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DESIGN AND ANALYSIS OFINDUSTRIAL SCISSOR LIFT

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***Abstract* - A Scissor Jack is a mechanical device used to easily lift a vehicle off the ground, to gain access to sections underneath vehicles or to change the wheel. The most important fact of a jack is that it gives the user a mechanical advantage by changing the rotational force on power screw into linear motion, allowing user to lift a heavy car to the required height. It is called a scissor jack as the structure consists of diagonal metal components that expand and contract in the same way as a pair of scissors. In this project an attempt has been made to design and fabricate a power scissor jack to lift and support a load of 4.5kN, for typical use in four wheeler. The entire work has been divided into eight chapters. 1st chapter deals with Introduction, explaining a jack. The objectives of the project work have been also presented in this chapter. 2nd chapter presents the Literature Review. This chapter covers various developments in screw jack, other types of load lifting mechanisms and present status of screw jacks in use. 3rd chapter highlights Power Screws. In this chapter application of power screws, their advantages and dis advantages, forms of power screws, terminology and efficiency of power screw are discussed. 4th chapter deals with Design of various elements of proposed jack, with due consideration regarding selection of materials, their working stress along with necessary assumptions made. 5th chapter presents Drawings, which includes part drawings, assembly drawings, exploded views and bill of materials. 6th chapter emphasize on the different Manufacturing Methods which are in practice to get the elements that are designed. 7th chapter highlights Fabrication and assembly details of the proposed power scissor jack along with the pictorial views of the fabricated unit. 8th chapter deals with the Conclusions which are drawn based on the present work. A few suggestions are given as a Scope for further development.**

I. INTRODUCTION TO POWER SCISSOR JACK

Jack is a mechanical device used to lift heavy loads or apply great forces. A mechanical jack employ a square thread for lifting heavy equipment. The most common form is a car jack, floor jack or garage jack which lifts vehicles so that maintenance can be performed. Mechanical jacks are usually rated for a maximum lifting capacity (for example, 1.5 tons to 3 tons). More powerful jacks use hydraulic power to provide greater lift.

1.1 Problem Statement

Available jacks present difficulties for the elderly people and women and are especially disadvantageous under adverse weather conditions. Presently available jacks further require the operator to remain in prolonged bent or squatting position to operate the jack which is not ergonomic to human body. It will give physical problems in course of time. Moreover, the safety features are also not enough for operator to operate the present jack. Furthermore, available jacks are typically large, heavy and also difficult to store, transport, carry or move into the proper position under an automobile. The purpose of this project is to overcome these problems. An electric car jack which has a frame type of design by using electricity from the car will be developed. Operator only needs to press the button from the controller without working in a bent or squatting position for a long period of time to change the tire.

1.2 Objective of The Project

1. To design a power scissor jack which is safe and reliable to raise and lower the load easily.
2. Use of double start square thread in power screw.
3. Pins in bearings.
4. To fabricate the prototype of a scissor jack which is operated by a gun powered by the car battery.

1.3 Literature Survey

Screw type mechanical jacks were very common for jeeps and trucks of World War II vintage.

For example, the World War II jeeps (Willys MB and Ford GPW) issued the "Jack, Automobile, Screw type, Capacity 1 1/2 ton", Ordinance part number 41-J-66. These jacks, and similar jacks for trucks, were activated by using the lug wrench as a handle for the ratchet action to the jack. The 41-J-66 jack was carried in the jeep's tool compartment. Screw type jacks continued in use for small capacity requirements due to low cost of production to raise or lower the load. A control tab is marked up/down and its position determines the direction of movement and with no maintenance. The virtues of using a screw as a machine element, which is essentially an inclined plane wound round a cylinder, was first demonstrated by Archimedes in 200BC with his device used for pumping water.

2.1 Various Developments in Lifting Devices

1. Levers
2. Screw threads
3. Gears
4. Wheels and axles
5. Hydraulics

2.1.1 Levers

Use of the lever gives the operator much greater lifting force than that available to a person who tried to lift with only the strength of his or her own body. Types of levers are first, second and third order.

