Design and Analysis of Electric Vehicle Chassis for Better Performance

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Abstract - *Vehicle chassis is considered the most important element in terms of absorbing impacts and carrying loads. This study mainly analyzes the electric vehicle chassis frame made of different materials and calculates the strength, deformation and weight of the frame under different operating conditions. To achieve this, the frame chassis was designed by fusion 360 and tested on Ansys software to obtain the predicted results. For maximum accuracy, different components are given to the chassis frame to measure the deformation and impact on the safety and durability of the product. The results are easily explained and a few screenshots are added for better understanding of the tests.*

Key Words: E rickshaw chassis frame, fusion 360, Ansys software.

1.INTRODUCTION

The search for sustainable, safe, clean and environmentally friendly fuels never ends. Carbon-based fuels such as fossil fuels are not sustainable and are harmful to our environment. Some other energy sources are renewable energy sources, which include all types of petroleum and non-fossil fuels such as solar, wind, tides, hydroelectric and biomass. Among these elements, solar energy is preferred because it provides the cleanest energy for the longest period (up to thousands of years). Photovoltaic electricity production doubles every two years and has been increasing by an average of 48% annually since 2002. Photovoltaic systems have become the world's largest source of energy due to their environmental, economic, and social benefits. The only limitation to solar energy as an undisputed source of energy is our understanding of how to develop effective and efficient technologies that make it possible. Nothing in this world is free, but what if we could find a way to ride for free? In fact, it would be great if our cars could move without spending billions of dollars every year buying fossil fuels and dealing with natural disasters that cause leaves to fall. If we could drive a car that runs on solar energy, it would be the car of our dreams. A solar car will use solar energy from a solar panel. A solar panel is a component of a solar cell, also known as a photovoltaic cell, and is an electrical device that can convert solar energy directly into electricity through quantum mechanical transitions. They are silent, do not pollute the environment, do not rotate, and require very little maintenance. The electricity generated will damage the batteries that power the car's engine. As a result, we will have an electric car that can run on "free" energy, does not produce harmful emissions, produces all its power at all speeds, and has very low maintenance costs.

1.1 E -Rickshaw

Since 2008, electric rickshaws have become popular in some cities as an alternative to auto rickshaws and rickshaws. The reasons for this preference are their lower cost and ease of use compared to rickshaws. They are widely accepted as an alternative to petrol/diesel/CNG auto rickshaws. They are three-wheelers that use electricity between 650 and 1400 watts. They are manufactured only in India and China. Battery-powered rickshaws can become a low-cost transportation option for the poorest of the poor, the low-income people, if transportation facilities are systematically demonstrated.

Figure 1 Vehicle's components

Figure 2 E - rickshaw

1.2 Chassis Details

The chassis is the manufacturer's load that supports the structure and function of the product. An example of a chassis is the frame, which is the lower part of the motor vehicle to which the body is mounted;

Figure 3 Real chassis

1.3 PROJECT SCOPES

The project focuses on the combination design and development of a three-wheeled solar vehicle with aerodynamic power and long-distance travel suitable for Asian drivers. This important part is done as follows:

1. Build a three-wheeled solar car chassis using aluminum and fiberglass. Analyze the frame-frame chassis properties and explore the effects of stress, torsion and deflection on the chassis. Perform fluid dynamics analysis to determine positive and negative pressure and drag forces. The chassis provides support and rigidity to the vehicle. The chassis usually consists of a series of cross members that cross a pair of long cables and channels. The cross members have a small cross section to provide long storage space. The safety of the chassis is an important part of the design and must be considered at every stage. Generally speaking, the basic types of chassis include the backbone, ladder, midframe and monocoque. Different types of chassis structure will lead to different characteristics of each chassis.

2.1 MANUFACTURE CONSIDERATIONS

To increase efficiency, round tubes can be used for frame members. This makes it easier to cut the joints and remove the mounting points. Building a jig is very labor intensive and can use as many components as the chassis itself. To improve chassis manufacturing, the chassis should be designed to be "self-clamping", a type that allows the chassis to be built in separate pieces and then clamped together. This reduces the time and materials required to build the chassis, thus reducing costs. It is worth noting that this method is suitable for a single operation, which is the document for the construction of this chassis. However, if a large number of identical chassis are to be produced, the cost of making the apparatus is reasonable as it reduces the time required to make each chassis.

2.2 MAIN HOOP

As a rule, the main loop shall be made of a single piece, non-uniform, continuous, closed section steel pipe. The main loop shall commence at the lowest member on one side of the frame and shall extend upward, upward and downward to the lowest member of the frame. In the side view of the car, the greater part of the first loop preventing rolling shall be within ten degrees (10°) of its vertical connection to the first frame structure. When viewed from the perspective of the car, each deflection of the connection between the upper part of the main rolling ring and the main structure of the frame shall be supported on the ball of the main ring supporting the structure and the pipes shall meet the requirements. Rolling ring support Rules.11.6 In the car Viewed from the front, the main sheave is fixed to the main structure of the frame and the vertical members of the main sheave have a minimum long person (internal dimension) of 380 mm (15 in.). .

2.3 Main Hoop Bracing

Main Hoop braces must be constructed of closed section steel tubing per Rule. The Main Hoop devoir be supported by two braces spanning in the forward or rearward direction on twain the left and right sides of the Main Hoop. In the side perspective of the Frame, the Main Hoop and the Main Hoop braces devoir not lie on the aforementioned side of the vertical line by way of the top of the Main Hoop, i.e. if the Main Hoop bows forward, the braces devoir be forward of the Main Hoop, and if the Main Hoop bows rearward, the braces devoir be rearward of the Main Hoop. The Main Hoop braces devoir be attached as adjacent as possible to the crown of the Main Hoop but not more than 160 mm (6.3 in) beneath the highest-most surface of the Main Hoop. The included angle formed by the Main Hoop and the Main Hoop braces must be at least thirty degrees (30Â°). See the figure. The Main Hoop braces must be straight, i.e. without any bends. If any item which is farther, the envelope of the Primary Structure is attached to the Main Hoop braces, then extra bracing devoir be added to hamper bending loads in the braces in any rollover attitude.

3.1 TYPES OF CHASSIS

Chassis is considered as one of the main structures of the car. It is usually made of steel frame and supports the body and engine of the car. To put it simply, car chassis or car frame is the skeleton that brings together many components such as engine, tires, brakes, steering gear and drivetrain. Chassis is usually made of heavy steel or composite plastic and provides the strength required to support the vehicle and the load. Here I have listed different types of car chassis such as ladder chassis, skeletal chassis, monocoque chassis and tubular space frame chassis (Wake ham, 2009). The ladder frame is considered one of the oldest vehicle chassis designs and is still used today by SUVs. It resembles a ladder, consisting of two long rows connected by several external and transverse supports. The side and transverse members provide rigidity to the structure (Wakeham, 2009). Usually made of fiberglass, it connects the front and rear axles and carries most of the overall strength of the frame. The void in the structure is used to accommodate the driveshaft in rear-wheel drive situations. In addition, the drivetrain, engine and suspension are all attached to the chassis. This type of chassis is strong enough to support small cars and is easy and cost-effective to manufacture (Wake ham, 2009). . A monocoque chassis is a single-piece chassis that shapes the shape of the car. A unibody chassis is made by welding many pieces together. It differs from the ladder and body chassis in that they are integrated with the body; the ladder supports only the rigid elements. The demand for monocoque chassis has increased due to its cost effectiveness and suitability for robotic production (Christopher, 2004). Since the ladder chassis was not strong enough, racing engineers developed a 3D design called a tubular space frame. The tubular part of the chassis uses a large number of circular tubes (sometimes square tubes are used to allow easy connection to the body panel, but the cross-sections provide the highest strength), arranged in different directions to protect against the forces from all sources of energy. These tubes are welded together to form a complex structure. To meet the increased strength requirements of high-performance sports cars, the tubular space frame chassis usually has a strong structure under the two doors. Compared to ladder and monocoque chassis of the same weight, the tubular space frame chassis is very strong in all respects. Figure 3.1 below shows an example of the TVR Tuscan tubular space frame chassis (Christopher, 2004). For example, Lotus Engineering has been producing cars with aluminum chassis for many years. Lotus successfully explained that not all chassis are welded because aluminum would lose its strength when welded. They decided to use only screws and adhesives to hold the chassis together. When Lotus first introduced the low-volume Elise concept in 1996, the company's management was primarily concerned about what kind of hybrid car would be accepted by the market, but the technology has proven to be so good (over 23,000 cars have been produced) that it could become the basis for new high-end businesses and help bring more aluminum-powered vehicles into the mainstream (Whitfield, 2004).

