did this first by skinning a space frame to retain a supporting structure. It then eliminated this space frame and replaced it with light weight honeycomb material. This was due to the thin walls being strong in shear but in the compressive direction were unstable and buckled easily. The honeycomb material added.

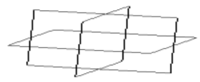
Reinforcing structure, and coupling two layers surrounds the driver in a very strong enclosure that is resistant to penetrative loads. Today the focus is on the material of the structure and layering techniques since the underlying concept is well developed. When cornering torques is applied to the chassis it causes it to twist. The engineering solution for this torsion problem is simply a tube. Understanding of basic mechanics, the further the material is away from the center of application of the torque; the more resistive it is to deflections to the power of four. One thing that competition designs normally quote is torsional rigidity in Newton-Meters/Degree of twist. Not all chassis torsion tests are the same but all give a general idea of how stiff the chassis is. The stiffer the chassis the more cornering torque it can handle with less effect on suspension geometry.

From this principle it is easy to see how a "perfect" chassis is a large diameter tube. It would be very resistant to torsional forces as well as good for holding the heavy components of a vehicle such as an engine and dealing with the lateral loads. But this is an ideal case. In reality loads are distributed over small areas and design elements cause huge stress. For instance an engine could not be mounted to a thin walled tube. It would need some sort of reinforcement to handle the localized bending this imposes. This brings us to the second problem of design. How do you design a box that people can get in and out of along with mount all the required components and protect the occupants. That is where chassis design becomes complicated. Once a hole for a entrance is created it gets significantly weaker in that area. A window is needed to see through and adds another hole. Soon the perfect chassis is a playground for walls to buckle and less predictable deflections to occur. As a result of all these holes and component weight is a significant problem and brings up the issue of wall buckling. Applying any load to a thin wall will cause it to buckle before the normal theoretical failure point. Space frames work well because the members are small enough to be self supporting against buckling. Monocoques require a secondary layer and supporting material to solve this problem. This is the where the bulk of design problem.

II. INTRODUCTION TO CATIA

CATIA V5 is the leading solution for product success. It addresses all manufacturing organizations. CATIA can be applied to a wide variety of industries, from aerospace, automotive, and industrial machinery, to electronics, shipbuilding, plant design, and consumer goods. Today, CATIA is used to design anything from an airplane to jewelry and clothing. With the power and functional range to address the complete product development process, CATIA supports product engineering, from initial specification to product-in-service, in a fully-integrated manner. It facilitates reuse of product design knowledge and shortens development cycles, helping enterprises to accelerate their response to market needs. CatiaV5 R16 is an interactive Computer- Aided Design and Computer Aided Manufacturing system. The CAD functions automate the normal engineering, design and drafting capabilities found in today's manufacturing companies. The CAM functions provide NC programming for modern machine tools using the CatiaV5 R16 design model to describe the finished part. CatiaV5 R16 functions are divided into "applications" of common capabilities. These applications are supported by a prerequisite application called "CatiaV5 R16 Gateway". CatiaV5R16 is fully three dimensional, double precision system that allows to accurately describing almost any geometric shape. By combining these shapes, one can design, analyze, and create drawings of products.

2.1 MODELLING

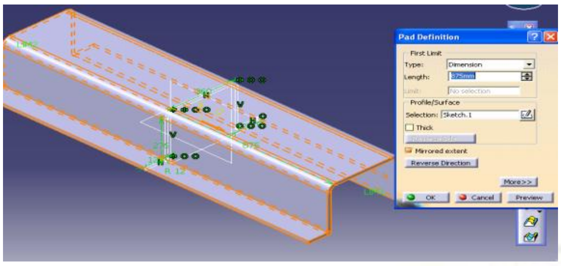


"Feature" is an all-encompassing term that refers to all solids, bodies and primitives used in CatiaV5 R15Form Features are used to supply detail to the model in the form of standard feature types. These include hole, slot, groove, pocket, rib and pad. We can also create our own custom features using the User Defined option. All of these features are associative. Reference Features allow creating reference planes, reference lines and reference points. These references can assist in creating features on cylinders, cones, spheres and revolved solid bodies. Reference planes can also aid in creating features at angles other than normal to the faces of a target solid. Dress up Feature options let's us modify existing solid bodies and features. These include a wide assortment of options such as edge fillet, variable fillet, chamfers, draft, offset face, shell and tapers.
Wire frame and Surface design lets us create surface and solid bodies. A surface body with zero thickness, and consists of a collection of faces and edges that do not close up to enclose a volume. Most Free Form Feature options create surface bodies.