2.1.2 Screw Thread

A screw is a mechanism that converts rotational motion to linear motion, and a torque to a linear force. The most common form consists of a cylindrical shaft with helical grooves or ridges called threads around the outside. The screw passes through a hole in another object or medium, with threads on the inside of the hole that mesh with the screw's threads. When the screw is rotated relative to the stationary threads, the screw moves along its axis relative to the medium surrounding it for example rotating a wood screw forces it into wood. In screw mechanisms, either the screw can rotate through a threaded hole in a stationary object, or a threaded collar such as a nut can rotate around a stationary screw. Geometrically, a screw can be viewed as a narrow inclined plane wrapped around a cylinder

2.1.3 Gears

The jack will lift a load in contact with the load platform when the power screw is rotated through its connecting gear with the pinion gear when connected to the motor, plugged to theautomobile 12V battery source to generate power for the prime mover (motor), which transmits its rotating speed to the pinion gear meshing with the bigger gear connected to the power screw to be rotated with required speed reduction and increased torque to drive the power screw. The power screw rotates within the threaded hole of its connecting members in the clockwise direction that will cause the connecting members to be drawn along the threaded portion towards each other during a typical load-raising process. During the typical loadraising process, the jack will first be positioned beneath the load to be lifted such that at least a small clearance space will exist between the load platform and the object to be raised. Next, power screw will be turned so that the load platform makes contact with the object and the clearance space is eliminated.

2.2 Necessity of Jack

In the repair and maintenance of automobiles (car), it is often necessary to raise an automobile to change a tire or access the underside of the automobile. Accordingly, a variety of car jacks have been developed for lifting an automobile from a ground surface. Available car jacks, however, are typically manually operated and therefore require substantial laborious physical effort on the part of the user. Such jacks present difficulties for the elderly and handicapped and are especially disadvantageous under adverse weather conditions. Furthermore, available jacks are typically large, heavy and also difficult to store, transport, carry or move into the proper position under an automobile. In addition, to the difficulties in assembling and setting up jacks, such jacks are generally not adapted to be readily disassembled and stored after automobile repairs have been completed. Car jacks must be easy to use for women or whoever had problem with the tire in the middle of nowhere. In light of such inherent disadvantages, commercial automobile repair and service stations are commonly equipped with large and hi-tech car lift, wherein such lifts are raised and lowered via electrically-powered systems. However, due to their size and high costs of purchasing and maintaining electrically-powered car lifts, such lifts are not available to the average car owner. Engineering is about making things simpler or improving and effective. Such electricalpowered portable jacks not only remove the arduous task of lifting an automobile via manuallyoperated

2.3 Types of Load Lifting Devices

1. Artificial Lifting Devices (ALD)
2. Portable Automotive Lifting Devices (PALD)

2.3.1 Artificial Lifting Devices

1. Hydraulic pumping system
2. Electric Submersible Pumps
3. Gas lifts

4. Hybrid gas lifts

2.3.2 Portable Automotive Lifting Devices

1. Hydraulic hand jacks
2. Transmission jacks
3. Engine Stands
4. Vehicle support stands
5. Upright type mobile lifts
6. Service jacks
7. Wheel dollies
8. Swing type mobile lifts
9. Scissor type mobile lifts
10. Auxiliary stands
11. Automotive ramps
12. High rich supplementary stands
13. Fork lift jacks
14. High reach fixed stands
15. Vehicle transport lifts
16. Cranes
17. Lever
18. Hydraulic ram
19. Block and tackle
20. Wedge
21. Escalator

2.4 Types of Jacks Used Today

2.4.1 Scissor Jack

Scissor jacks are mechanical devices and have been in use since 1930s. A scissor jack is a device constructed with a cross-hatch mechanism, much like a scissor, to lift up a vehicle for repair. It typically works in a vertical manner. The jack opens and folds closed, applying pressure to the bottom supports along the crossed pattern to move the lift. When closed, they have a diamond shape. Scissor jacks are simple mechanisms used to handle large loads over short distances. The power screw design of a common scissor jack reduces the amount of force required by the user to drive the mechanism. Most scissor jacks are similar in design, consisting of four main members driven by a power screw [7] [9]. A scissor jack is operated simply by turning a small crank that is inserted into one end of the scissor jack. This crank is usually "Z" shaped. The end fits into a ring hole mounted on the end of the screw, which is the object of force on the scissor jack. When this crank is turned, the screw turns, and this raises the jack.

