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Comparing Mathematical Model of Scissors Jack Analytically and by Using CAE Tools

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ABSTRACT
A scissors jack is a device used for the maintenance purpose and for changing the flat tyre. It is a jack in which rotatory motion is converted into a reciprocating motion .in this paper we have calculated the designing criteria of various components of scissors jack analytically with the help of data book and the calculated analytical model is compared with the result obtained from CAE tools i.e. ANSYS. In this paper we have chosen two different sections of three different materials and our objective of this paper is to select an individual material which can sustain high yield strength and less deformation without any failure.

Keywords: *Scissors jack, Maximum tensile stress, maximum shear stress, total deformation, CATIA, ANSYS*

I. Introduction

A mechanical jack employs 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 used for maximum lifting capacity.Screw type jacks were very common for jeeps and trucks of World War 2. A motor Screw jack has been introduced by using an electric motor in the Screw (A.S.Akinonmi et.al, 2012.Leonardo, who first demonstrated the use of a screw jack for lifting loads. Mechanical engineer Joseph Whitworth, who found the need for precision had become as important part in industry. The jacks with wedge mechanism had introduced in Nigeria because they eventually not able afford higher price of Jack due to their low standard of living and this jack provide a lift with a self-locking capability for vehicles (Ademola A. Dare and Sunday A. Oke, 2008). The design is based on 3D software Pro/E with 8m high scissors lift platform. The platform is designed to save more space for efficient storage (TianHongyu et.al, 2014). The first idea of using a screw as a machine element was given by Archimedes with his device used for pumping water. Another paper published under the influence of key factors and to provide design components to work safely (R. Zhang, 2011).In the next 20 years the Duff Manufacturing Company was the largest manufacturer of lifting jacks in the world.

Next 20 years the Duff Manufacturing Company was the leading manufacturer of lifting jacks in the world. In 1930, the First worm gear screw jack that is instantly recognizable was found. In Toggle jack different pairs of screw and nut have used to get induce stresses within the safe limit under the loading condition (Prof. N. R. Patel et. al, 2013). With the ability to linked mechanically and driven by either air or electric motors. A new design with a new methodology was made to give a new design that can produce greater capacity within the economic range (Vishesh Ranglani et.al, 2014). Today, scissors jacks can be linked mechanically and also electronically. The new type of jack which is operated by using the power of car battery was introduced by G. S. Udgirkar et.al, 2014. A screw jack which uses motor is now referred to as a linear actuator which is essentially still a screw jack. Study of Various failures occurred in the jacks due to Different stresses induced in the jack was published by C.S.Dhamak et.al, 2015.

The calculation made in this paper is used to reduce the failure occurred during operation using two different sections of three different materials and comparing which is best suited material which is chosen for this paper without affecting its strength The Mathematical model solved analytically is presented in my previous paper entitled "Designing and calculating the stresses induced in the scissors jack for three different materials" IJSTR vol-5 issue 7 in july 2016.

II. Necessity of jack

In repair and maintenance of automobiles it is necessary to raise an automobile to change a tire or access the underside of the automobile. A variety of jacks have been used for lifting an automobile from a ground surface. Available car jacks are typically manually operated and therefore require substantial laborious physical effort on the part of the user.

Available jacks are typically large and difficult to store, transport, carry or move into the proper position under an automobile. Existing jacks are generally not adapted to be readily disassembled and stored after automobile repairs have been completed.

In light of such inherent disadvantages, commercial automobile repair and service stations are commonly equipped with large and hi-tech car lift, where in such lifts are raised and lowered via electrically-powered systems.

Engineering is about making things easy and cost effective. Such electrical powered portable jacks not only remove the hazardous task of lifting an automobile but further decrease the time needed to repair the automobile. Such a feature can be especially advantageous when it is necessary to repair an automobile on the side of a roadway.There are many reports registered on car jacks which lead to a serious number of accidents.

A specified jack purposed to hold up to 1000 kilograms, but tests undertaken has revealed that it fails to work after lifting certain kilograms and may physically break when it has a weight close to its 1000 kilograms capacity. Tests have proven that the jack has the property to buckle well under the weight when it is in static condition.

III. Problem Formulation

As we know that jacks used for maintenance in service station is very heavy and due to this many accident had been taken due to Failure of scissors Jack. A number of accidents such as severe injury and death were cause due to manufacturing defects and poor machinability, chosen of poor materials and impurities present in it. It can also be done due to bad working conditions and mistakes done by user. By using the internet we found that 60% of the accidents were taken place by using poor grade of material. Available jacks have difficulties for elderly people especially disadvantageous under adverse conditions. 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 to move into proper positions under an automobile. The cost of jack is much that a common man can't afford this. The significance of this is paper is to choose the best grade of material without affecting its strength and to reduce its chances of failure.

