Design And Analysis Of An Excavator

A. V. Pradeep*, CH. Jagadeesh**, S. V. S. Satya Prasad***

* (Mechanical Engineering, SVP Engineering College,)
**(Mechanical Engineering, SVP Engineering College)
***(Mechanical Engineering, SVP Engineering College)

ABSTRACT

The main aim of the project is to design every component of an excavator, assemble it and to carry out analysis on the 'bucket teeth' taking different materials considering the impact load on it. Deformations, von mises stresses and strain energies are compared for the different materials and the optimum material with less weight, high strength and good sustainability is to be found out. So, we can achieve a bucket of less weight and high strength which gives a saving in material and manufacturing cost. Design and assembly is being done in CATIA and analysis is being done in ANSYS

1. Introduction

An excavator primarily consist of four main functional systems:
1.Base with translation system
2.Transmission system
3.Operational system
4.Excavating device

1. Base with translation system: It consists of the main base on which various parts like engine, arm support, drivers cabin are mounted, along with this it has a chain sprocket belt mechanism to move machine from one place to other.

2. Transmission System: It consists of two arms which are used to transmit the motion and are called as front arm and back arm.

3. Operational system: It consists of a hydraulic cylinder rod mechanism which is used to drive the transmission system.

4. Excavating system: It contains a bucket and bucket linkage which is connected to the front arm by hydraulic cylinder rod mechanism and is used to lift the material.

The Hydraulic Excavator is most commonly used for digging rocks and soil, but with its many attachments it can also be used for cutting steel, breaking concrete, drilling holes in the earth, laying gravel onto the road prior to paving crushing rocks, steel, and concrete, and even mowing landscapes. Hydraulic excavator has an operating weight of more than 12000kgs.

1.1 Components of an Excavator

The main basic components of an excavator are as follows:

1. THE ARM: The arm is comprised of two hydraulic cylinders, a bucket and boom which is on the upper part of the arm. The arm moves in two parts just like a human arm would be at the wrist and the elbow.

2. CYLINDER ROD: Inside of the hydraulic cylinder is a rod, which is the inner part of the cylinder and a Piston, which is at the end of the cylinder and enables the arm to move with the help of oil. If there were no oil in the cylinder, the piston would drop to the bottom, but because of the nature of oil, its volume always stays the same. Oil is pumped through the end of the piston and in turn pushes the rod through the cylinder, thus creating movement of one or both parts of the arm. By control of the amount of oil is pumped through the Valve, the accuracy of the arm can be easily manipulated. This movement is activated by the use of control valves that are positioned inside the Cab where the driver seat is.

3. THE ENGINE: Power in an automobile is normally received straight from the engine but it works differently in a hydraulic excavator. Because the machine uses a lot of force, it is able to move by changing the energy it receives from the engine into hydraulic power.

4. THE SWING: One of the functions of this machine is its ability to turn. The swing of the excavator enables it to turn. The swing circle comprises of an outer race, an inner race, ball bearings and a pinion. As the outer race turns, the pinion runs alongside the unmoving inner race. The ball bearings work to ensure that this is done smoothly.

5. THE CAB: The upper structure where the driver's seat is located and the controls are

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positioned. With the help of two levers on both side and two in the front, the driver can move both at the same time to control direction and height.

6. THE FEET: There are two types of excavator bases. One type has wheels just as a regular car would, also known as the wheel type. Because of the nature of the base, it is primarily used on hard surfaces, such as concrete and gravel. The second type is known as a crawler because of its ability to drive on less stable surfaces, such as mud, sand. Unlike the wheel type, the crawler covers more the ground and thus will not sink into the ground. It does just as the name suggests, crawls, with a conveyor belt-like mechanism. This machine can only be used on site and would have to be transported by another vehicle to get from one point to another.

7. THE BOOM: An excavator boom is a component used to operate an excavator, a piece of heavy machinery used for digging holes or otherwise moving large amounts of material. The excavator usually consists of a base with tracks or treads attached to rotating wheels, as well as a unit known as the house that rotates 360 degrees so the operator can access material on all sides of the machine without repositioning the entire unit. The excavator boom extends off the front of the house, and it usually consists of two pieces that articulate for better reach.

8. THE BUCKET: A bucket is mounted to the end of the excavator boom. Bucket is responsible for doing the digging as well as for containing the materials to be moved. All components of the excavator boom as well as the bucket itself are controlled by hydraulics; an outer stanchion filled with fluid usually some sort of oil can be pressurized, thereby causing an internal piston to push forward. When the pressure is released, the piston will retract. In this way, the two parts of the excavator boom as well as the bucket can be controlled from the operator's cabin of the machine.

1.2 Excavator Uses

Excavators are used in many ways:

- Digging of trenches, holes, foundations
- Material handling
- Brush cutting with hydraulic attachments
- Forestry work
- demolition
- General grading/landscaping
- Heavy lift, e.g. lifting and placing of pipes
- Mining
- River dredging

1.3 Types of Excavators

- Long reach excavators
- Power shovels
- Skid steer excavators
- Steam shovels
- suction excavators
- drag line excavators
- bucket wheel excavators
- midi excavators
- mini excavators etc….

2. 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. CATIA offers a solution to model complex and intelligent products through the systems engineering approach. It covers the requirements definition, the systems architecture, the behaviour modelling and the virtual product or embedded software generation. CATIA is used by the automotive and aerospace industries for automobile and aircraft product and tooling design. CATIA is found in a variety of industries throughout the world. Some of these industries include; Aerospace, Appliances, Architecture, Automotive, Construction, Consumer Goods, Electronics, Medical, Furniture, Machinery, Mould and Die, and Shipbuilding.

