INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

Mechanical and Industrial Engineering Department

MIN 291-Engineering Analysis and Design

Group Project

Scissors Jack

by Group 25

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“Simplicity is the best sophistication”

An engineering product’s design typically deals with aspects involving cost effectiveness, manufacturing, versatility in application, maintenance of aesthetics, meeting of needs, deliverance, and service life against failure.

ABSTRACT

In the following document, keeping in mind the parameters of engineering design, we have attempted to design and analyse the scissors jack model for real life applications in the locomotive vehicle industry, for varying models of automobiles. We, just like the automobile sector, are interested in reducing the cost and increasing the productivity, by introducing certain changes in the pre-existing models. We have made use of softwares such as SolidWorks, ANSYS and techniques of Finite Element Analysis for the same.

INTRODUCTION

Out of all the varieties of traditional jacks present, we have chosen the designing of scissors jack for the locomotive vehicles.

HISTORICAL BACKGROUND

The first ever patent received on the name scissor jack was of joseph lafrance. The main objective behind this invention was to make a device that will be strong, easily operated and simple and cheap to construct. The model was also able to eliminate the ratchet and toothed racks in the jack. Later on many modifications were made and many new patents were received for these advancements.
Learning from the past, we have focused on removing permanent welds, which happen to be the most vulnerable to failure.
cxPatent no:(Us3614065)-
Objective of this invention was
1. to produce a scissors-type screw-operated lift jack having a secondary upper link arrangement which is attached to the upper ends of the primary lower links
2. which has a substantial extended height capacity and an extremely shortened and compact package in the retracted position for storage in the trunk of a motor vehicle.
Patent no:(Us3684243)-
This model of the screw jack was able to overcome the limited degree of extension unless long linkage dimensions are employed,it had a low retracted height and the structure was similar to the above mentioned patent. US3741524-
Objectives

a lower link assembly, an intermediate link assembly and an upper link assembly, all of which cooperate with each other and with a screw assembly for driving a load lifting element between a lowered or load releasing position and a raised or load lifting position.
US6695289B1-
Objectives
1. to provide a motorized Scissor jack for automobiles that can be used during inclement weather.
2. connectable to a vehicular or Standard alternating current power Source
3. a two Speed motor configured for providing a slow and a rapid lift capability
US 20090200527A1
This model of the screw jack was designed to overcome the following problems:
1. Where jacks are used in off-road conditions they are often Subjected to more severe mechanical stresses. These can increase the chance of component structural failure. The problems with inefficient lifting and mechanical failure are emphasized where heavier vehicles need to be lifted
2. A relatively large amount of force is required to lift a load with these jacks or, alternatively, the lifting rate is made slower so that less force is required.
Some of the features of the above jack are:
1. The scissor jack has a brace that includes a guide which slidably engages the shaft and connectors pivoted between the guide and each of the four arms. The connectors are extensible
each connector includes a spring which is compressed on extension of the jack.each connector is a socket and rod arrangement with a coil spring located over the rod in the socket
us Us7988131
1. The ideal embodiment uses a cigar lighter plug of an auto to power the apparatus, however, converters for wall outlet power are optionally provided. The motor is in communication with the Scissor jack via the gear reduction member so that maximum torque is applied to the Scissor jack
2. the fail-safe coupling between the gear reduction drive and the Scissor jack ensures against
excessive or premature wear, failure, and danger to an operator .
US8740191B2-
Objectives
1. a scissors-type jack assembly connected to upper and lower platforms includes guide members and thrust bearings/rollers, which provide improved stability across a longer stroke than previous laboratory jacks
2. Guide rods, carried by cross brace members, are disposed between the ends of each upper and lower arm.