IV. Objectives

A- To design a power scissor jack which is safe and reliable to raise and lower the load easily with the help of CATIA a designing software CAE tool.

B- To reduce weight of scissor jack with good strength.

C- To calculate and compare the strength to weight ratio of three different material which we have taken.

D- To calculate the stresses like Maximum principal stress, maximum shear stress, bending stress, torsion shear stress, Crushing stress induced in scissors jack and comparing it with the analysis done using ANSYS software, so that we can replace the existing material used in the manufacturing of scissors jack with the material used by us.

E-To reduce the weight with high strength (Load carrying capacity).For that we have taken three different materials and by using two different sections (box section and C-section) of the members (Top and Bottom arm) used in designing the jack .

V. Methodology

Here we divide the completion of various aspects for this paper. The schedule is set so that the project is completed in phases.

Phase I

In phase 1 we have make market research with the help of internet and contacting various scissors jack manufacturing firms. With the study made by us we concluded the cost of the scissors jack increases with increase in its load carrying capacity and secondly that various number of accidents was happen due to failure of the scissors jack at various points.

Phase II
It consists of the design process Firstly I have selected the reference scissors jack on which we have to make my studies so for this I have selected a scissors jack of Mahindra Bolero as a base for my project and after that we have started measuring all the dimensions of all the members of scissors jack and after that we started calculating designing steps for various members of scissors jack of three different materials (ASTM A36 Mild Steel, A1045 Grade Steel, and GS 52.3 Cast Steel) that we have taken in this project while modeling a scissors jack.

Phase III
It entails CATIA modeling of the scissors jack and Analysis in ANSYS software. At first I have joined CADD CENTRE for duration of six month to study modeling software CATIA and analysis software ANSYS .After that I have started modeling of various members of scissors jack with the help of dimensions of Mahindra bolero's scissors jack measured by me and by modeling all the members of scissors jack I have started analyzing all the members of scissors jack through ANSYS software.

Phase IV
In this phase the calculated stresses induced in all the members of scissors jack is compared it with the result made by the ANSYS software. The calculated result must be more than the result made by software.

VI. Result and Conclusion

On comparing the mathematical model of scissors jack analytically and by software .we found that the value of different stresses induced in two sections of three different material were less in software model as comparison two analytically solved mathematical model, but the value of ASTM A36 mild steel will be more equivalent for designing and modelling scissors jack on the basis of its load sustain capability and minimum deformation without causing any type of failure.

Table. 1
Results of Mathematical model calculated analytically

S.No	Channel Section			Hollow Box Section		
	Max.tensile Stress [MPa]	Max.Shear Stress [MPa]	Bearing Stress [N/mm2]	Max.tensile Stress [MPa]	Max.Shear Stress [MPa]	Bearing Stress [N/mm2]
ASTM A36 MILD STEEL	102.1	62.7	6.5	87.6	48.3	4.1
AISI 1045 GRADE STEEL	98.4	53.8	6.8	78.3	46.7	4.9
GS 52.3 CAST STEEL	93.3	52.4	7.8	82.7	43.4	5.8

Table.2
Results of Mathematical Model Solved by Software

S.No	Channel Section			Hollow Box Section		
	Von-mises Stress [MPa]	Equivalent elastic strain [mm/mm]	Total Deformation [mm]	Von-mises Stress [MPa]	Equivalent elastic strain [mm/mm]	Total Deformation [mm]
ASTM A36 MILD STEEL	11.48	6.89x 10-5	.007	9.85	5.36x 10-5	.0062
AISI 1045GRADE STEEL	10.34	4.50x10-5	.005	7.63	3.69x 10-5	.0053
GS 52.3 CAST STEEL	9.89	1.53x10-5	.001	8.58	1.08x 10-5	.0026