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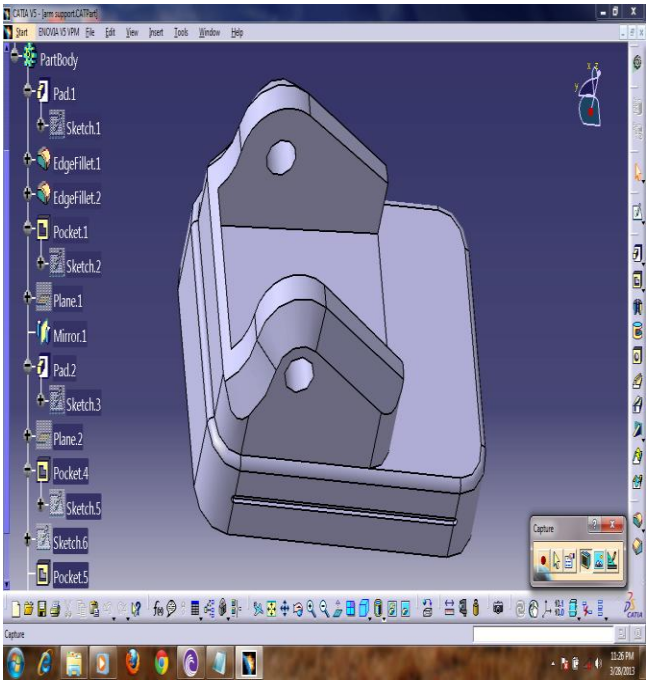
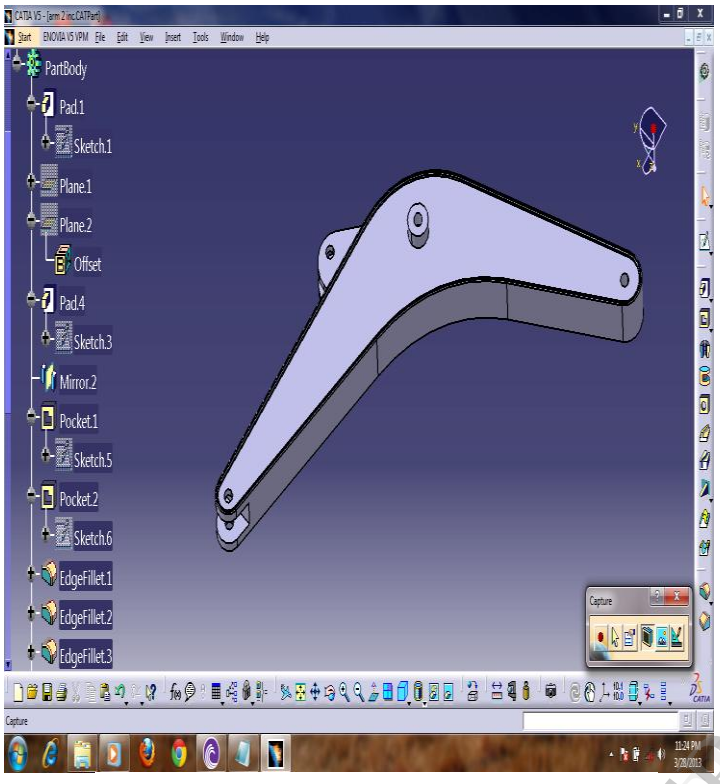
2.1 Design of components