3.2 MODELLING

What is Modelling?

Modeling is essentially the creation of models represented in 3D space with the desired shape, size, etc., For example, since Pro/E can be used to represent the design, there are some conditions and guidelines that must be followed for a good design: -

· Design is a process that analyzes the stability, strength and rigidity of the structure. structure. · The main purpose of analysis and design is to create a structure that can withstand all the equipment that does not work when needed. If the design or design is wrong or the actual product exceeds the design, the product will not do its job, which will have serious consequences.

3.3 Design Considerations

To design and fabricate an immense performance racing vehicle which will be intact by ergonomically, economically and by all means safety heeds following main parameters were set before the designing; on which whole design process is carried out,

· Driver Ergonomics.
· Serviceability and maintainability.
· Maneuverability.
· Design of flexible roll cage.
· Use of optimum power efficiency.
· Cost of the components.

To meet all above considerations and for ease in designing; all systems were designed individually along with mutual specifications considerations for interchange ability.

· Roll Cage
· Steering System
· Braking System
· Powertrain System

Design of the Eco-kart is to be taken into consideration i.e. Design of any component is consisting of three major principles:

· Optimization
· Safety
· Assuage

The main objective of the roll cage is to cater a 3-dimensional protected space over the driver that will foster the driver safe. Its secondary objectives are to foster reliable mounting locations for peripherals, be appealing, low in cost, and low in weight. These intentions were met by culling a roll cage material that has suitable strength and also weighs less giving us an influence in weight reduction. A low-cost roll cage was bestowed through material selection and assimilating more continuous members with bends instead of a collection of members welded collectively to cut down manufacturing Element Analysis. We focused on each point of roll cage to enhance the performance of vehicle without failure of roll cage. We began the task of designing by pervasive research of go kart roll cage through finite element analysis. Our frame's design is shown below;

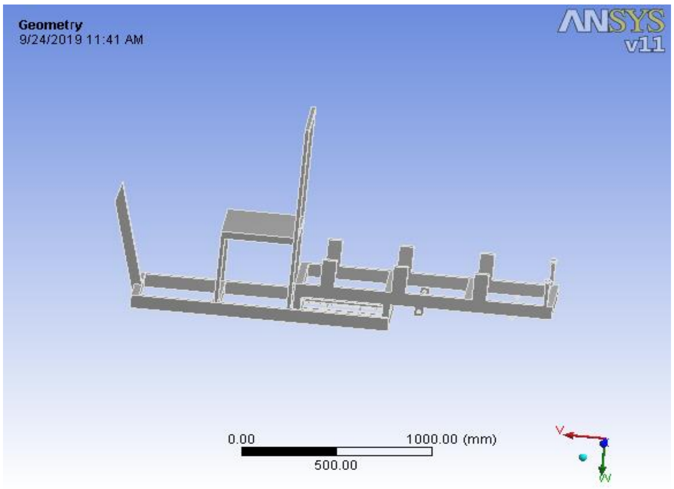


Figure 4 Geometry

Once cad modeling of the frame structure is contrived by using solid works, then this design is investigated by method of Finite Element Analysis. We have used ANSYS (workbench) software for Finite Elemental Analysis RESULT. We first imported the solid works file model in ANSYS (work bench by) IGES Model format, then imparted the properties of material & defined the cross-section of tube created component, then discredited by 3D meshing, and then applied load and finally constrained. The final analysis is shown in ANSYS. We have to lower the deformation and stresses and target to least weight of chassis, the flow chart of entire process is shown in the below figure

Finally, drawings can be created either from parts or assemblies. Views are automatically generated from the solid model, and notes, dimensions and tolerances can then be easily added to the drawing as needed. The drawing module includes most paper sizes and standards (ANSI, ISO, DIN, GOST, JIS, BSI and SAC)

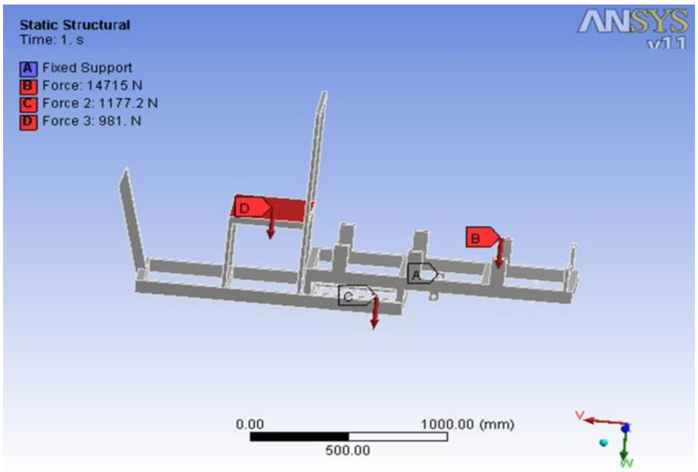


Figure 5 Static structure

3.4 MATERIAL SELECTION

The materials chosen must be able to withstand all types of environments so that the final product results are better than failure. The model here is the frame and chassis of the eco-kart. The selection of materials for the chassis is made by comparing the different properties of these elements and following the following order of priority: -

· The strength of the materials must be high. There are sections. %, otherwise the pearl will be brittle)

· Other impurities

· The material also plays an important role. The chassis for the best and safest results. The chassis is subjected to a lot of force during movement and must remain stable without flexing, be robust enough to absorb vibrations and work well at high temperatures. There is no lag in the kart. Therefore, the chassis must be modified to act as a suspension and must be strong enough not to break or be damaged during its life. In order to ensure the safety of the driver, the equipment must have good strength and durability. The chassis material is the main structure in the design and construction of go-karts. Although the tubular space frame chassis is heavier than the monocoque chassis, the tubular space frame chassis was eventually accepted because it was cheap to manufacture, required simple tools, and the damage to the chassis was easy to repair. Tubular sections can carry more than a kilogram more than solid or square sections.

3.5 CHASSIS DESIGN PRINCIPLE

The principle of chassis design is that the chassis must be designed to provide torsional rigidity and lightness in order to provide good control of the vehicle. By definition, torsional rigidity (TR) refers to the ability of the chassis to resist torsional forces or bending forces. In other words, torsional rigidity is the torque that must be torqued to a certain level on the frame. These restrictions also apply to the frame chassis. In general, the effect of torsional rigidity on the field is different from that of the monocoque chassis due to its design, but the model used to predict the results is the same as for the monocoque chassis, which is difficult to torsion. shows the torsional stiffness used for the racing chassis. (Matt, 1999)

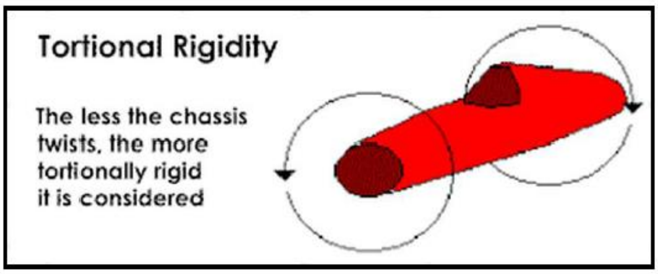


Figure 6 Torsional rigidity

According to the above explanation, the chassis must be designed with high torsional strength to resist torsional or twisting forces. In order to increase the torsional stiffness of the chassis, the tube configuration should be taken into account. The torsional stiffness is increased from the input frame members. The principle is to place the frame members in a triangle as shown in the picture.