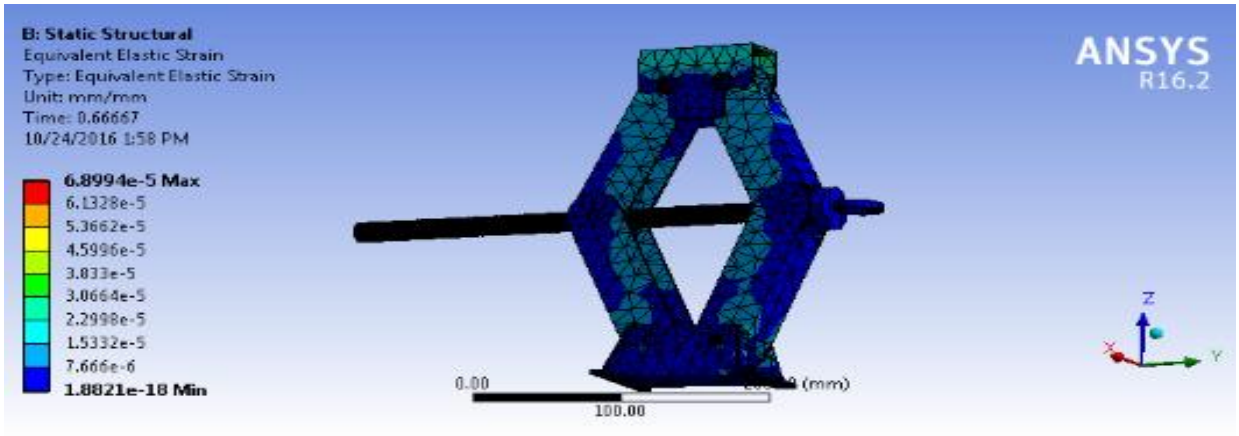

Figure1. Equivalent elastic strain

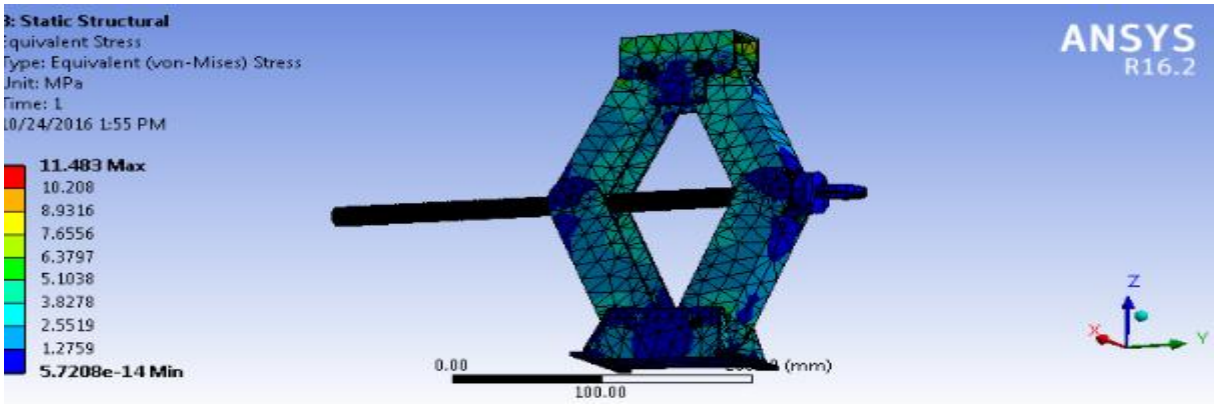

Figure2.Von–mises Stress

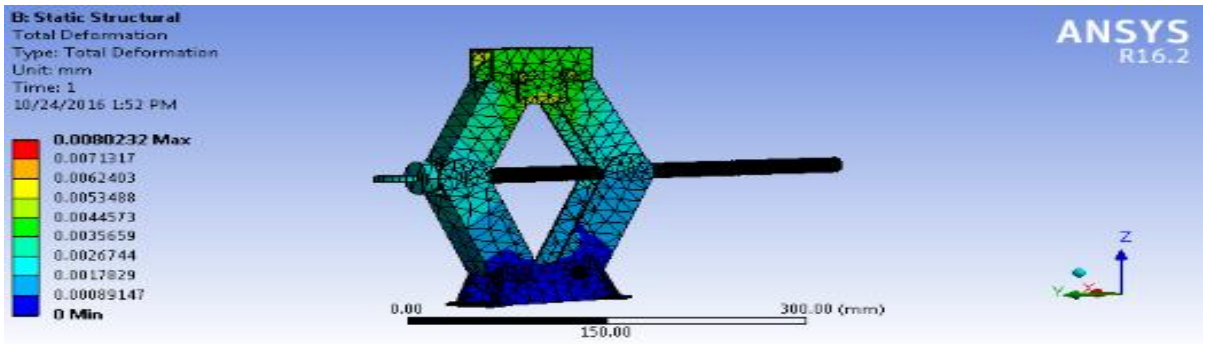

Figure3. Total deformation

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VIII. Scope for future work

As a development of the scissor jack with high strength to weight ratio there is less chance of failure of power screw which may causes injury to the user. The top and base plates can be made foldable to make the unit more compact. Permanently mounted jacks on the vehicle can be developed so that tire change can be completely easily and do not cause any injuries during the maintenance process.

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