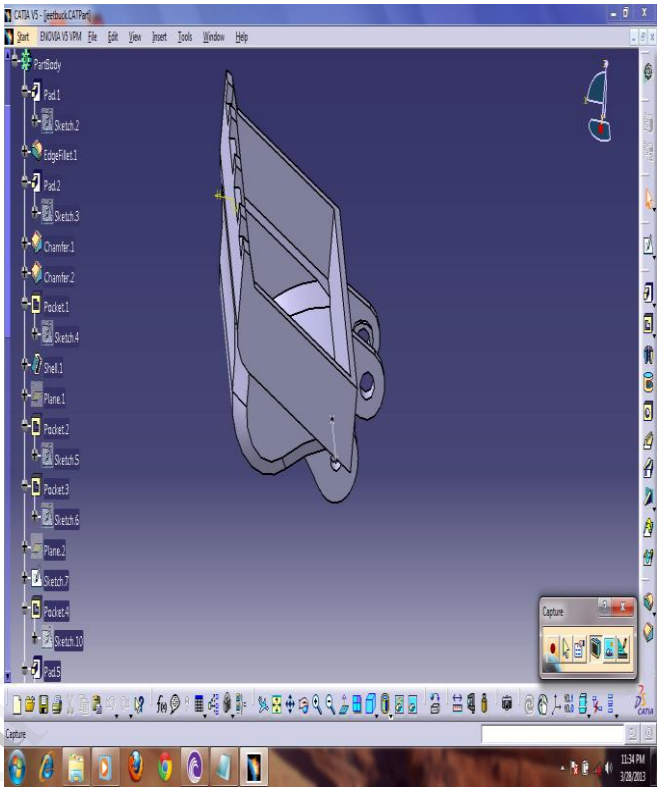
- DESIGN OF ARM SUPPORT



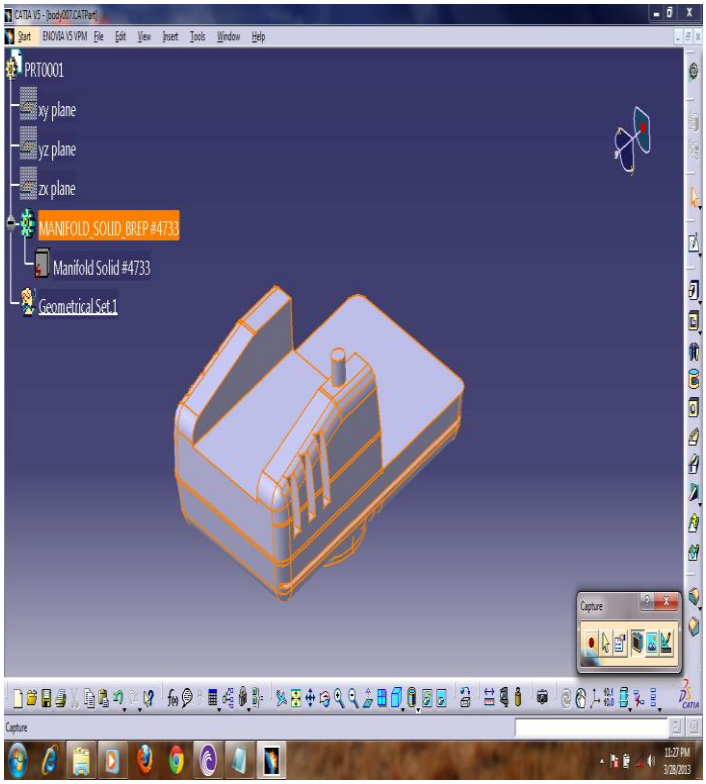
- DESIGN OF ARM



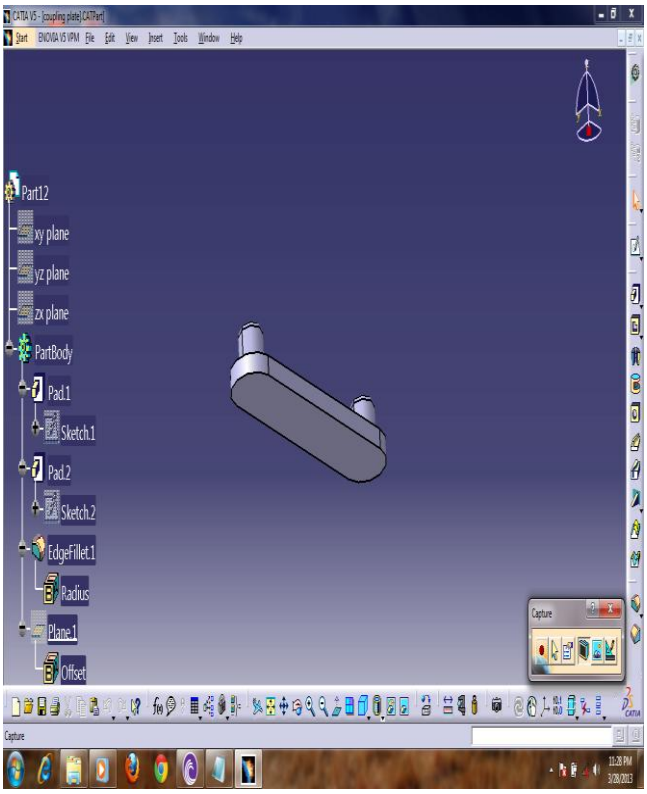
- DESIGN OF BUCKET



- DESIGN OF BODY



- DESIGN OF COUPLE PLATE



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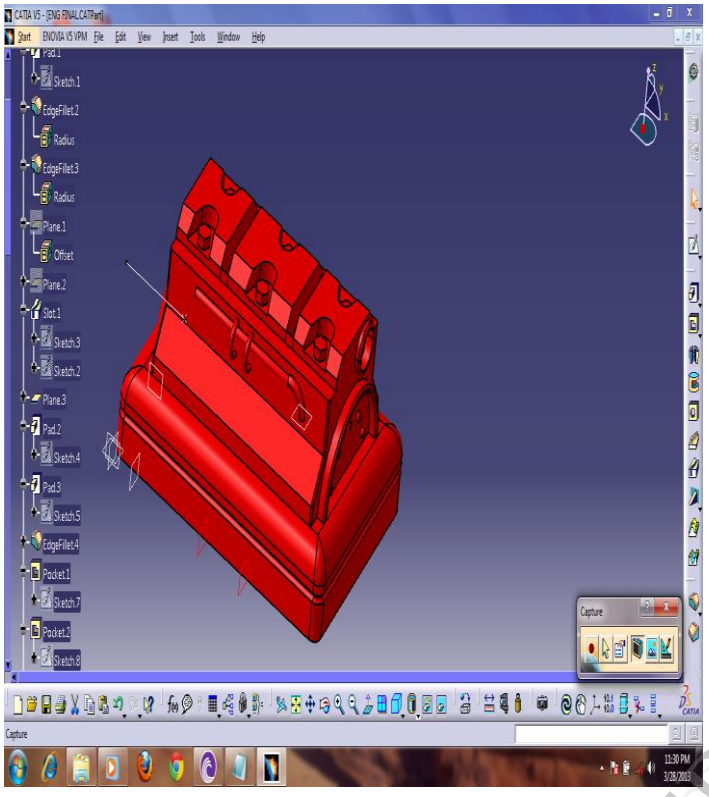
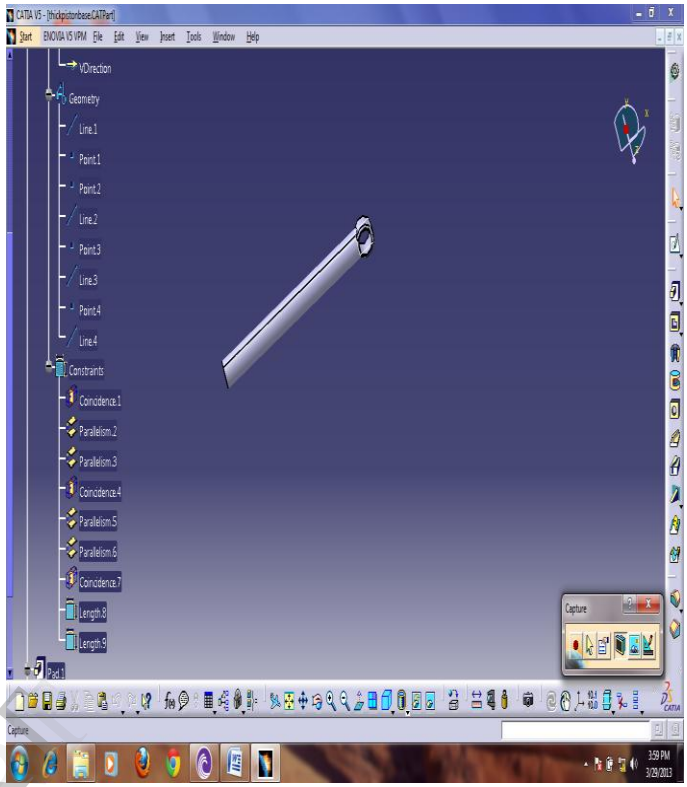
- DESIGN OF ENGINE