2.1.1 CREATION OF SOLID/SURFACE BODIES

We can create solid bodies by padding the sketch geometry to create associative features or Creating primitives for the basic building blocks, then adding more specific features (for example, holes and slots etc.). Shafting the sketch and non-sketch geometry lets us to create a solid body with complex geometry. This method also gives us total control over the editing of the body. Editing is done by changing the swept creation parameters or by changing the sketch. Editing the sketch causes the swept feature to update to match the sketch. Dress-up features are used to modify the part bodies according to given specifications these are the most important features to modify the objects.

III. CHASIS MODELLING



SUPPORT

This chassis is done mainly by using the following features.

Pad: Pad is used to add material normal to a cross section or along a reference line.

Mirror: It is used to creates a body in opposite location through a reference plane.

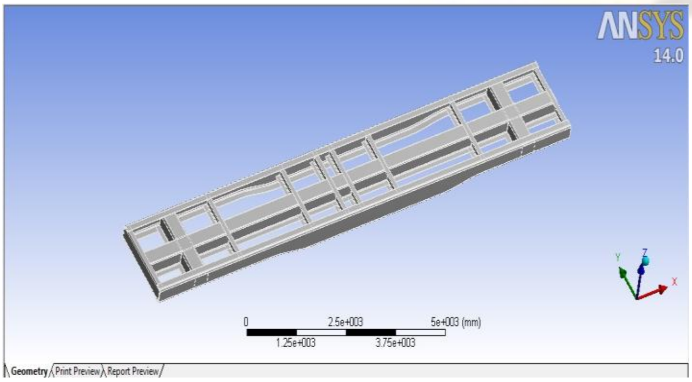
Rectangular pattern: It is used to creates duplicate objects in a rectangular way with required measurements in a linear direction.

Multi section solid: It is used to add material among multiple cross section with equal ratio or unequal ratio.

Shaft: It is used to create a circular or cylindrical shape objects with required cross section through an axis line with required angle.

Rib: It adds material by sweeping a profile along a center curve.

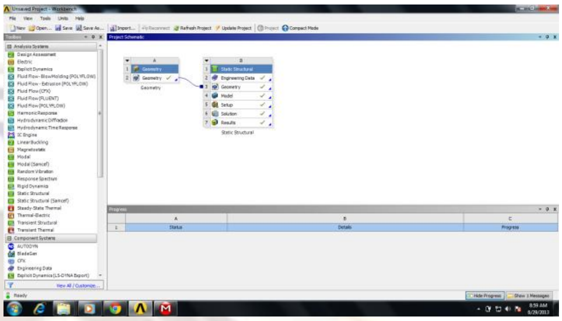
The sketch is created on the right plane and exit work bench then used pad tool to add the material as shown below with required length. In this line feature is used to draw the sketch. And for the bending portion at the edges corner tool is used After completion of the sketch selected the exit work bench to enter into the part for adding of material. Then select pad feature tool and select the sketch and give the required length for extrusion. Then select ok. After creating the first component, a reference plane is created with required distance. For that reference element toolbar is used parallel to the front plane. Then mirror feature is selected from the transformation tool. Select the tool then select the object and select the plane then the object will be mirrored.



FINAL CHASSIS

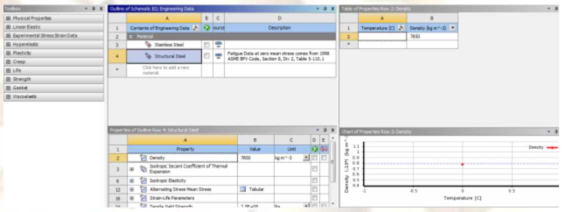
3.1 STATIC ANALYSIS

After the preprocessing, the solution has to be done. From solution phase, choose the new analysis as static. Then solve the current load step option. The solution will be done, the following table given the Von – Mises stress at various loads. Importing of the chassis will be done after opening of the workbench. For the supporting purpose of the geometry, the file format of .catpart will be changed into IGES format.