OBJECTIVES

The objective of

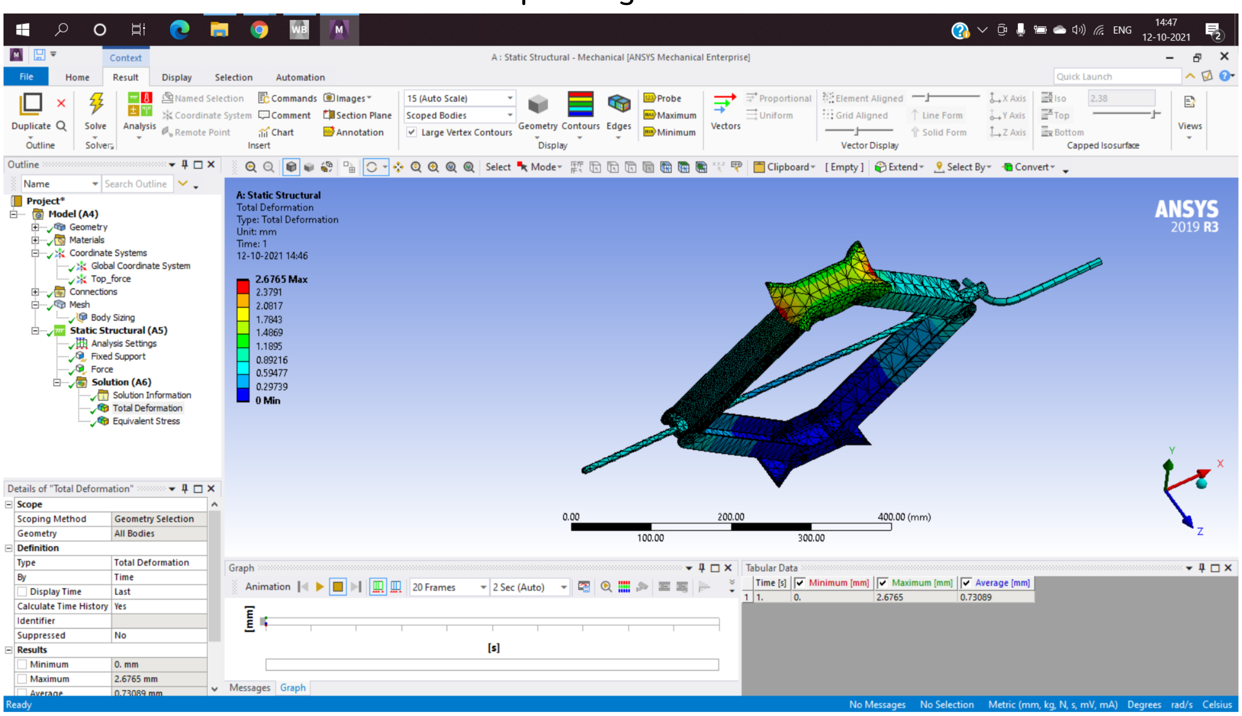
SOLID MODELLING

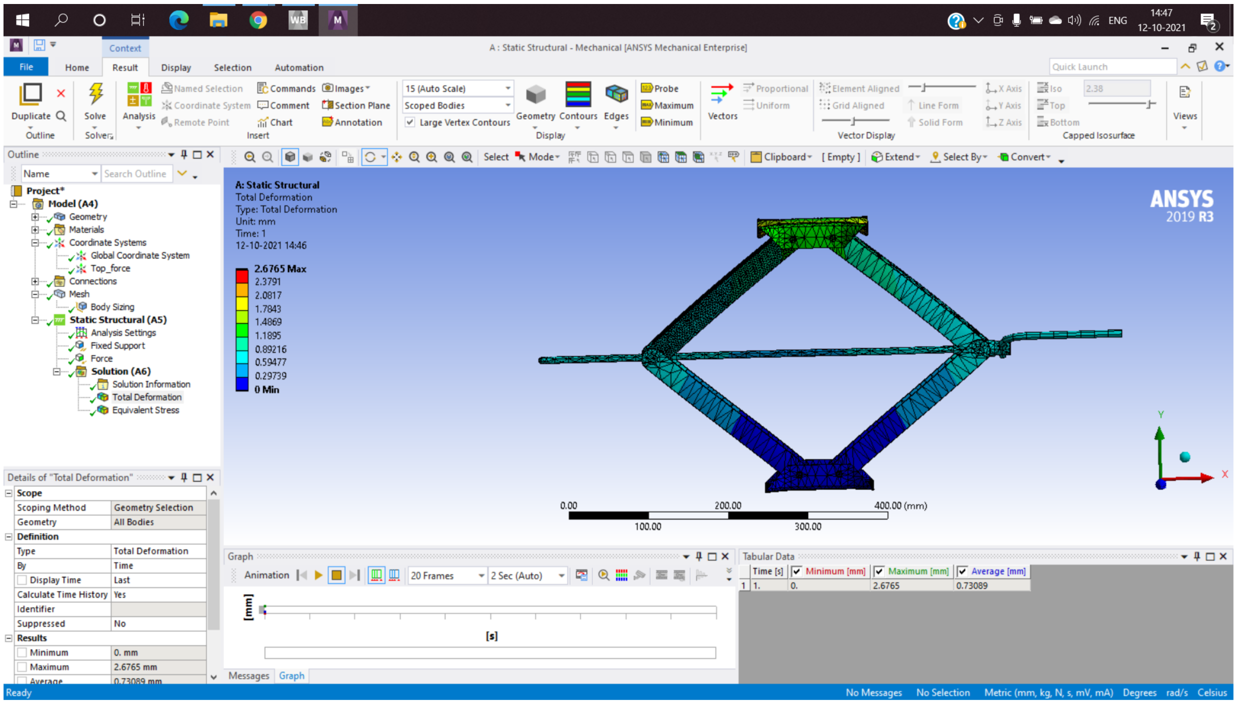
Software used:

DESIGN DETAILS:

- Material used:
- Total maximum height of the screw jack= 425 mm
- Total minimum height of the screw jack= 88 mm approx.
- Total mass of the jack=
- Total width in x direction, when height is maximum= 385 mm
- Total width in x direction, when height is minimum= 580 mm
- Screw length along x= 580 mm
- Deformation in y direction=
- Permanent set in y direction=

<sample images inserted>





FINITE ELEMENT ANALYSIS

The

MESH DEPENDENCY

FAILURE ANALYSIS

A study shows that it is the shear strain energy rather than shear stress which is the main culprit behind yielding of ductile materials. Hence, we have made use of Von Mises Failure Criterion, also known as maximum distortion energy theory, shear strain energy theory or octahedral shear stress theory, for failure analysis.

According to Von Mises's theory, yielding will occur when shear strain energy or distortion energy of unit volume will exceed the shear strain energy of the same volume subjected to uni-axial stress by yield strength. The equation of total strain energy is given as:

$$U_\sigma = U_V + U_D$$

Where U_σ -->Total Strain energy

U_V -->Volumetric Strain energy

U_D -->Pure Shear Strain energy

$$U_\sigma = \{ (\sigma_1^2 + \sigma_2^2 + \sigma_3^2) - 2\nu (\sigma_1 \sigma_2 + \sigma_2 \sigma_3 + \sigma_3 \sigma_1) \} / 2E$$

To obtain pure shear energy from this equation, we substitute the value of volumetric strain energy:

$$U_V = 3\, \sigma_{avrg}^2\ (1 - 2\nu) / 2E$$

Where $\sigma_{avrg} = (\sigma_1 + \sigma_2 + \sigma_3) / 3$

Thus, $U_D = U_\sigma - U_V \Rightarrow U_D = (1 + \nu) \{ (\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2 \} / 6E$

For Von Mises Criteria to be met, $U_D \le U_{Distortion}$, at $\sigma_1 = S_y$ (yield strength at uniaxial tensile strength) and $\sigma_2 = \sigma_3 = 0$

$U_{Distortion} = (1 + \nu)\, \sigma_1^2 / 3E$

MATERIAL SELECTION ANALYSIS

The primary criteria for the selection of material is that it must have high strength so that it can resist high loads without breaking. Metals/Metal alloys satisfy this criteria. As we know, alloying is done to improve over the properties of base metal, therefore, designing our model using metal alloys is a wise decision.
Based on these constraints, steel alloys, aluminium alloys, copper alloys and non-ferrous alloys are studied for the purpose. After thorough evaluation, the following alloys have been sorted for comparative study based on their mechanical properties and cost :
Structural steel, Aluminium alloy 6061-T6, Aluminium alloy A356.0-T6 and Brass.
Cost (per kg):
Brass (Rs 300-315) > Aluminium alloy 6061-T6 (Rs 275) > Aluminium alloy A356.0-T6 (Rs 158) > Structural steel (Rs 90).
Mechanical properties:
Mass density d, weight density w, modulus of elasticity E, shear modulus of elasticity G and Poisson's ratio v.

1. Structural steel: d= 7850 kg/m^3, w= 77 kN/m^3, E= 190-210 GPa, G= 75-80 GPa, v= 0.27-0.3
2. Aluminium alloy 6061-T6: d= 2700 kg/m^3, w= 26 kN/m^3, E= 70 GPa, G= 26 GPa, v= 0.33
3. Aluminium alloy A356.0-T6: d= 2670 kg/m^3, w= _kN/m^3, E= 72.4 GPa, G= 27.2 GPa, v= 0.33
4. Brass: d= 8400-8600 kg/m^3, w= 82-85 kN/m^3, E= 96-110 GPa, G= 36-41 GPa, v= 0.34

RESULT

The analysed data of scissor jack's static loading conditions subjected to the point load of _____ kg is shown above.

CONCLUSION

The document describes the

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3. EML4500 Finite Element Analysis and Design (ufl.edu)
4. Theories of failure for ductile materials :Von Mises Criterion (mechguru.com)
5. http://www.matweb.com/search/datasheet_print.aspx?matguid=d524d6bf305c4ce99414cabd1c7ed070
6.

MEMBER CONTRIBUTIONS

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   Historical research, Failure analysis, Documentation, Finite Element Analysis

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   Material Selection, Documentation, Finite Element Analysis

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   Solid modelling, Force Analysis, Meshing Analysis, Finite Element Analysis

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