- DESIGN OF PISTON BASE



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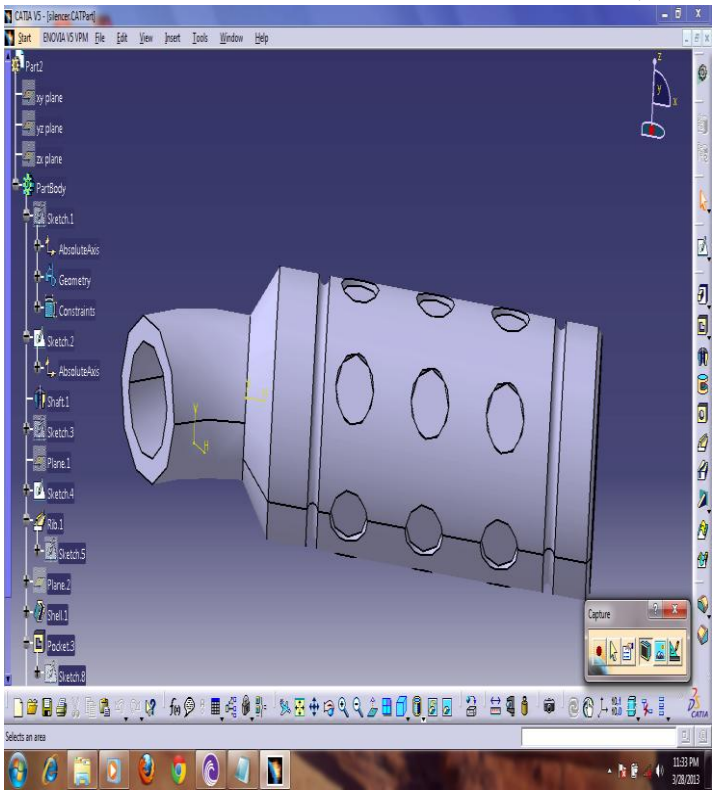
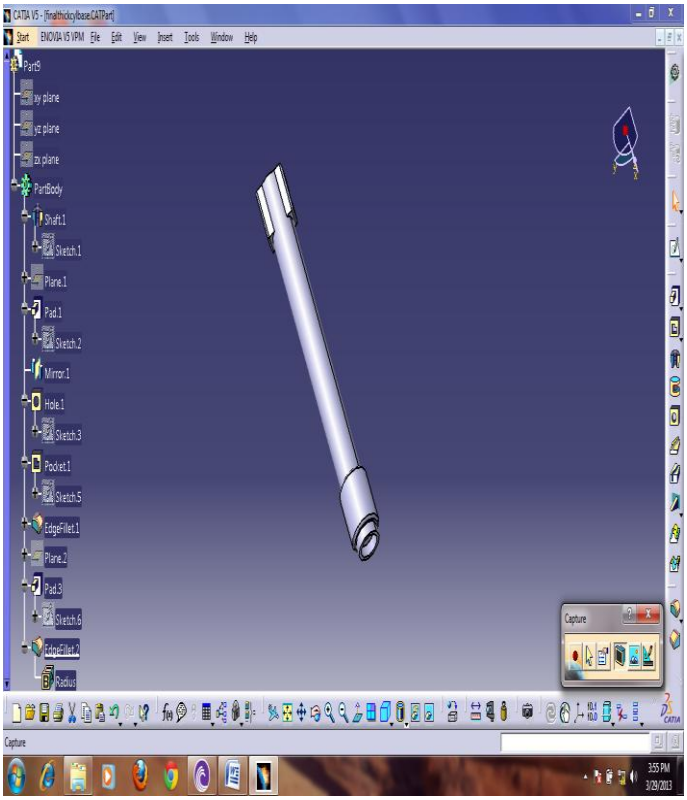
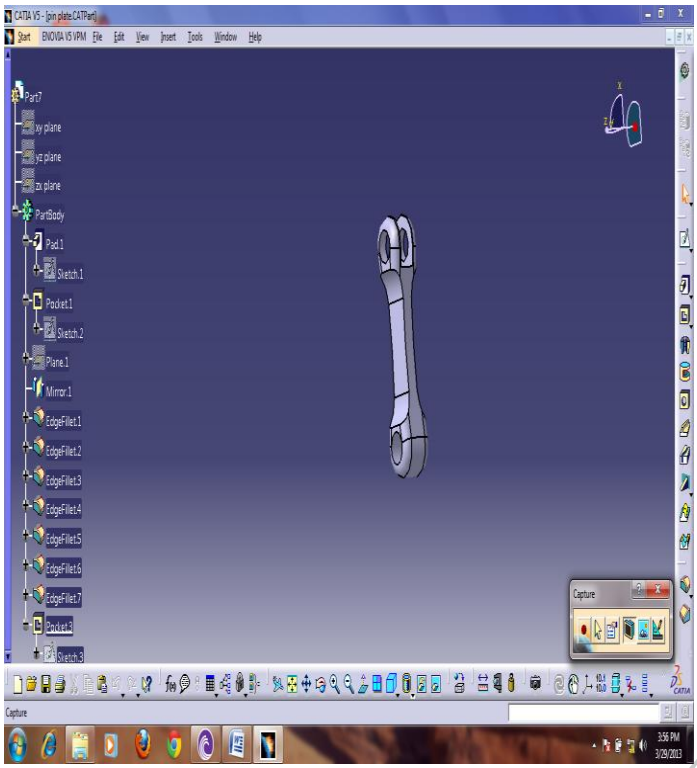
- DESIGN OF SILENCER