MAIN WINDOW OF ANALYSIS WORKBENCH

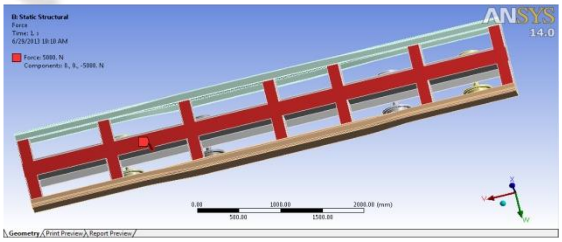
3.2 MATERIAL PROPERTIES



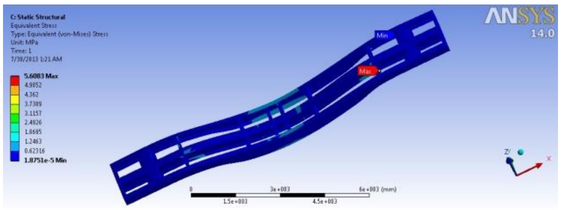
MATERAIL PROPERTIES

The full form of the IGES is Initial Graphics Exchange Specification which itself states that will exchange the graphical properties. The material properties are the important factor which will be considered as the second preference after importing or creating the geometry. The procedure of material application, double click on the engineering data which will appear on the top of the analysis system. The analysis system which we are using in this project is STATIC STRUCTURAL ANALYSIS. After opening the window of engineering data the material application will be done by selecting the add symbol in the general materials. In this project we are working on structural steel and stainless steel.

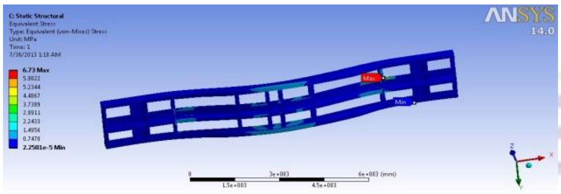
3.3 LOAD APPLICATION



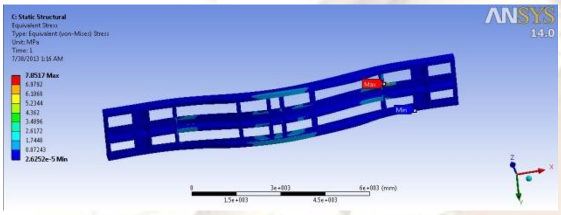
LOAD APPLICATION



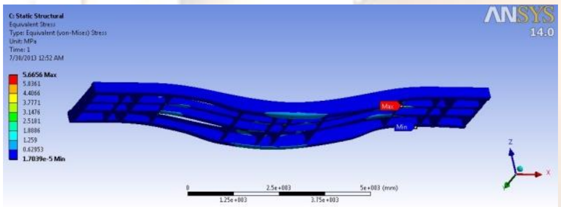
STRESS AT LOAD 5000N IN STRUCTURAL STEEL



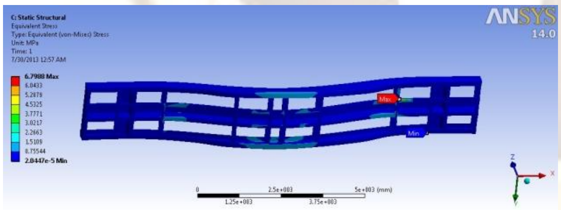
STRESS AT LOAD 6000N IN STRUCTURAL STEEL



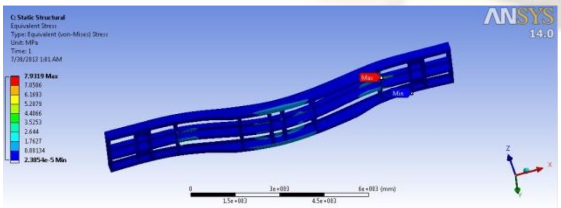
STRESS AT LOAD 7000N IN STRUCTURAL STEEL