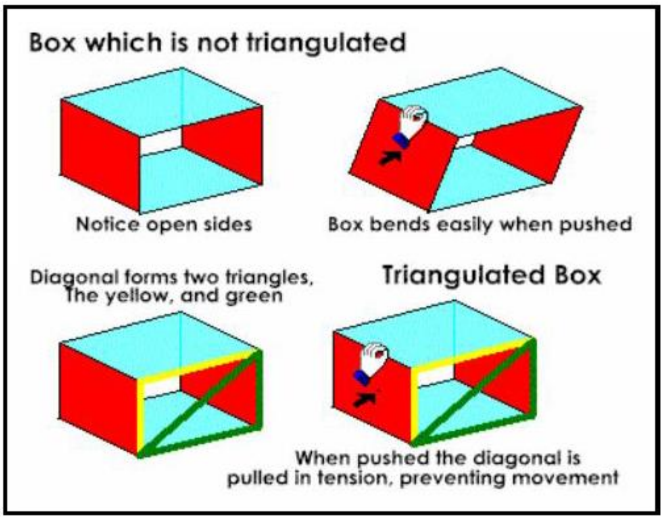


Figure 7 Box variations

3.6 ADVANTAGES OF SELECTED CHASSIS

Since the Spaceframe chassis is the most suitable chassis type for the World Solar Challenge model design compared to other chassis types, I decided to use this concept in my project.) Since the system takes a triangular shape, it will provide maximum strength and minimum design deflection compared to other chassis types thanks to the support of the pipe channels. Therefore, significant savings can be achieved in initial costs. This means that the frame chassis design will improve the stiffness/weight ratio.

3.7 CHASSIS DESCRIPTION

There are many things that are not considered when building the frame of a solar car. Due to the importance of low aerodynamic drag (Roche et al., 1997), the design of the frame is very difficult. The frame also needs to meet the required strength and stiffness for all loads. In addition, mounting points must be provided to connect different components such as battery components, electronic components, suspended components, body panels, etc. Therefore, the team chose to use a traditional space frame instead of a monocoque structure. Although composite monocoques can be very light, they are very difficult to calculate and manufacture, which often makes the body stronger (Potter Kevin, 1997). The space frame is very efficient. The bending moment is distributed in the form of tension and compression loads along the length of each tube. Therefore, the strength calculation can be accurate and simple. Manufacturing can be done by welding extruded pipes together.

INTRODUCTION TO CAD/CAM

4.1 COMPUTER AIDED DESIGN (CAD):

Computer-aided design (CAD) is the use of various computer-aided design tools to assist engineers, architects, and other designers in their design work. It is the initial geometry creation tool in the product lifecycle management process, with software and sometimes specialized hardware. Available software packages range from 2D vector-based drawing to 3D parametric surface and rough design.

4.1.1 Introduction:

CAD is used to design and manufacture products that can be end-user products or intermediate products used for other products. Cadis is also widely used in tools and machinery used by manufacturing companies. Cadis is also used in the design and construction of all types of construction, from small homes (houses) to the largest businesses and industries. CAD is used throughout the engineering process, from conceptual design and layout to detailed engineering and analysis of manufacturing details.

4.2 INTRODUCTION TO PRO/E:

PRO/E is the industry's de facto 3D mechanical design suite. It is the world's leading CAD/CAM/CAE software that provides a broad range of solutions covering all aspects of product design and manufacturing. Its success is driven by technology that enables customers to create more robust, parametric, model-based models faster and more consistently. Because PRO/E is no different in any region, in any process, in any country, in any company type, on any equipment basis. This flexibility makes it the ultimate flexible engineering solution for rapid acceleration. PRO/E provides flexible solutions that meet the needs of small and medium-sized businesses, materials, manufacturing and assembly, and large corporations in all industries. Electrical and electronics, automotive, aviation, shipbuilding and factory construction. User-friendly and easy to design products and surfaces.

4.2.1 Advantages of *PRO/E:*

▪ Faster and more accurate.

Once the design is complete. 2D and 3D views are easily available.

• Ability to make changes in post-production.

- Provides a perfect representation of the model by showing all other dimensions to hide geometry etc. Flexibility for change. For example, if we want to change the dimensions of the model, then all dimensions such as design, assembly, production will change.

• Provides clear 3D models that are easy to see and understand.

™ PRO/E simplifies the assembly of a person or model you create, while also reducing the time required for assembly.

4.3 *PRO/E* INTERFACE:

The main modules are:

- **Sketcher**
- **Part Design**
- **Assembly**
- **Drafting**
- **Sheet metal**

4.3.1 Sketcher:

Pro/E sketcher tools initially drafts a rough sketch following the shape of the profile. The objects created are converted into a proper sketch by applying geometric constraints and dimensional constraints. These constraints refine the sketch according to a rule. Adding parametric dimensions further control the shape and size of the feature.

Line, rectangle, palette, constrain, dimension modification, and text etc., are used as one of the feature creations tools to convert the sketcher entity into a part feature.

4.3.2 PART DESIGN:

The Pro/E is a 3D parametric solid modeler with both part and assembly modelling abilities. You can use Pro/E to model simple parts and then combine them into more complex assemblies. With Pro/E, you design a part by sketching its component shapes and defining their size, shape, and inter relationships. By successively creating these shapes, called features, you can construct the part.

The general modelling process-

- Planning concept of designing
- Creation of base feature
- Completion of other features
- Analysing the part design
- Modifying the design as necessary

4.3.3 ASSEMBLY DESIGN:

Pro-E Assembly Design allows users to design with user-controlled integration. Pro-E hierarchically creates separate parts and subassemblies into assemblies based on relationships defined by constraints. Parametric relationships, like the part model, allow you to quickly modify the entire assembly based on changes in one of the components.

4.3.3.1 Top-down Assembly:

In the top-down component assembly approach, components are designed for themselves during assembly and assembled using limited materials. The parts you create in assembly mode are saved as part files.

4.3.3.2 Bottom-up Assembly:

Products created in Part mode are assembled in Assembly mode using constraints. Assembly files created in this way use less disk space because they only contain information about the assembly. However, if the assembly is moved from its original location, the assembly will not open. Below or below:

Check assembly

Update assembly

4.3.4 DRAFTING:

Drawings and documents are real products because they take on mechanical properties. Pro-E automatically generates drawings from 3D mechanical designers and assemblies. Integration of the drawing into the 3D master display leads to design and drawing completion. Pro-E enhances generative drawings with 2D interaction capabilities and a rich environment for drawing decoration and annotations.

4.3.5 SHEETMETAL:

Thin plates with a thickness between 0.006 inches and 0.249 inches are often called plates. It is one of the simplest materials used in metalworking. It can be cut and bent into various shapes.

4.4 FEATURES OF *PRO/E*:

Pro/Engineer is a one stop store for any manufacturing industry. It offers effective features, incorporated for a wide variety or purpose.