The screw acts like a gear mechanism. It has teeth (the screw thread), which turn and move the two arms, producing work. Just by turning this screw thread, the scissor jack can lift a vehicle that is several thousand pounds. A scissor jack has four main pieces of metal and two base ends. The four metal pieces are all connected at the corners with a bolt that allows the corners to swivel. A screw thread runs across this assembly and through the corners. When opened, the four metal arms contract together, coming together at the middle, raising the jack.

2.4.2 Bottle (Cylinder) Jack

Bottle screws may be operated by either rotating the screw when the nut is fixed or by rotating the nut and preventing rotation of the screw. Bottle jacks mainly consist of a screw, a nut, thrust bearings, and a body. A stationary platform is attached to the top of the screw. This platform acts as a support for the load and also assists it in lifting or lowering of the load. These jacks are sturdier than the scissor jacks and can lift heavier loads. In a bottle jack the piston is vertical and directly supports a bearing pad that contacts the object being lifted. With a single action piston the lift is somewhat less than twice the collapsed height of the jack, making it suitable only for vehicles with a relatively high clearance.

2.4.3 Hydraulic Jacks

Hydraulic jacks are typically used for shop work, rather than as an emergency jack to be carried with the vehicle. Use of jacks not designed for a specific vehicle requires more than the usual care in selecting ground conditions, the jacking point on the vehicle, and to ensure stability when the jack is extended. Hydraulic jacks are often used to lift elevators in low and medium rise buildings.

A hydraulic jack uses a fluid, which is incompressible. Oil is used since it is self-lubricating and stable. When the plunger pulls back, it draws oil out of the reservoir through a suction check valve into the pump chamber. When the plunger moves forward, it pushes the oil through a discharge check valve into the cylinder. The suction valve ball is within the chamber and opens with each draw of the plunger. The discharge valve ball is outside the chamber and opens when the oil is pushed into the cylinder [9]. At this point the suction ball within the chamber is forced to shut and oil pressure builds in the cylinder. For lifting structures such as houses the hydraulic interconnection of multiple vertical jacks through valves enables the even distribution of forces while enabling close control of the lift.

In a floor jack a horizontal piston pushes on the short end of a bell crank, with the long arm providing the vertical motion to a lifting pad, kept horizontal with a horizontal linkage. Floor jacks usually include castors and wheels, allowing compensation for the arc taken by the lifting pad. This mechanism provide a low profile when collapsed, for easy maneuvering underneath the vehicle, while allowing considerable extension.

2.5 Operational Considerations of a screw jack [11]

1. Maintain low surface contact pressure Increasing the screw size and nut size will reduce thread contact pressure for the same working load. The higher the unit pressure and the higher the surface speed, the more rapid the wear will be.
2. Maintain low surface speed .Increasing the screw head will reduce the surface speed for the same linear speed.
3. Keep the mating surfaces well lubricated .The better the lubrication, the longer is the service life. Grease fittings or other lubrication means must be provided for the power screw and nut.
4. Keep the mating surfaces clean Dirt can easily embed itself in the soft nut material. It will act as a file and abrade the mating screw surface. The soft nut material backs away during contact leaving the hard dirt particles to scrap away the mating screw material.
5. Keep heat away. When the mating surfaces heat up, they become much softer and are more easily worn away. Means to remove the heat such as limited duty cycles or heat sinks must be provided so that rapid wear of over-heated materials can be avoided.

Power Screws

A power screw is a mechanical device used for converting rotary motion into linear motion and transmitting power. A power screw is also called translation screw. It uses helical translatory motion of the screw thread in transmitting power rather than clamping the machine components.

3.1 Applications

The main applications of power screws are as follows:
1. To raise the load, e.g. screw-jack, scissor jack,
2. To obtain accurate motion in machining operations, e.g. lead-screw of lathe,
3. To clamp a work piece, e.g. vice, and

3.2 Advantages

Power screws offer the following advantages:
1. Power screw has large load carrying capacity.
2. The overall dimensions of the power screw are small, resulting in compact construction.
3. Power screw is simple to design

3.3 Disadvantages

The disadvantages of power screws are as follows:
1. Power screws have very poor efficiency; as low as 40%.Therefore, it is not used in continuous power transmission in machine tools, with the exception of the lead screw.