STRESS AT LOAD 5000N IN STAINLESS STELL



STRESS AT LOAD 6000N IN STAINLESS STEEL

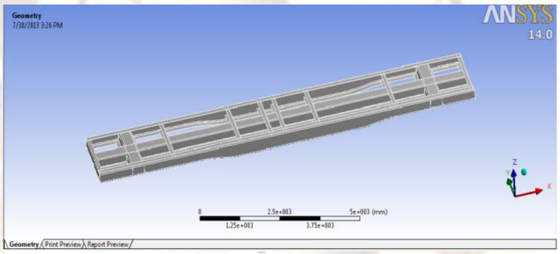


STRESS AT LOAD 7000N IN STAINLESS STELL

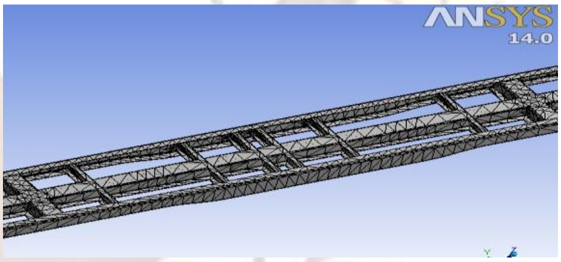
According to the problem statement we are doing the impact analysis on the frame less heavy vehicle chassis. To do the analysis the force application on the chassis top will be required. Because it is the impact analysis we will consider higher loads 5000N, 6000N and 7000N The "equivalent" stress output from LUSAS and MYSTRO (also known as "effective" or "generalised" stress) represents an envelope of the direct and shear stress components and is based upon classical failure criteria theorems. There are a number of these theorems, each of which caters for the varying failure characteristics of different materials. In this note, the von Mises failure criterion is in focus, but the general points made apply equally to other yield functions such as Tresca, Mohr-Coulomb and the like. When using the von Mises material models in LUSAS, the equivalent stress is computed from equations based upon the distortion-energy theorem (also known as the shear-energy or von Mises-Hencky theory). This yield criterion has been shown to be particularly effective in the prediction of failure for ductile materials such as metals.