Some of the important features are as follows:

- Simple and powerful tools
- Parametric Design
- Feature-Based Approach

- Parent Child Relationship
- Associative and Model Centric

4.4.1 Simple and Powerful Tools:

Pro/Engineer tools are user friendly. Although the execution of any operation using the tools is simple, the tools can create a highly complex model.

4.4.2 Parametric Design:

Pro/Engineer designs are parametric. The term Parametric means that design operations that are captured, can be stored as they take place. They can be used effectively in the future for modifying and editing the design. These types of modeling help in faster and easier modifications of design. If the model is parametric and related properly, a change in one value, automatically edits the related values.

4.4.3 Feature-Based Approach:

Features are the basic building blocks required to create an object. Pro/Engineer wild fire models are based on a series of features. Each feature builds upon the previous feature, to create the model (only one single feature can be modified at a time). Each feature may appear simple, individually, but collectively forms a complex part and assemblies.

4.4.4 Parent Child Relationship:

Parent-child relationships are a great way to capture design patterns in your design. This relationship is created between features during the design process. When we create a new feature, the corresponding existing feature becomes the parent feature of the new feature.

4.4.5Associative and Model Centric:

Pro/Engineer wild fire drawings are model centric. This means that Pro/ Engineer models that are represented in assembly or drawings are associative. If changes are made in one module, these will automatically get updated in the referenced module.

4.5 GENERAL OPERATIONS:

4.5.1Start with a Sketch:

Use the sketch to draw a free, long "pattern" of the curve. You can then scan the sketch using extruded or rotated bodies to create objects or forms. You can then adjust the dimensions and create relationships between geometric objects to accurately represent the objects you are interested in. Editing the dimensions of the sketch not only changes the sketch, it also changes the objects that the sketch creates.

4.5.2 Creating and Editing Features:

Feature modeling lets you create features such as holes, extrudes and revolves on a model. You can then directly edit the dimensions of the feature and locate the feature by dimensions. For example, a Hole is defined by its diameter and length. You can directly edit all of these parameters by entering new values.

4.5.3 Associatively:

. An association is a term used to describe the geometric relationship between different parts of a model. These relationships are created when designers put a lot of energy into creating designs. In collaborative modeling, constraints and relationships are captured as a design. For example, in a relational model, a bead coming out of a hole is associated with the face that the hole goes into. If you then change the pattern, move one or both faces, the hole will be updated with its relationship to the face. For more information, see Introduction to Patterns

4.5.4 Positioning a Feature:

In modeling, you use placement methods (where dimensions are positioned) to position features relative to the geometry of the model. The feature is then associated with the geometry, and these relationships are maintained when you change the model. You can adjust the feature position by changing the value of the connection dimension.

4.5.5 Reference Features:

You can create reference features, such as datum planes, datum axes, and datum coordinate systems, that you can use as reference geometry or as tools for other features when needed. Anything created using a feature application is associated with that feature application, and this association is maintained when editing the model. You can use datum planes as reference planes when creating drawings, creating features, and working. You can use datum axes to create datum planes, place objects concentrically, or create radial arrays.

4.5.6 Expressions:

. Expression tools allow you to combine your needs and create constraints by interpreting the relationship between different parts of your design. For example, you can define the height of an extrusion to be three times its diameter, so that when the diameter changes, the height changes as well.

4.5.7 Undo:

Use the Undo feature to revert your design to a previous state multiple time. It doesn't require the designer to spend a lot of time making sure everything is correct because mistakes can be easily fixed. The freedom to easily modify your model eliminates the worry of getting it wrong and allows you to explore different ways to get it right.

4.5.8 Advantages of PRO/E:

- ✓ It is much faster and more accurate.
- ✓ Once a design is completed. 2D and 3D views are readily obtainable.
- ✓ The ability to changes in late design process is possible.
- ✓ It provides a very accurate representation of model specifying all other dimensions hidden geometry etc.
- ✓ It is user friendly both solid and surface modelling can be done.
- ✓ It provides a greater flexibility for change. For example, if we like to change the dimensions of our model, all the related dimensions in design assembly, manufacturing etc. will automatically change.
- ✓ It provides clear 3D models, which are easy to visualize and understand.
- ✓ PRO/E provides easy assembly of the individual parts or models created it also decreases the time required for the assembly to a large extent.

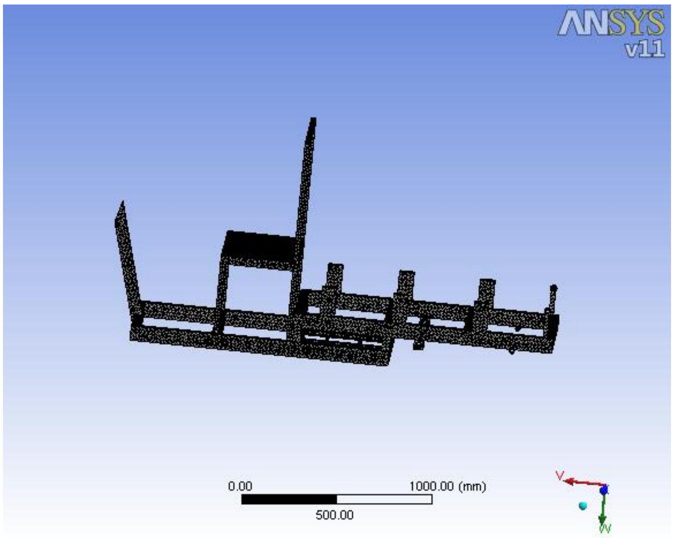


Figure 8 Ansys

INTRODUCTION TO ANSYS

5.1 INTRODUCTION

ANSYS is a general-purpose finite element analysis (FEA) software package. Finite element analysis is a numerical method that decomposes complex systems into very small parts (of user-defined size) called elements. The software uses the equations that govern the behaviour of these elements and solves them all; these results can be presented in words or pictures. This type of analysis is often used in the design and optimization of systems that are too difficult to analyse manually. Systems that fall into this category are very complex due to their geometry, scale or balance. ANSYS can also be used in Civil and Electrical Engineering, Physics and Chemistry Departments.

ANSYS provides a great way to explore the performance of your product or process in a virtual environment. This type of manufacturing is called virtual prototyping.

Generic Steps to Solving any Problem in ANSYS:

Like solving any problem analytically, you need to define (1) your solution domain, (2) the physical model, (3) boundary conditions and (4) the physical properties. You then solve the problem and present the results. In numerical methods, the main difference is an extra step called mesh generation. This is the step that divides the complex model into small elements that become solvable in an otherwise too complex situation. Below describe the processes in terminology slightly more attune to the software.

- Build Geometry
- Define Material Properties
- Generate Mesh
- Apply Loads
- Obtain Solution
- Present the Results

5.2 OVERVIEW OF STRUCTURAL ANALYSIS

Structural analysis is probably the most common application of the finite element method. The term structure (or edifice) is used not only for civil engineering, such as bridges and buildings, but also for marine, aerospace, and mechanical structures, such as ship hulls, aircraft fuselages, machine bodies, and anything else like pistons and machines.

5.3 TYPES OF STRUCTURAL ANALYSIS

5.3.1Static Analysis

Used to determine displacements, stresses, etc. under static loading conditions. Both linear and nonlinear static analyses. Nonlinearities can include plasticity, stress stiffening, large deflection, large strain, hyper elasticity, contact surfaces, and creep.

5.3.2Modal Analysis

Used to calculate the natural frequencies and mode shapes of a structure. Different mode extraction methods are available.

5.3.3Harmonic Analysis

Used to determine the response of a structure to harmonically time-varying loads.

5.3.4 Transient Dynamic Analysis

Used to determine the response of a structure to arbitrarily time-varying loads. All nonlinearities mentioned under Static Analysis above are allowed.