Power screws are mainly used for intermittent motion that is occasionally required for lifting the load or actuating the mechanism.

3.4 Forms of Threads

There are two popular types of threads used for power screws viz. Square, I.S.O metric trapezoidal and Acme threads.

3.4.1 Square Thread

The square thread form is a common screw thread form, used in high load applications such as lead screws and jackscrews. It gets its name from the square cross-section of the thread. It is the lowest friction and most efficient thread form.

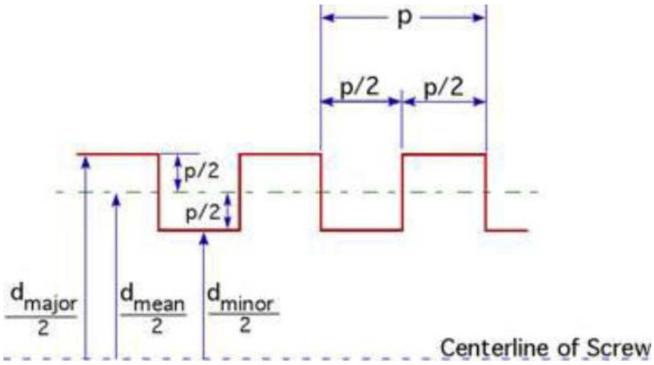


Fig 3.1 Nomenclature of Square Thread

3.4.2 Trapezoidal Threads

Trapezoidal thread forms are screw thread profiles with trapezoidal outlines. They are the most common forms used for lead screws. They offer high strength and ease of manufacture.

3.5 Designation of Threads

There is a particular method of designation for square and trapezoidal threads. A power screw with single-start square threads is designated by the letters '*Sq*' followed by the nominal diameter and the pitch expressed in millimeters and separated by the sign 'x'. For example, *Sq* 30 x 6 It indicates single-start square threads with 30mm nominal diameter and 6mm pitch. Similarly single-start I.S.O metric trapezoidal threads are designated by letters '*Tr*' followed by the nominal diameter and the pitch expressed in millimeters and separated by the sign 'x'. For example, *Tr* 40x7 It indicates single-start trapezoidal threads with 40mm nominal diameter and 7mm pitch.

3.5.1 Multiple Threaded Power Screws

Multiple threaded power screws as shown in Fig 3.4 are used in certain applications where higher travelling speed is required. They are also called multiple start screws such as doublestart or triple-start screws. These screws have two or more threads cut side by side, around the rod.

III PARTS OF THE HYDRAULIC PAPER CUTTING MACHINE

The main parts of our Cutting machine

1. A – Stand
2. Main frame
3. Slider
4. Supporting frame
5. Bed
6. Hydraulic cylinder
7. Piston
8. Piston rod
9. Cylinder barrel
10. Mechanical screw tight
11. Mechanical arm
12. Power pack

3.1a-Stand

TheA–stand which bears the total weight of the machine. The components are placed above the A – Stand. The material used in this stand is cast iron. It looks like 'A' so it is called as A-stand. Most of the A-stands are used in the various heavy machines.

3.2 Main Frame

Main frame will be supporting all the mechanical components and the mechanical screw tight and sliding knife. It is made up of cast iron. It is supported by the A - Stand