IV. RESULTS AND DISCUSSIONS

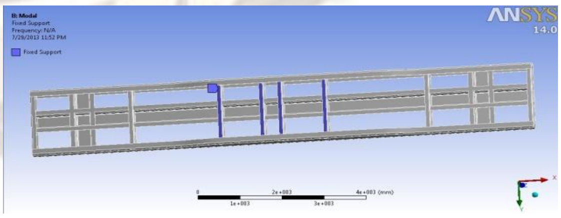
4.1 MODEL ANALYSIS



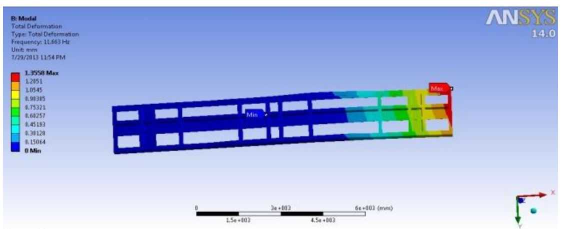
GEOMETRY



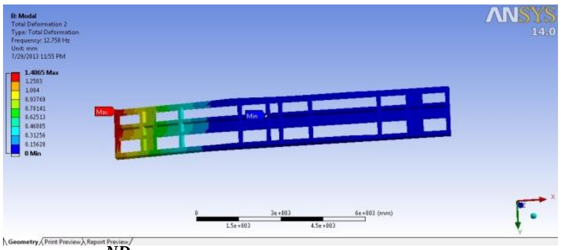
MESH



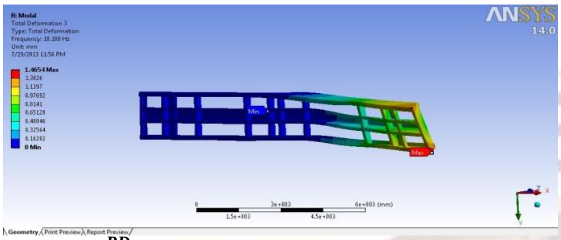
FIXED SUPPORT



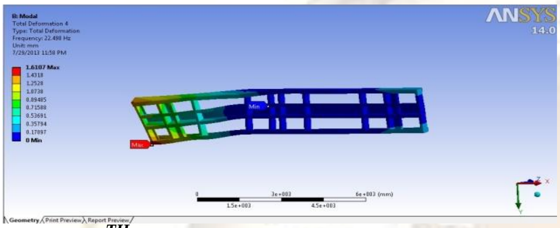
1^{ST} MODE OF DEFORMATION



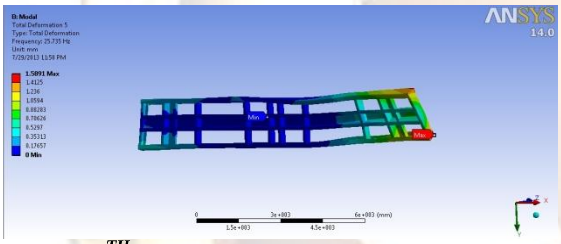
2ND MODE OF DEFORMATION



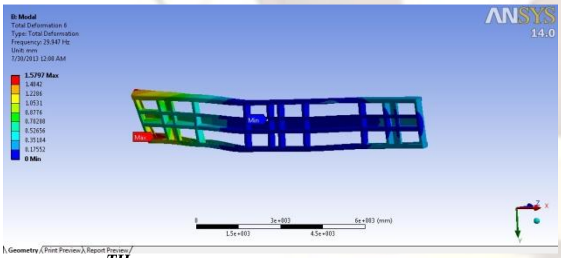
3RD MODE OF DEFORMATION



4TH MODE OF DEFORMATION



5TH MODE OF DEFORMATION



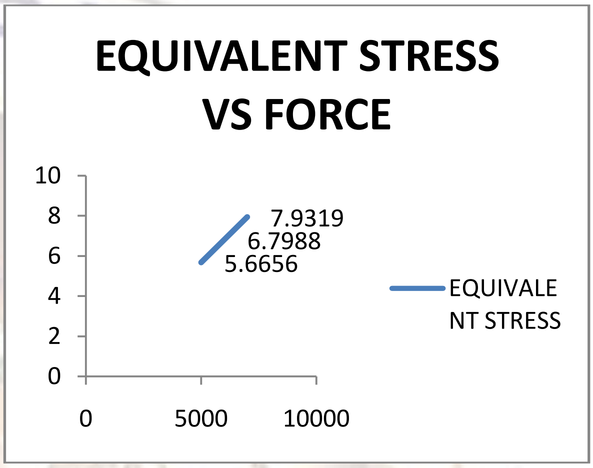
6TH MODE OF DEFORMATION

MODES	FREQUENCY
1	11.663
2	12.758
3	18.188
4	22.498
5	25.735
6	29.947

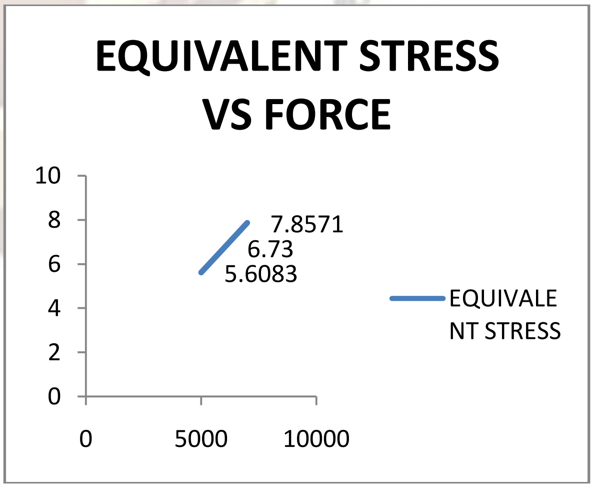
MODAL ANALYSIS

4.2 STRUCTURAL ANALYSIS

MATERIAL: STRUCTURAL STEEL		
S.NO	LOAD N	EQUIVALENT STRESS
1	5000	5.6656 M Pa
2	6000	6.7988 M Pa
3	7000	7.9319 M Pa



MATERIAL: STAINLESS STEEL		
S.NO	LOAD	EQUIVALENT STRESS
1	5000	5.6083 M Pa
2	6000	6.73 M Pa
3	7000	7.8571 M Pa



V. CONCLUSION

The modelling of the chassis was completed by using CATIA V5 and analysis and comparison was done for structural steel and stainless steel at different load conditions. Results are tabulated and graphs plotted. From the modal analysis 6 mode shapes, deformation and natural frequency was acquired successfully. According to the results achieved and tabular data and graphs for the materials structural steel and stainless steel are plotted. From the results the structural steel is better material for the heavy vehicle chassis.