- DESIGN OF CYLINDER BASE

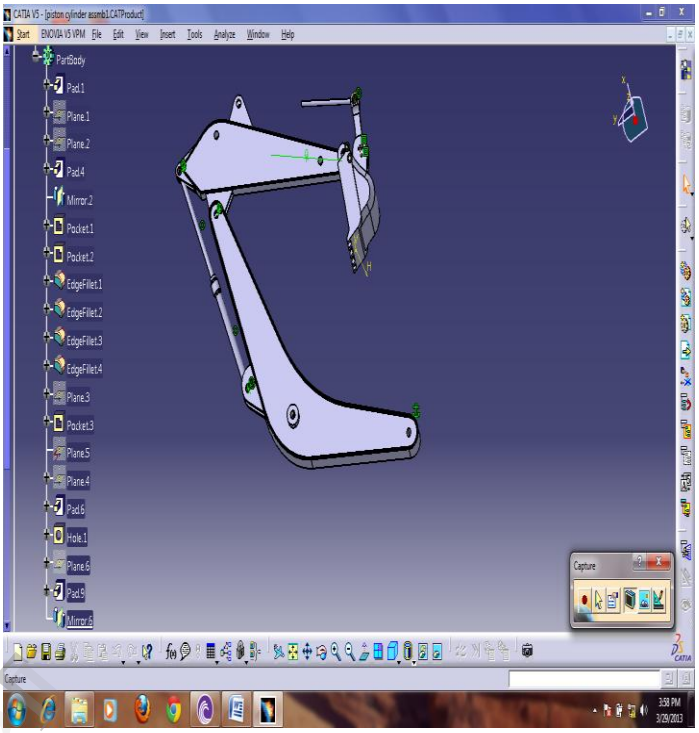


- DESIGN OF PIN PLATE



2.2 Assembly in CATIA

- PISTON CYLINDER ASSEMBLY



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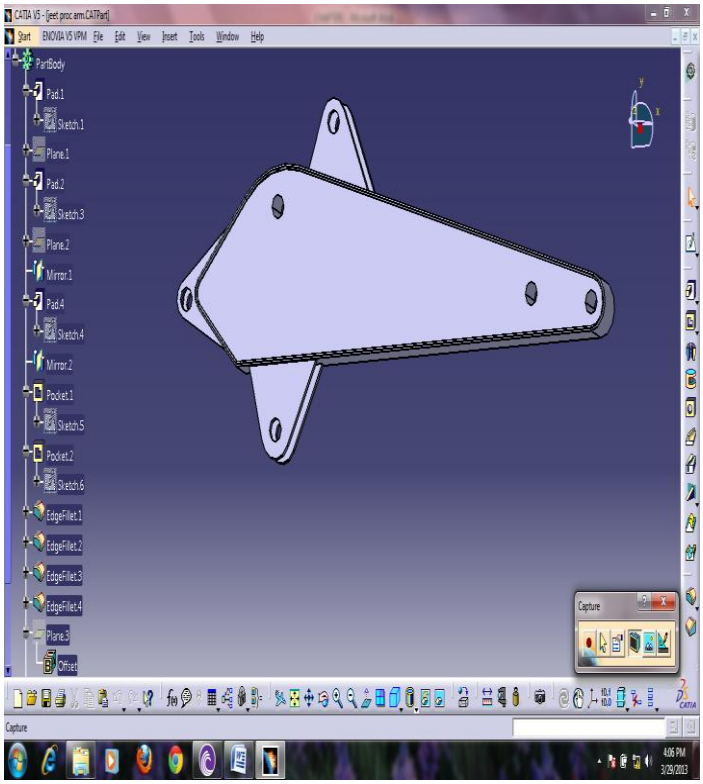
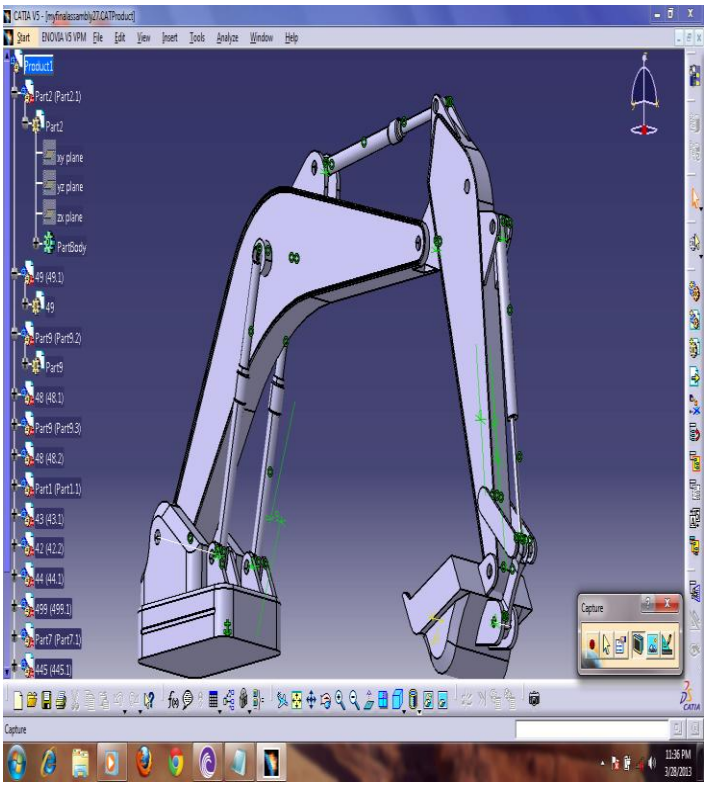
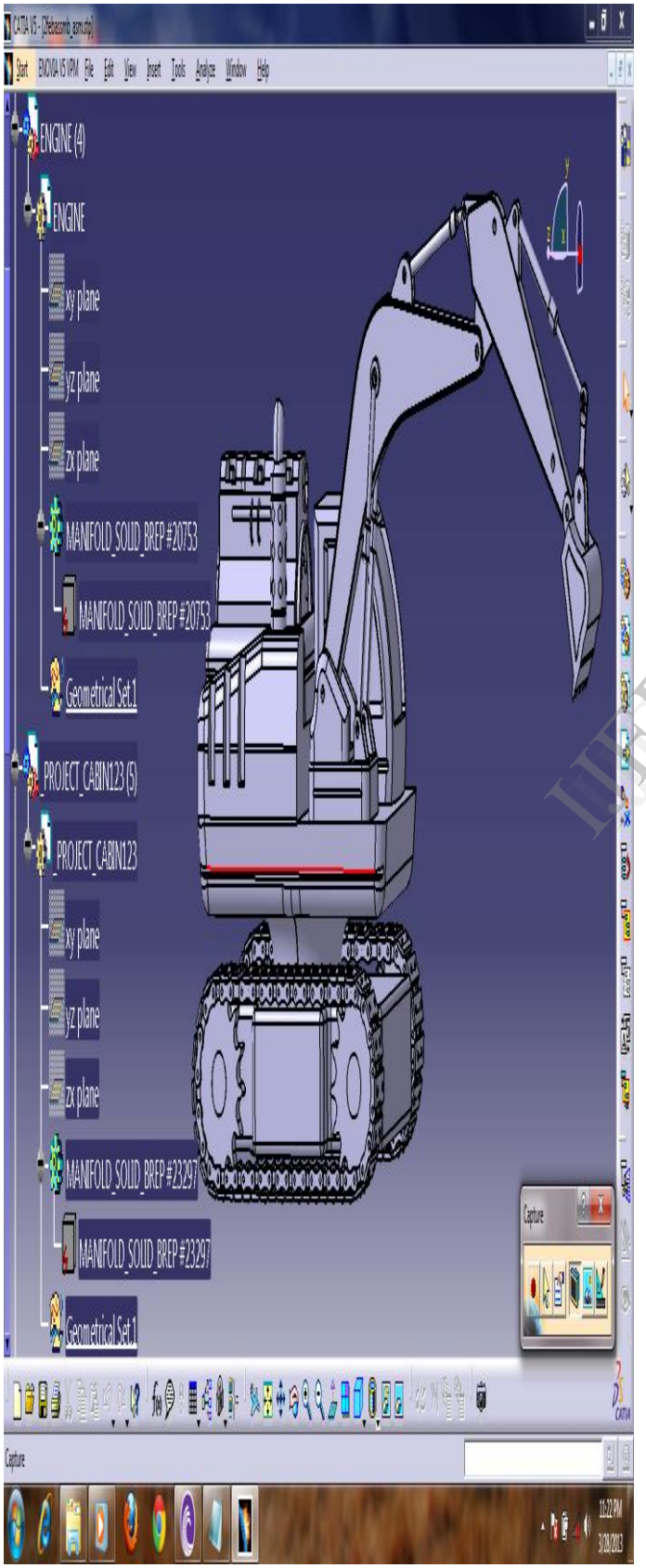
- DESIGN OF JEET PROC ARM



- TOP ASSEMBLY



- FINAL ASSEMBLY



3. Analysis of Excavator Bucket in ANSYS

The bucket of an excavator has to come in contact with the substance which is to be removed, lift and carry the load and has to dump it somewhere. While it is being meeting the material, a sudden impact of high pressure falls on the teeth of the bucket. Hence it has to withstand this high impact load. So, the analysis has been performed on the bucket considering different materials. Material properties such as weight, poisons ratio and young's modulus are fed to ANSYS and the results are compared.

1. STEEL: Steel is an alloy of iron and other elements including carbon. When carbon is primary alloying element, its content in the steel is between o.oo2% and 2.1% by weight. carbon, manganese, phosphorus, sulphur, silicon and traces of oxygen, nitrogen and aluminium. Its young's modulus is 210gpa. Its weight for 1cu.m is 7840kgs. In case of excavator bucket capacity, its weight is 700kgs.

2. CAST IRON: Cast iron is iron or a ferrous alloy which has been heated until it liquefies, and is then poured into a mould to solidify. It is usually made from pig iron. Carbon and silicon are the main alloying elements, with the amount ranging from 2.1 to4% weight and 1 to3% respectively. Its young's modulus is 89gpa. For 1cu.m its weight is 7300 kgs. In case of excavator bucket capacity, its weight is 650kgs.

3. WROUGHT IRON: Wrought iron is an iron alloy with very low carbon content in contrast to cast iron. Many items, before they came to be made of mild steel, were produced from wrought iron, including wire, chains, rails, nuts, bolts. Its young's modulus is 190gpa. For 1cu.m its weight is 7550kgs. In case of excavator bucket capacity, its weight is 675kgs.