5.3.5 Spectrum Analysis

An extension of analysis that calculates stress and strain due to response spectra or PSD inputs (random vibrations**).**

5.3.6 Buckling Analysis

Used to calculate buckling loads and determine buckling mode shapes. Both linear (eigenvalue) and nonlinear buckling analysis are possible.

5.3.7 Explicit Dynamic Analysis

This type of structural analysis is available only in the ANSYS LS-DYNA program. ANSYS LS-DYNA provides a comprehensive solution to the detailed analysis of LS-DYNA. Dynamic analysis is used to calculate large deformation dynamics and provide rapid solutions to complex contact problems.

In addition to the above analysis types, several special-purpose features are available:

- Fracture mechanics
- Composites
- Fatigue
- P-Method
- Beam Analyses

5.4 PROCEDURE FOR ANSYS SOLUTIONS

Static analysis is used to determine the stress, strain, and strength changes in a structure or material due to significant impact and non-impact loads, such as a constant load in response. Types of loads that can be used in static analysis include external forces and stresses, constant inertial forces such as gravity or rotational speed (non-zero) displacement, and temperature (for thermal strains). Static analysis can be linear or non-linear. In our current work, we consider linear static analysis.

. The procedure for static analysis consists of these main steps

- Building the model
- Obtaining the solution
- Reviewing the results.
- Build the Model

  In this step we show the job name and analysis name, we use PREP7 to define the main type, main constant, material and geometry model type, allowing linear and nonlinear models. ANSYS library contains more than 80 different object types. A unique and predefined number for each product type. For example. Beam 94, Plane 71, Solid 96 and Pipe 16.

5.5 MATERIAL PROPERTIES

Young's Modulus (EX) must be defined for a static analysis. If we plan to apply inertia loads (such as gravity) we define mass properties such as density (DENS). Similarly, if we plan to apply thermal loads (temperatures) we define coefficient of thermal expansion (ALPX).

5.6 GEOMETRICAL DEFINITIONS

There are four different geometric parameters in the preprocessor: points, lines, areas, and volumes. These settings can be used to obtain the geometric shape of the structure. Each area is independent and has unique symbols.

5.7 Model Generations

Two different methods are used to generate a model:

- Direct generation.
- Solid modelling

  With good modeling, we can define the geometric space of the model, create the control point size and the desired shape, and then tell the ANSYS program to get all the nodes and elements. In contrast, using the direct energy generation method, we determine the location of each element in terms of size, shape, and the connection between each element before defining these locations in the ANSYS model. Although some files can be created (using commands such as FILL, NGEN, EGEN, etc.), the direct generation method is the main part of the code guide and requires us to keep track of every part of the number mesh when creating finite elements. This detailed information can be difficult for large samples and can leave room for modeling errors. Product models are generally more powerful and versatile than direct models and are often the preferred method for design.

5.8 MESH GENERATION

The basic idea in finite element analysis is to analyse a structure that is composed of a collection of individual parts called elements, which are connected by a small number of elements called nodes. Load boundary conditions are then applied to the elements and nodes. This network of elements is called a grid.

5.9 FINITE ELEMENT GENERATION

In content analysis, the largest amount of time is spent on creating content and node information. The pre-processor allows users to create nodes and elements simultaneously, thus controlling the size and content. Various elements can be created or generated from different geometric areas.

The pre-processor can control cell properties that need to be checked before finite element analysis, such as units, connections, different connections, etc. generated by various automatic cell generation functions. Work on nodes instead of defining them one by one. This can be easily defined by defining functions or modifying existing nodes if necessary. Additionally, nodes can be downloaded, deleted or searched.

5.10 BOUNDARY CONDITIONS AND LOADING

After completion of the finite element model it has to constrain and load has to be applied to the model. User can define constraints and loads in various ways. All constraints and loads are assigned set ID. This helps the user to keep track of load cases.

5.11 MODEL DISPLAY

During the development and validation phase of a model, you may need to look at it from different angles. You need to rotate the model relative to the world and look at it from different angles. The pre-processor provides these functions. Through the feature pre-processor window, users can zoom in on parts of the model to gain clarity and detail. The pre-processor also provides features such as smoothing, scaling, regions, active sets, and more. Look for good models and correct them.

5.12 MATERIAL DEFLECTIONS

All elements are defined by nodes that define only their function. There is no thickness indicator for plate and shell elements. This thickness can be used as an entity. The attribute table must be entered for a given set of one-dimensional attributes.

Different objects have different properties, for example

Beam: cross-sectional area, moment of inertia, etc. The user must also define the material of the element. For static beam analysis, elastic model and Poisson's ratio are needed. For heat transfer, thermal expansion coefficient, density and other requirements. They can be sent to the object by adjusting the length of the object.

5.13 SOLUTION

The solution solves the problem according to the problem definition. All the tedious work of formulation and combination of matrix is done by the computer and finally the displacement or stress value is given as output. Some of the features of ANSYS include linear static analysis, nonlinear static analysis, transient dynamic analysis etc.

5.14 POST-PROCESSOR

It is a powerful, user-friendly post-processing program that uses interactive color graphics. It has the ability to expand the scope of results obtained from the analysis of facts. The display of test results (i.e. visual representation of results) can usually be presented in seconds, which takes time to measure from digital results (comparison, i.e. in tabular form). Professionals can also see important results that are easily overlooked in masses of numerical data. Using the best tools to enhance the image, you can display: stress profile, displacement, temperature, etc.

- Deform geometric plots
- Animated deformed shapes
- Time-history plots
- Solid sectioning
- Hidden line plot
- Light source shaded plot
- Boundary line plot etc.

The entire range of post processing options of different types of analysis can be accessed through the command/menu mode there by giving the user added flexibility and convenience.

5.15 TYPES OF STRUCTURAL ANALYSIS

Seven types of analysis models in ANSYS. The following analysis models can be followed. Each type of analysis is discussed below:

- Static analysis
- Modal analysis
- Harmonic analysis
- Transient dynamic analysis
- Spectrum analysis
- Buckling analysis
- Explicit dynamic analysis

5.15.1 STUCTURAL STATIC ANALYSIS

Static analysis calculates the effect of static loading on a structure, ignoring the inertia and damping effects caused by time-varying loading. However, a static analysis may include time variables that can be approximated as static equilibrium (such as equal wind and seismic loads) as well as constant loads (such as gravity and rotational speed)

5.15.2 MODELLING AND ANALYSIS

Brakes are difficult to model accurately and research is ongoing to understand the thermal changes of disc brakes during braking. Modelling complex geometries always requires some assumptions. When making these assumptions, keep in mind the problems with theoretical calculations and the importance of not taking them, not ignoring them. In modelling, we often ignore things that are not important and have little impact on the analysis. The requirements always relate to the level of detail and accuracy required for the model. The assumptions made while modelling the process are as follows:

1. The disc material is considered as homogeneous and isotropic.
2. The domain is considered as axis-symmetric.
3. Inertia and body force effects are negligible during the analysis.
4. The disc is stress free before the application of brake.
5. Brakes are applied on the entire four wheels.
6. The analysis is based on pure thermal loading and vibration and thus only stress level due to the above said is done. The analysis does not determine the life of the disc brake.
7. Only ambient air-cooling is taken into account and no forced Convection is taken.
8. The kinetic energy of the vehicle is lost through the brake discs i.e. no heat loss between the tire and the road surface and deceleration is uniform.
9. The disc brake model used is of solid type and not ventilated one.
10. The thermal conductivity of the material used for the analysis is uniform throughout.
11. The specific heat of the material used is constant throughout and does not change with temperature.