REFERENCES

[1] Sairam Kotari, V.Gopichand PG student, associate professor, department of mechanical engineering QIS college of engineering& technology vol 2, issue1,pp-086-094

[2] Manpreet singh bajwa, Sinthiya pundir, amit joshi, mechanical engineering department G.B.pant engineering college, paurigarhwal, uttarakhand, India

[3] juvvi siva nagaraju, u. Hari babu, PG student, Professor, Department of Mechanical Engineering, QIS College of Engineering and Technology

[4] Alireza Arab Solghar, Zeinab Arsalanloo, Department of Mechanical Engineering, Faculty of Engineering, Vail-e-Asr University of Rafsanjani, Iran.

[5] Shupeng zhao, Miao tian, Shifang zhang, Jiuxi li, journal networks, vol8,no 6(2013),1343-1349, jan2013, doi;10.4304/jnw.8.6.1343-1349

[6] Hirak Patel, Khushbu C. Panchal, Chetan S. Jadav International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Volume-2, Issue-4, April 2013

[7] Deulgaonkar V.R, Dr.A.G Matani, Dr.S.P Kallurkar International Journal of Engineering and Innovative Technology (IJEIT) Volume 1, Issue 3, March 2012

[8] M. Ravi Chandra, S.Srinivasulu, Syed altaf hussian, International Journal of Modern Engineering Research Vol.2, Issue.4, July-Aug. 2012 pp-2594-2600

[9] Dario Croccolo* – Massimiliano De Agostinis – Nicolò VincenziDIEM, Department of Mechanical Engineering, University of Bologna, Italy Journal of Mechanical Engineering 57(2011)11, 799-809

[10] Vijaykumar V. Patel1and R. I. Patel2 Mechanical Department, Government Engineering Collage, Dahod, Gujarat, India. I. Patel, Mechanical Department, Government engineering Collage, Dahod, Gujarat, India, April 21, 2012

[11] Alireza Arab Solghar*, Zeinab Arsalanloo Department of Mechanical Engineering, Faculty of Engineering, Vali-e-Asr University of Rafsanjan, Iran Corresponding Author:a.arabsolghar@vru.ac.ir Received 21 January 2013; Accepted 09 March 2013

[12] Deulgaonkar V.R, Dr.A.G Matani, Dr.S.P Kallurkar International Journal of Engineering and Innovative Technology (IJEIT) Volume 1, Issue 3, March 2012

[13] Monika S. Agrawal, Md. RazikPursuing M.E. Mechanical Engineering, Department, Babasaheb Naik college of Engineering, pusad, India 2Assistant Professor, Mechanical Engineering, Department, Babasaheb Naik college of Engineering, pusad, India

[14] Haval Kamal Asker, Thaker Salih Dawood and Arkan Fawzi Said, Mechanical Engineering, University of Duhok, Faculty of Agriculture and Forestry, Iraq, Mechanical Engineering, University of Duhok, Faculty of Engineering and Applied Sciences, IraqVOL. 7, NO. 6, JUNE 2012

[15] Patel Vijay kumar V #1, Prof. R. I. Patel*2 #Mechanical Department, Government Engineering Collage, Dahod Gujarat, India * Government Engineering Collage, Dahod Gujarat, India, Vol. 1 Issue 3, May – 2012

[16] Sandip Godse [1], Prof. D.A.Patel M. E 4th Semester year Student, Department of ME, S.P.C.E, Visnagar, Gujarat, INDIA] Associate Professor & Head, Mech. Dept, SPCE, Visnagar, Gujarat, INDIA