3.1 Meshing Of Bucket

Mesh generation is one of the most critical aspects of engineering simulation. Too many cells may result in long solver runs, and too few may lead to inaccurate results. ANSYS Meshing technology provides a means to balance these requirements and obtain the right mesh for each simulation in the most automated way possible. ANSYS Meshing technology has been built on the strengths of stand-alone, class-leading meshing tools. The strongest aspects of these separate tools have been brought

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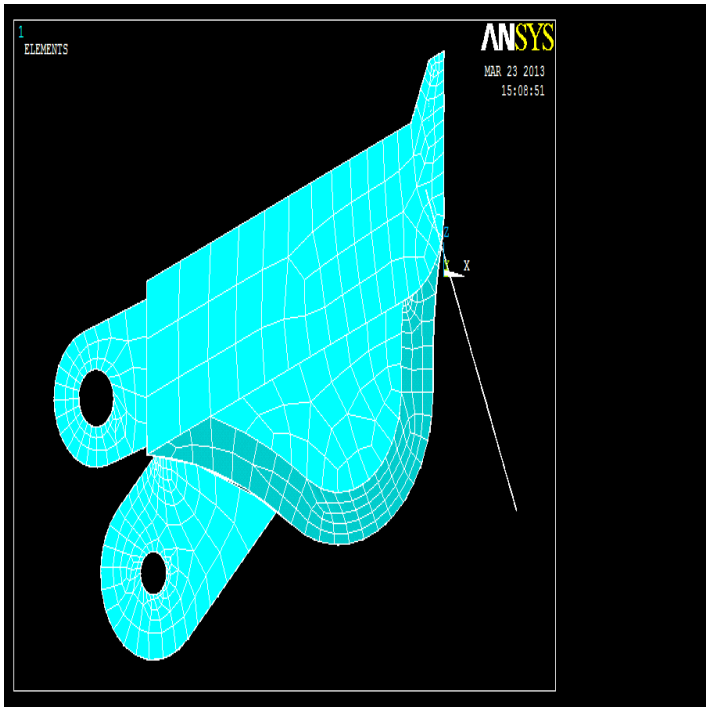
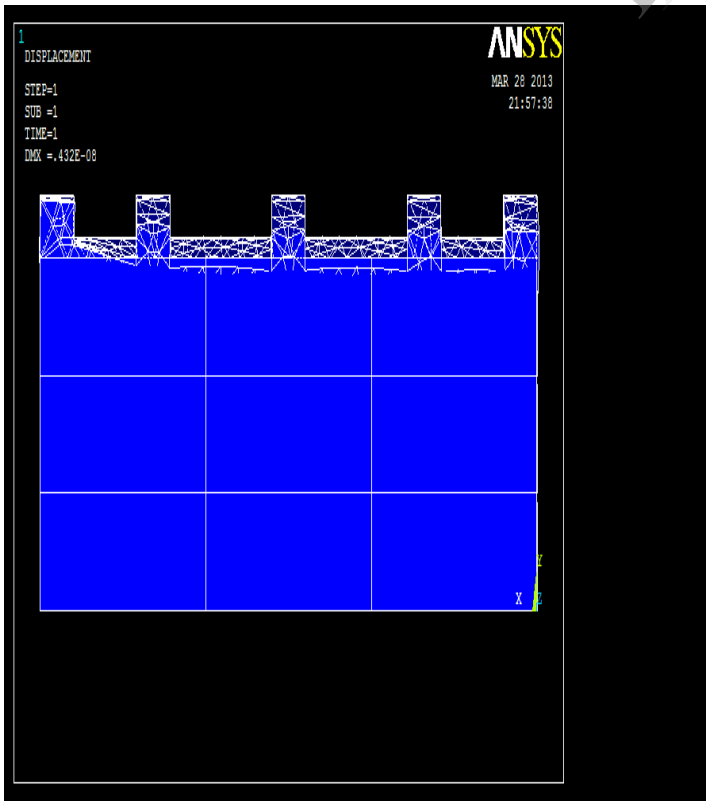
together in a single environment to produce some of the most powerful meshing available.