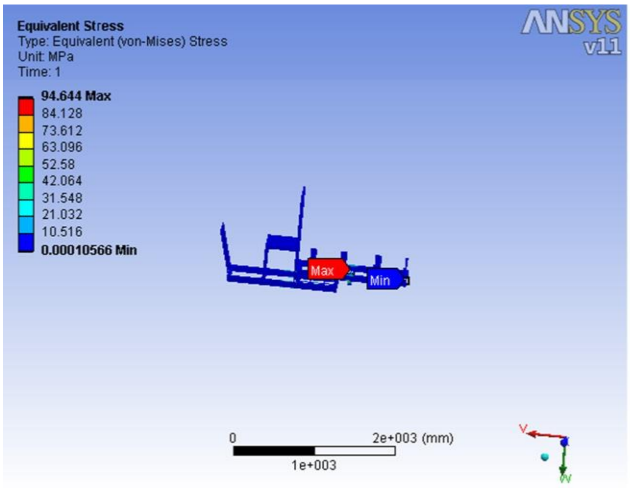
5.16 Definition of problem domain

When the brakes are applied to the disc brake rotor of the car, friction generates heat, and this heat must be transmitted and distributed across the cross-section of the disc rotor. Braking conditions are very severe and require thermal analysis. Thermal loads and structures are axially symmetric. Therefore, it is possible to perform an axially symmetric analysis, but in this study, we performed a 3D analysis that is a true representation of this temperature. In order to verify the stability of the structure, heat tests were performed on the above product and structural analysis was performed.

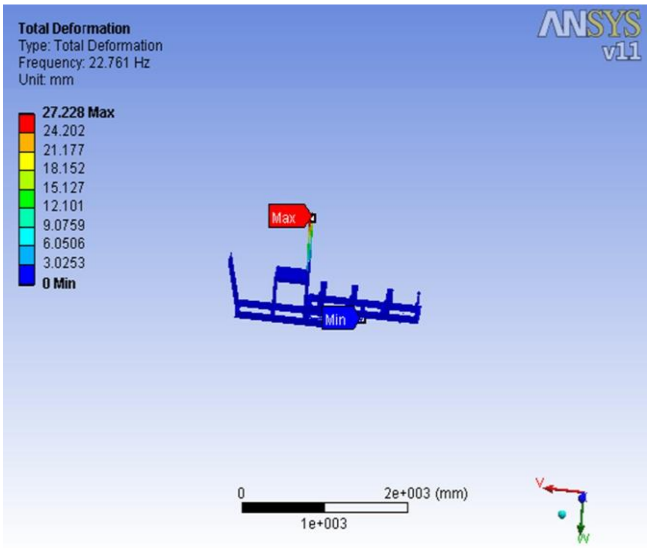
RESULTS AND DISCUSSIONS

6.1 ALUMINIUM RESULTS

- **EQUALENT STRESS**



- **AT MODE 1**



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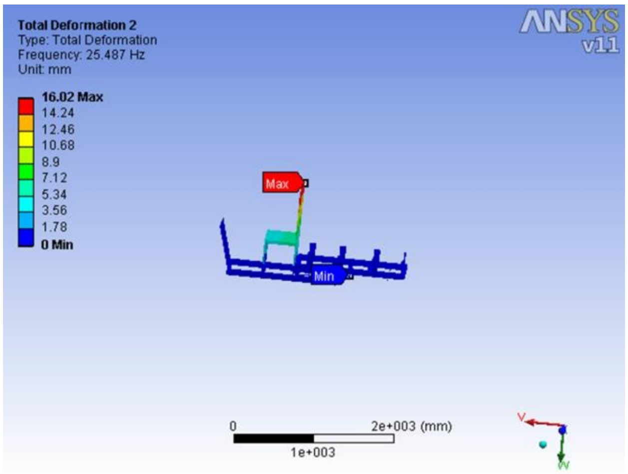

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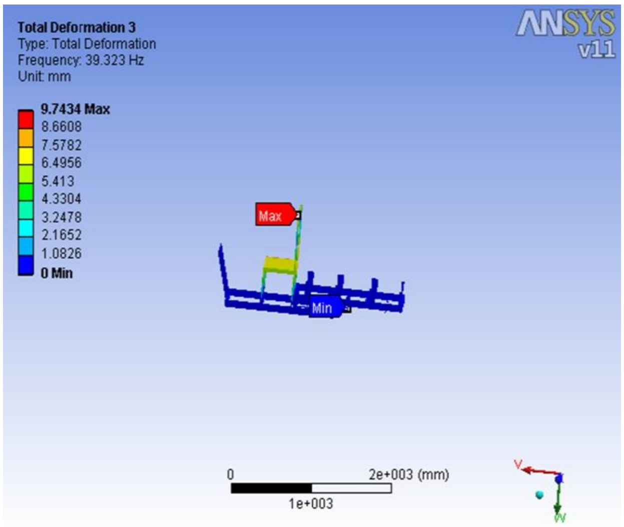
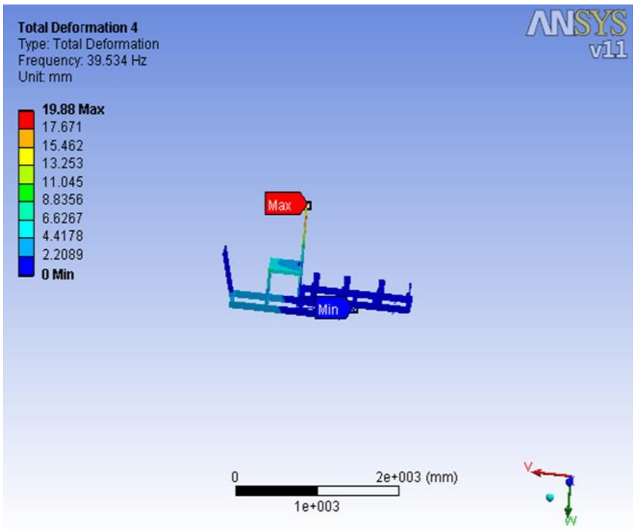
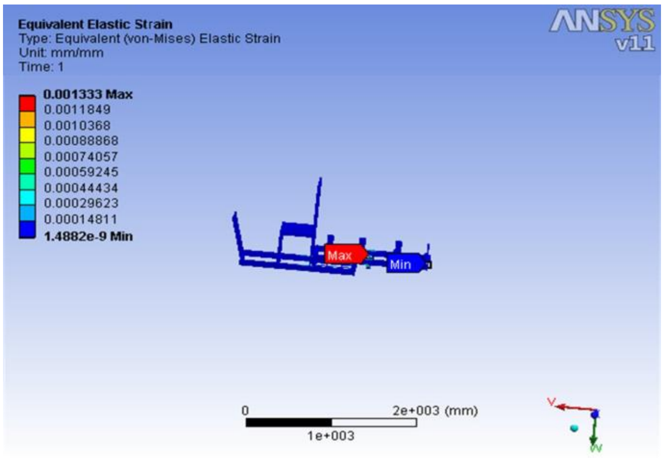