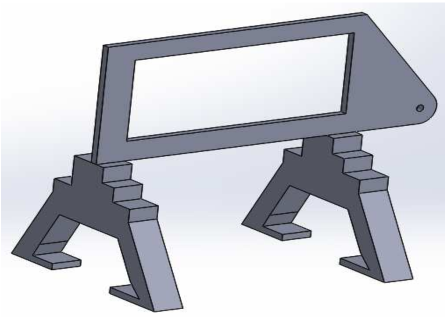


Fig no.4 Main frame

Part dimensions

1. Inner length – 1066.8mm
2. Outer length – 1346.2mm
3. Thickness – 200mm
4. Height – 711mm

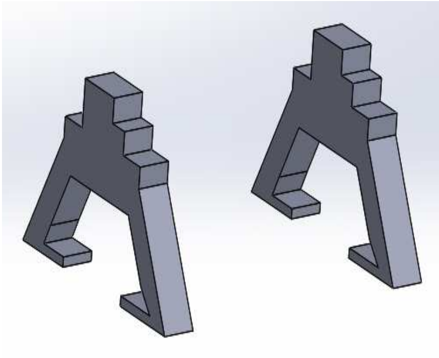


Fig no.2 A stand

Part Dimensions

1. Trapezium height – 597mm
2. Trapezium long length – 640mm
3. Trapezium short length – 300mm
4. Trapezium thickness – 127mm

3.3 Slider

It slides in between the supporting frame and main frame. And the total load is applied on the sliding part only. The knife is fixed in this part only. This is made up of cast iron. The slider is fixed with the hydraulic ram and at the top of the slider a shaft is placed in which the hydraulic arm is connected.

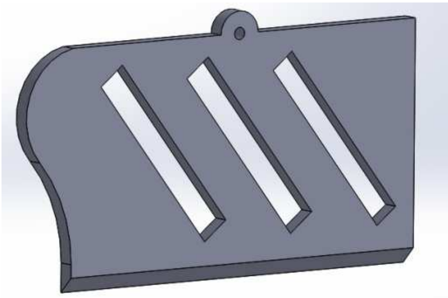


Fig no.5 slider

Part dimensions

1. Length – 1270mm
2. Height – 477.5mm
3. Thickness – 45.7mm

3.4 Supporting Frame

It holds the sliding part with main frame and it stands with the help of A-stand. It is made up of cast iron. It supports the slider with the help of bolt and nut.

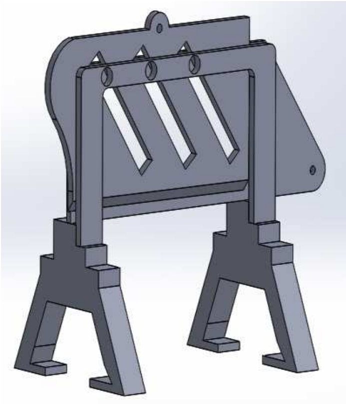


Fig no.6 supporting frame

Part dimensions

1. Inner length – 1079.5mm
2. Outer length – 1328mm
3. Thickness – 122mm
4. Height – 533mm

3.5 BED

It is a cast iron body. And the paper is placed on the bed only and the bed supported by the main frame. And there will be a stand at the end of the bed to support the bed. The can be adjusted to its cutting dimensions using bed.

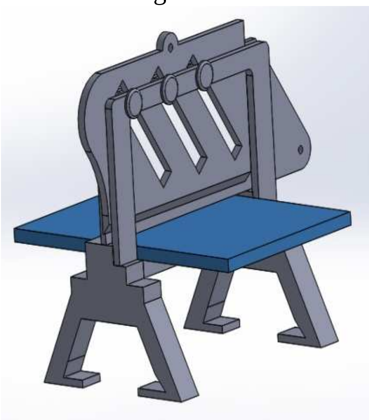


Fig no.7 Bed

Part dimensions

1. Bed length – 1066.8mm
2. Bed height – 1670mm
3. Bed thickness – 127mm

3.6 Mechanical Screw Tight

The bunch of papers is tightly hold by the mechanical press. It will prevent the paper not to move while the paper is getting sheared.

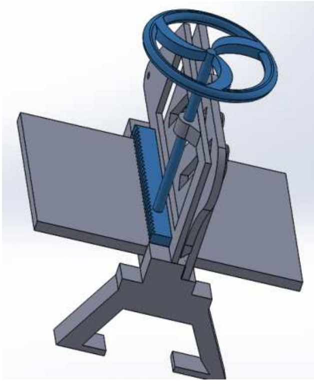


Fig no.8 Mechanical screw tight

Part dimensions

1. Inner diameter of the wheel – 482mm
2. Outer diameter of the wheel – 533mm
3. Height – 660mm

3.7 Mechanical Arm

The arm which makes the sliding part to slide and it is a solid shaft. One end of the shaft is fixed to top of the sliding part and the other end is fixed with shaft.