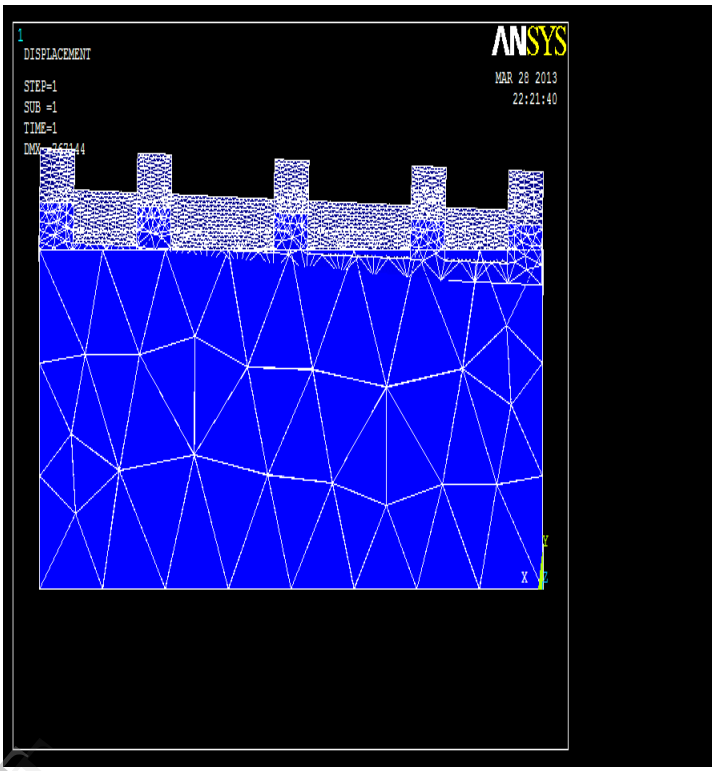


3.2 Deformations

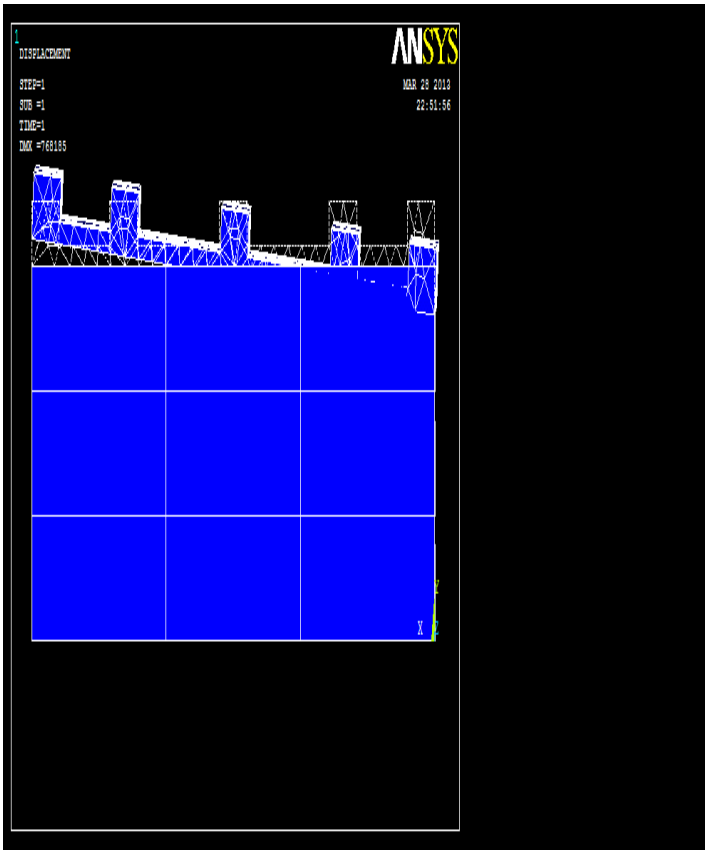
1. STEEL



2. WROUGHT IRON



3. CAST IRON



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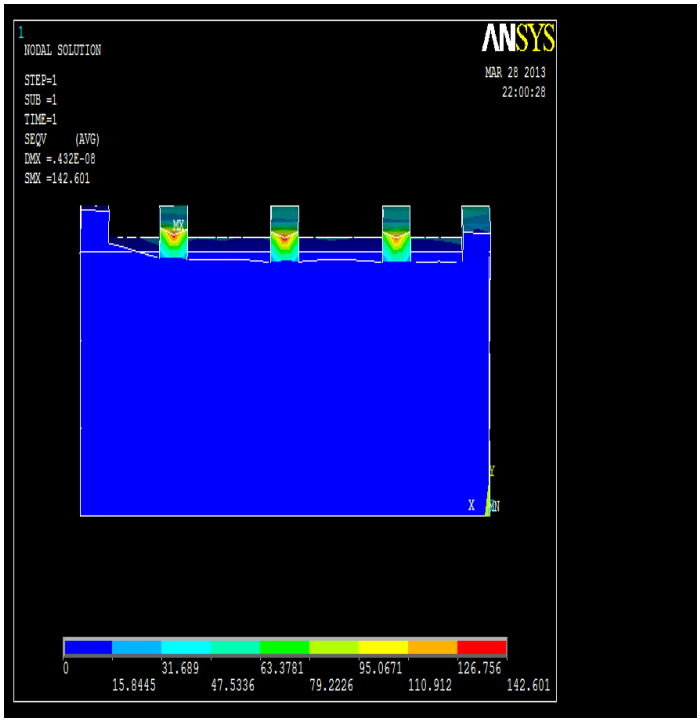
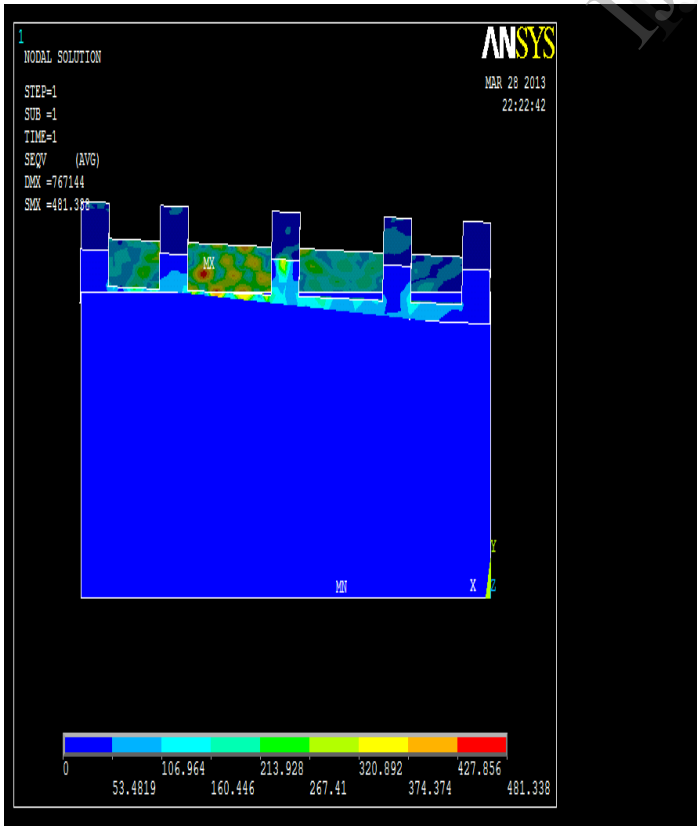
3.3 Von Mises Stress