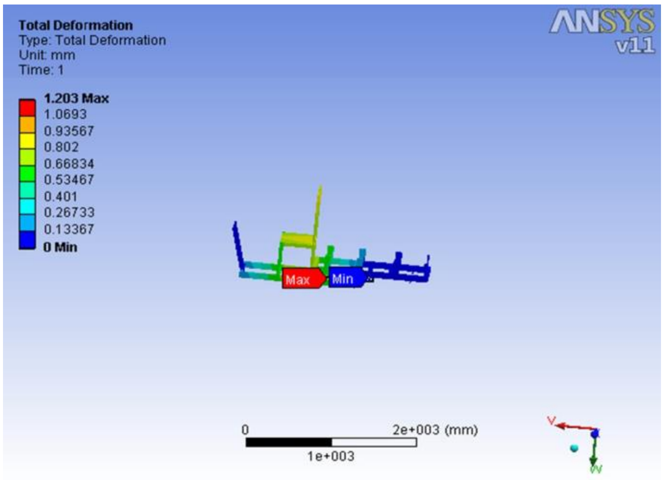
- **AT MODE 4**



- **STRAIN**

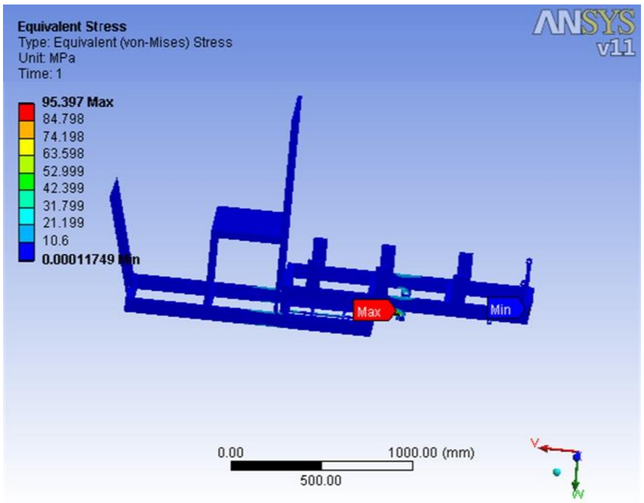


- **TOTAL DEFORMATION**

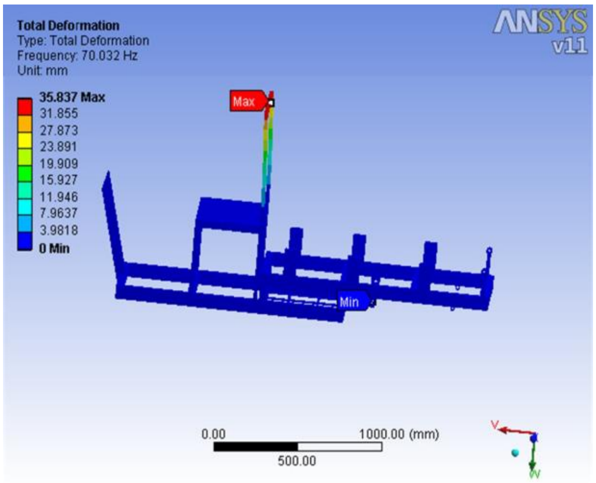


6.2 CARBON GLASS RESULTS

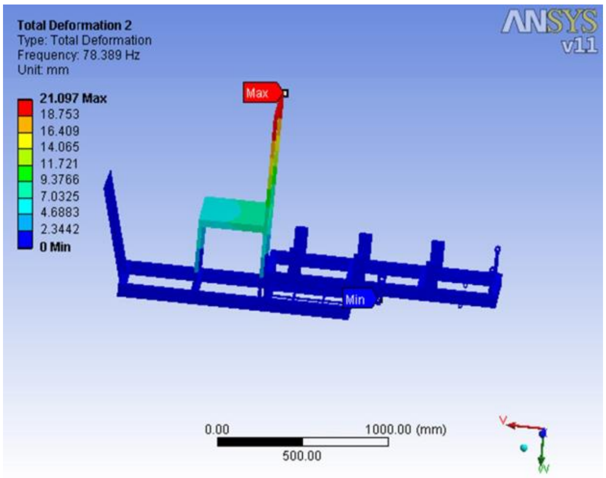
- **EQUALENT STRESS**



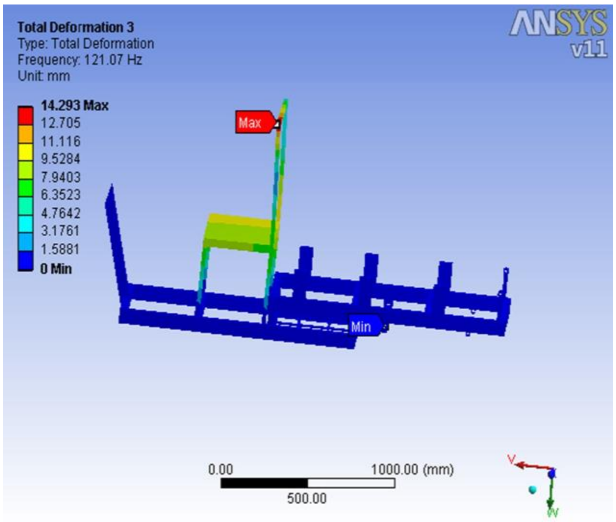
- **AT MODE1**



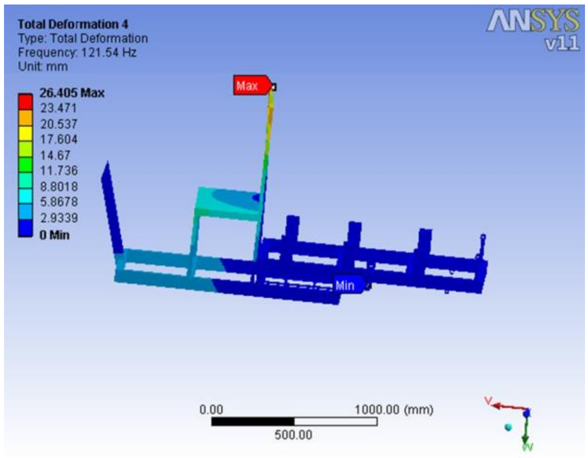
- **AT MODE2**



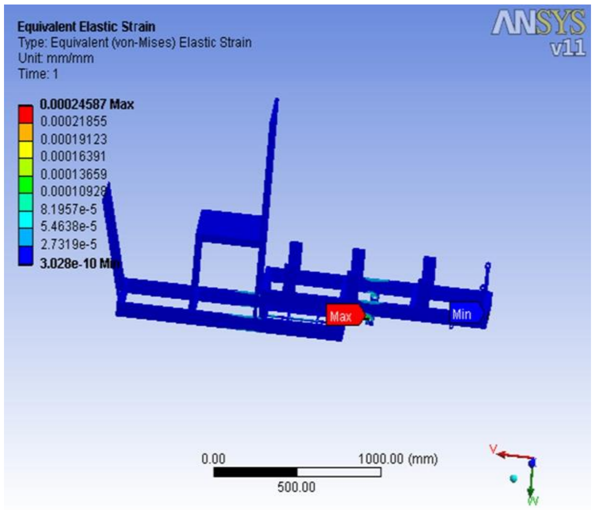
- **AT MODE3**



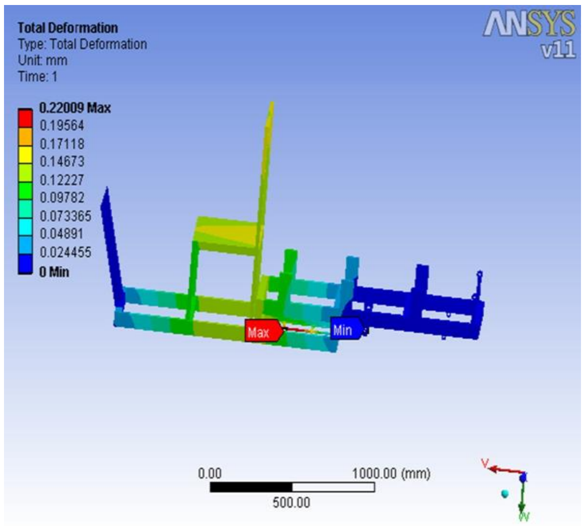
AT MODE4



- **STRAIN**

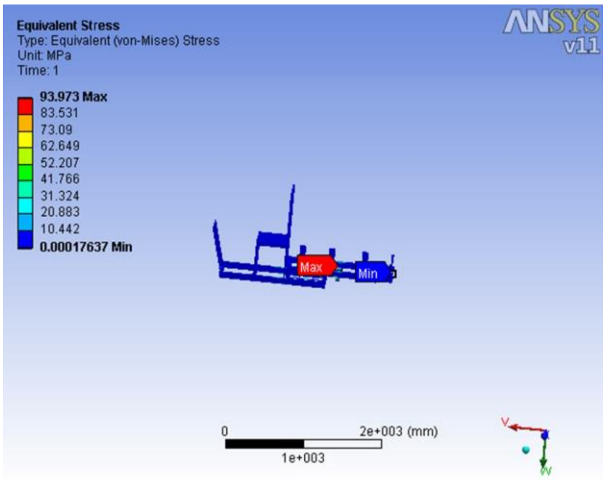


- **TOTAL DEFORMATION**

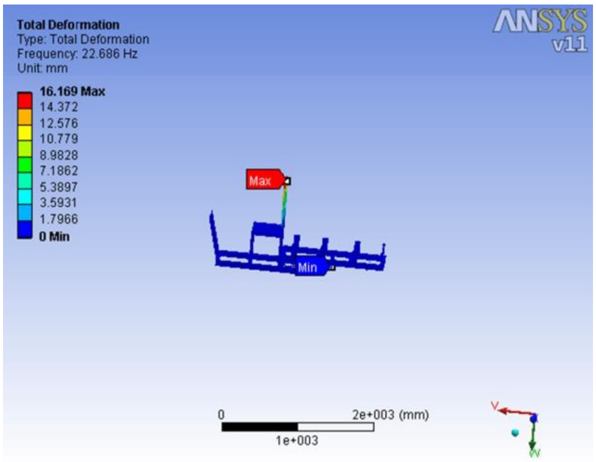


6.3 MILD STEEL RESULTS

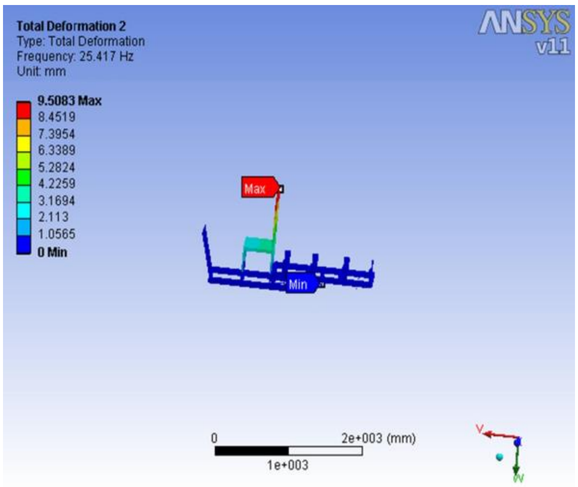
- **EQUALENT STRESS**



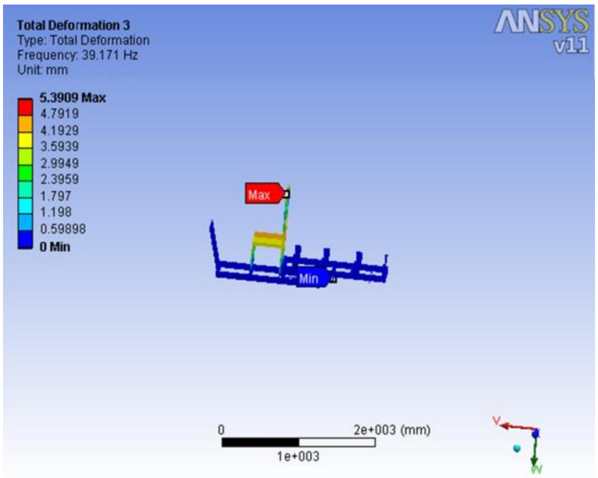
- **AT MODE1**



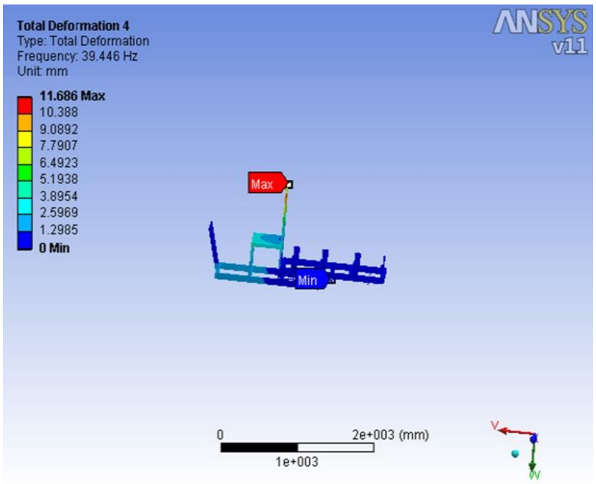
- **AT MODE2**