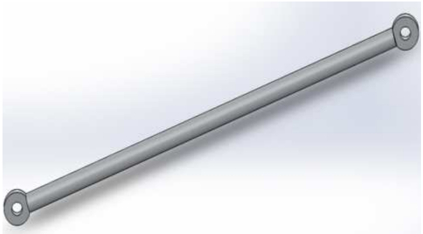


Fig no.9 Mechanical arm

Part dimensions

1. Arm length – 1800mm
2. Arm diameter – 180mm

3.8 Hydraulic Arm

The stroke length of the piston rod is 180mm. The cylinder which is used here is the double acting cylinder. The arm is connected to the cylinder is the screw type.

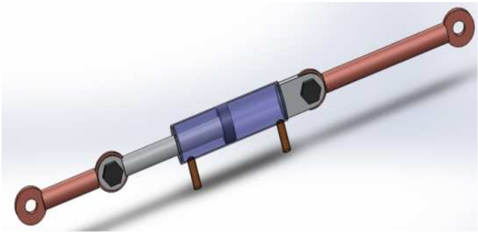


Fig no.10 Hydraulic arm

3.9 Blade

The material of the blade is High carbon steel. It is sharp in nature which shear the bunch of papers. It is attached to the sliding part pf our machine.

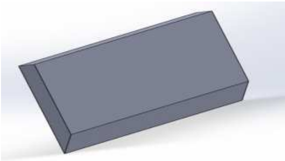


Fig no.11 blade

Part dimensions

1. Thickness (top edge) – 10mm
2. Thickness (bottom edge) – 0.1mm
3. Blade length – 1270mm
4. Blade height – 125mm

3.10 Hydraulic Cylinder

Our hydraulic cylinder is placed in between the rams. We are using two hydraulic cylinders for two rams and the stroke of our hydraulic cylinders slides the blade to shear the paper. It

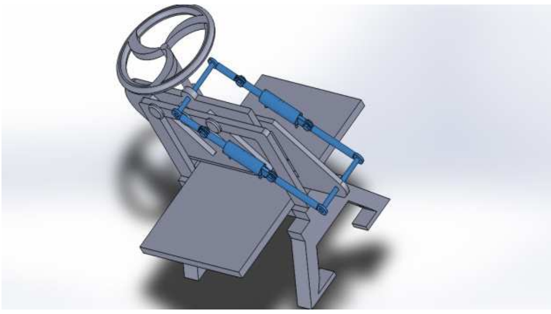


Fig no.12 Hydraulic cylinder

Part dimensions

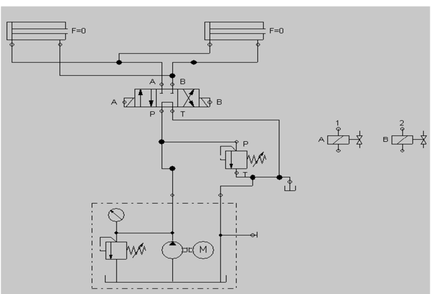
1. Cylinder bore – 100mm
2. Piston rod – 50mm
3. Piston rod length – 180mm
4. Piston material – EN8

4.6 Calculation For Paper 100 Gsm

Height of the 500 sheets = 50mm
Clearance between blade and bed = 110mm

The clearance of the blade and bed is 110mm. so we can load the paper on the bed for cut up to 100mm.

Because the travel load of the blade must be free to cut the paper. So we need certain height between blade and paper. So here we kept the 10mm clearance.



Loading height = 100mm
height of the 100 gsm paper of 500 sheets = 50mm
so, 500 × 2 = 1000 sheets
height of 1000 sheets = 50 × 2 = 100 mm
we can load 100gsm paper of 1000 sheets for one time cut.The cutting blade cuts 100gsm paper of 1000 sheets at the length of 1066.8mm in a single cut. So the design is safe.

M is the motor which pumps the hydraulic oil in uni-directional.

- We use 4/2 d.c valve which is operated by solenoid valves.
- Solenoid valves are energized by push button switches.
- We use two double acting cylinders to operate of our machine.