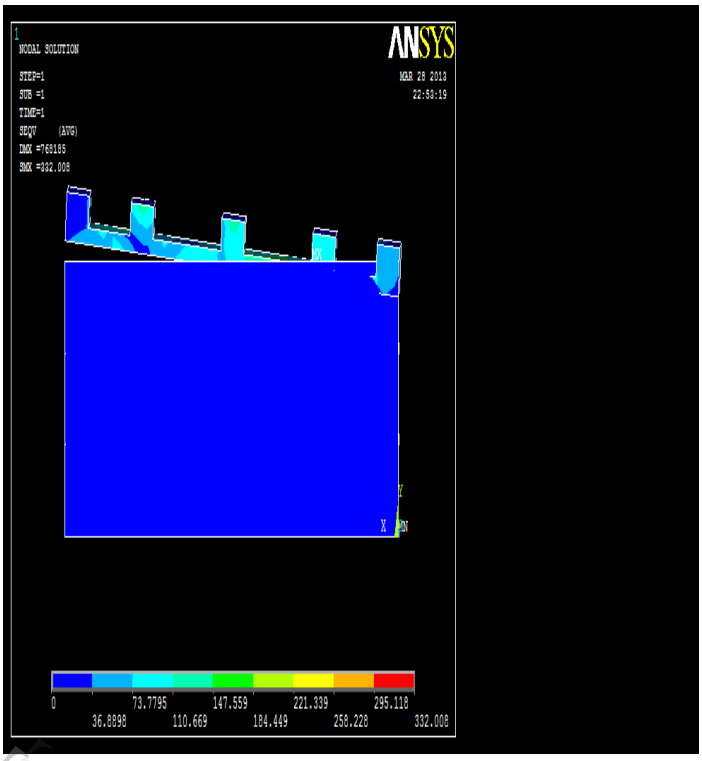
1. STEEL



2. WROUGHT IRON

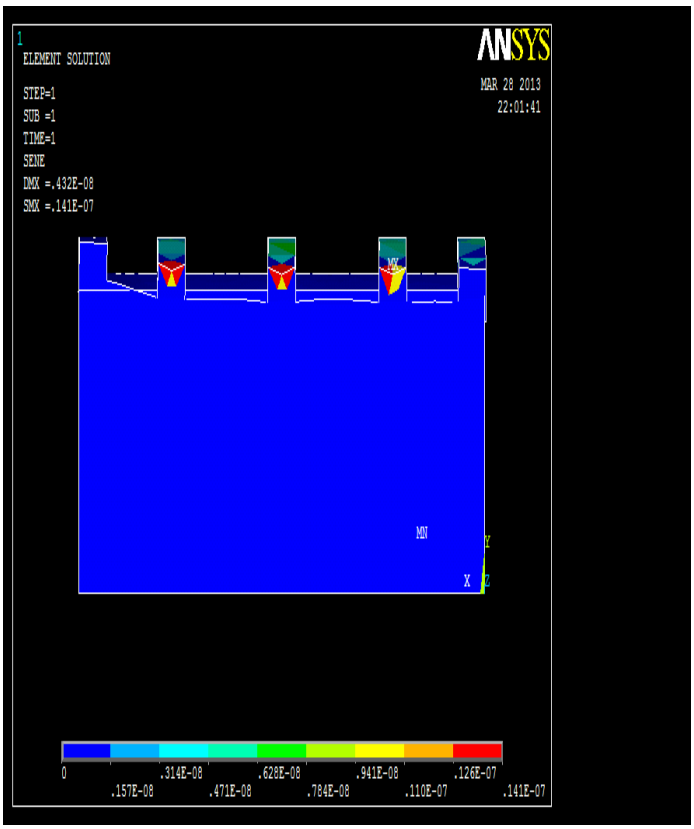


3. CAST IRON



3.4 Strain Energy

1. STEEL



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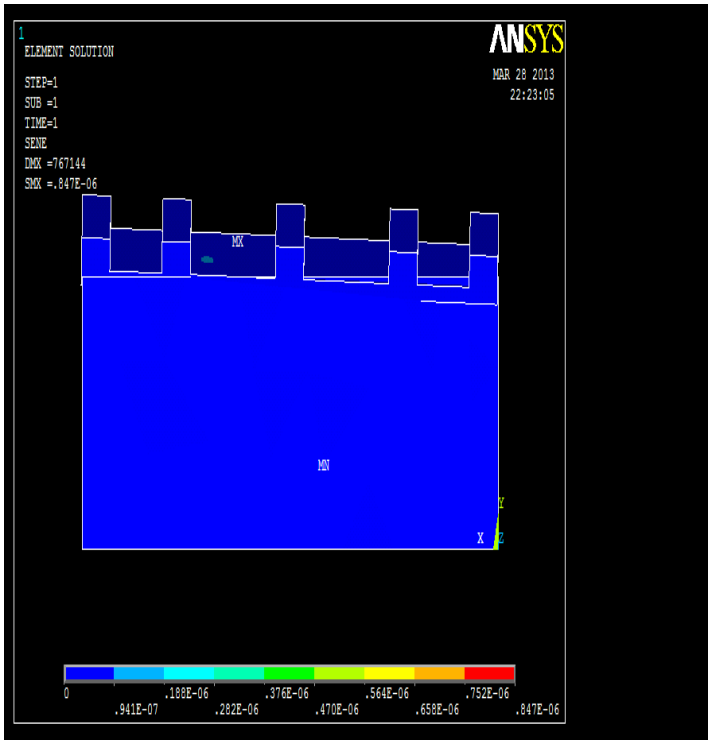
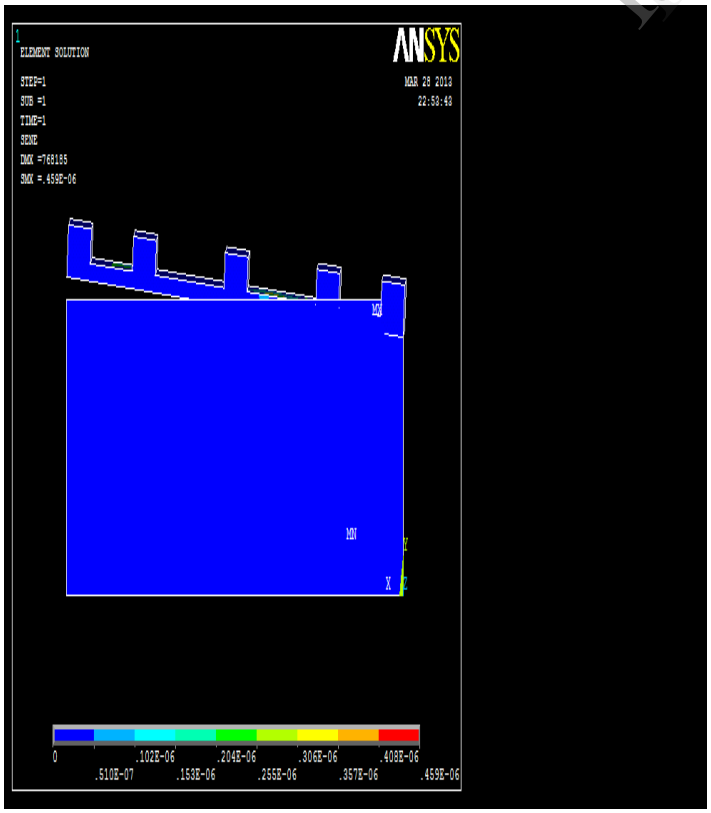
2. WROUGHT IRON



3. CAST IRON



4. Conclusion

Design of every component of an excavator and also assembly is done in CATIA. Meshing and analysis of excavator bucket is carried out in ANSYS. In general, excavator bucket is made of steel material, but our analysis is done for three materials, i.e. steel, wrought iron and cast iron. We found out the von mises stresses, deformations and the strain energy for all the three materials. Comparisons are made between these three materials and they are as follows:

Weight:

1. Steel: Its weight for 1cu.m is 7840kg.
2. Cast iron: For 1cu.m its weight is7300 kg.
3. Wrought iron: For 1cu.m its weight is 7550kg.

Deformation:

Steel has least deformation when compared to wrought iron and cast iron but wrought iron also can withstand the loads showing less deformation.

Von mises stresses:

Steel and wrought iron has lesser stresses developed when compared to cast iron.

Strain energy:

Wrought iron has more strain energy to sustain the load compared to steel and cast iron.

Wrought iron can has low weight, high strain energy, low stresses developed in it and showing a nominal deformation. Usually steel is used universally for the excavator bucket but if we replace steel with wrought iron, we can the following advantages:

Wrought iron is tough, malleable, ductile and easily welded. For the same strength we can have a reduction in weight, hence saving the manufacturing cost, material and time. Wrought iron is extremely durable. It's almost impossible to break or damage. However, you should be careful to keep a good paint job on the wrought iron to avoid rust, but other than that, it requires almost no maintenance and is weather-resistant.

Considering all the above advantages, wrought iron can be replaced with steel (material of an excavator bucket) for better results.

5. References

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