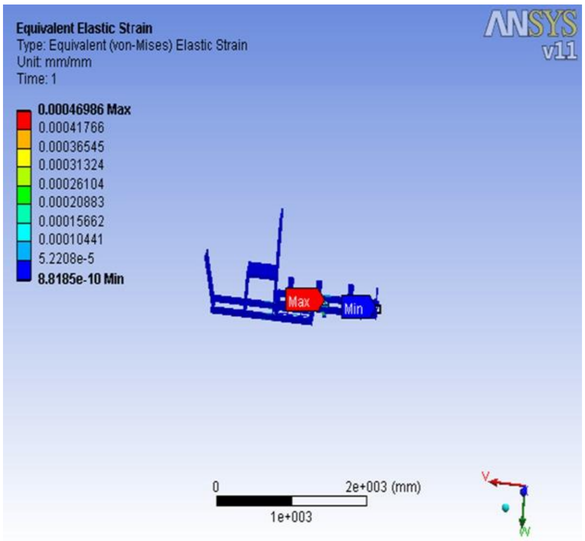
- **AT MODE3**



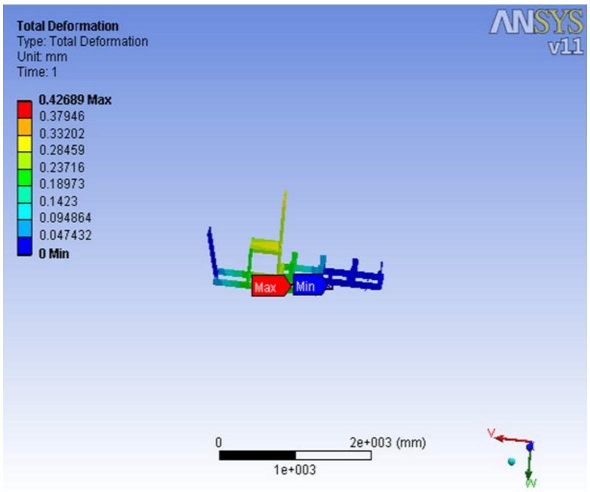
- **AT MODE4**



- **STRAIN**



- **TOTAL DEFORMATION**



6. CONCLUSIONS

The results of the study are as follows

1. Much stress can be reduced by ribbing the neck ring.

2. The quality of welds and welded joints should be designed to reduce joint failure. 3. Stress distribution should be equal.

4. According to analysis, some of them need to be rebuilt for safety reasons.

5. Overload factors should be taken into account to provide additional strength to the chassis.

Future Work for the Project

- Improve efficiency by using lighter chassis material (Alloy).
- Usage of more efficient Solar Panels (Carbon Nano-tubes).
- Usage of Lithium Batteries for better power consumption and reduction of weight.

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