1ST PRINCIPLE STRESS

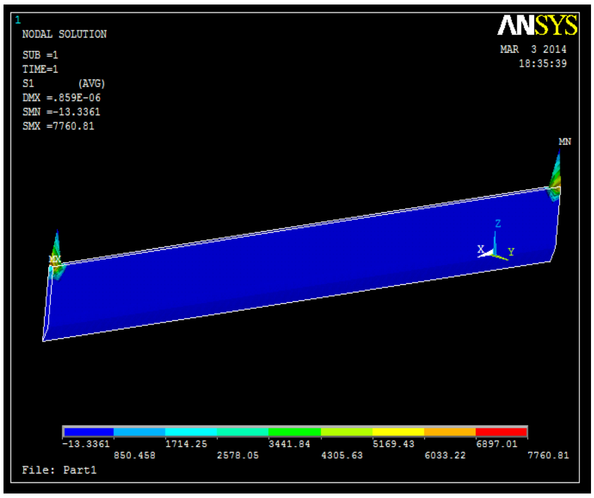


Fig no.32 1st principle stress

DISPLACEMENT STRESS

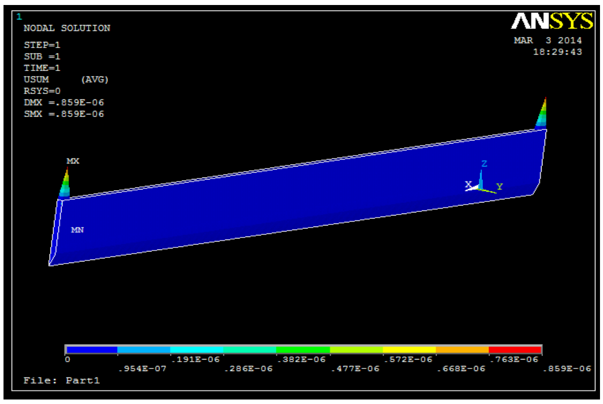


Fig no.33Displacement stress

VON MESIS STRESS

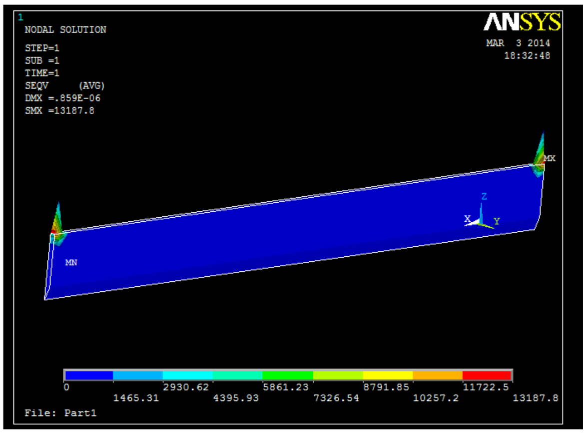


Fig no.34Von mesis stress

IV. CONCLUSION

PRXY = 0.29

EX = 210GPa

We assumed that the above values mentioned in the analysis of blade to calculate the stress. The load we given to the blade is 5 ton and there is no displacement or stress occurred in the blade.

V. ADVANTAGE

- When compare to mechanical paper cutting machine, in this no damage will be occur.
- Production will be increased.
- The maintenance of the machine is low.
- It is more efficient than the hydraulic paper cutting machine.
- In this machine there will be no damages will be occur often like the mechanical cutting machine.
- We can stop the process of cutting at any situation and we can proceed the process from that point.
- Safety measurement is high when compared to mechanical paper cutting machine.

VI. CONCLUSION

This project aims at the development of the cutting process through the hydraulic system to overcome the mechanical cutting machine which is get damaged due to the high maintenance like gear wheels, flywheel, shafts, engagement and disengagement of clutches. To overcome this we implemented the new hydraulic paper cutting machine which is low maintenance, low manual work and more efficient. The study is expected to come up with the development of hydraulic paper cutting machine. A literature review is provided in the following chapters in order to present the research undertaken on this topic to date, and demonstrate what further research is required on this issue.

FUTURE SCOPE

This prototype of hydraulic paper cutting machine must be developed to large scale paper board industries by increasing the maximum efficiency of this cutting machine. The pump of the hydraulic press must be designed gear pump with the power pack.

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