Design and Fabrication of a Customized Tool for Gearbox Casing

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Abstract- The focus of this work is to design a customized tool, a device for removing gearbox casing a safe and efficient manner and tooling to remove casing. The device includes an elongated hollow housing to place over a shaft on which the casing is seated, the designed puller will be able to dismantle the casing that fixed with tightest fit that is been used. The puller is attached on the casing, torque is applied on the gear shaft and in turn the casing will be removed. During removal of gear shafts from the housing, casing condition and shaft's surface smoothness will be considered as not to make the surface dented. The design of puller is designed in software fusion 360 and analyzed using software Ansys workbench. Finally, a number of recommendations are put forward at the end of this report

1. INTRODUCTION

This work is done as a part of Engineering Curriculum with an objective of knowing the working and the systems that are followed in the practical world. This work gives details of the customized tool we have designed.

Screw type Mechanical jacks were very commonly referred in jeeps and trucks at World War II vintage. For ex., the World War II jeeps (Ford GPW and Willys MB) were introduced with the Jack, Screw type, Capacity 1 1/2-ton, Ordnance part number 41-J-66. In that days, the 41-J-66 jack was carried in the jeep's tool box. Screw type jacks preferred continued for small capacity use due to minimum cost of production for raise or lower the load. It had negligible maintenance.

The concept of using a screw as a machine was first demonstrated by Archimedes in 200BC with his device used for pumping water.

There is also evidence that screws were preferred in the Ancient Roman world. But, in the late 1400s, the Leonardo da Vinci, who first displayed the method of use of a screw jack for lifting the loads. Its design used a threaded worm gear, supported on bearings, which is rotated by the turning of a worm shaft to drive a lifting screw to move the load instantly recognizable as the principle used today.

2. LITERATURE REVIEW

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) were issued the "Jack, Automobile, Screw type, Capacity 1 1/2 ton", Ordnance part number 41-J-66. This jacks, and similar jacks for trucks, were activated by using the lug wrench as a handle for the jack's ratchet action to of the jack. The 41-J-66 jack was carried in the jeep's tool compartment. Screw type jack's continued in use for small capacity requirements due to low cost of production raise or lower it.

There is evidence of the use of screws in the Ancient Roman world but it was the great Leonardo da Vinci, in the late 1400s, who first demonstrated the use of a screw jack for lifting loads. Leonardo's design used a threaded worm gear, supported on bearings, that rotated by the turning of a worm shaft to drive a lifting screw to move the load - instantly recognizable as the principle we use today.

It is not until the late 1800s that we have evidence of the product being developed further. With the industrial revolution of the late 18th and 19th centuries came the first use of screws in machine tools, via English inventors such as John Wilkinson and Henry Maudsley The most notable inventor in Mechanical engineering from the early 1800s was undoubtedly the Mechanical genius Joseph Whitworth, who recognized the need for precision had become as important in industry as the provision of power.

Inspired young engineers began to put Whitworth’s machine tools to new uses. During the early 1880s in Coaticook, a 24- year-old inventor named Frank Henry Sleeper designed a lifting jack. Like da Vinci’s jack, it was a technological innovation because it was based on the principle of the ball bearing for supporting a load and transferred rotary motion, through gearing and a screw, into linear motion for moving the load.

The device was efficient, reliable and easy to operate. It was used in the construction of bridges, but mostly by the railroad industry, where it was able to lift locomotives and railway cars. Local Coaticook industrialist, Arthur Osmore Norton, spotted the potential for Sleeper’s design and in 1886 hired the young man and purchased the patent.

Over the next 30 years the Duff Manufacturing Company became the largest manufacturer of lifting jacks in the world, developing many new types of jack for various applications including its own version of the ball bearing screw jack. It was only natural that in 1928, The Duff Manufacturing Company Inc. merged with A.O. Norton to create the Duff-Norton Manufacturing Company.

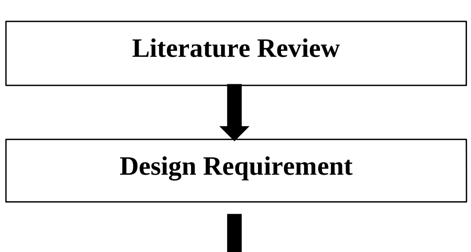
With the ability to be used individually or linked mechanically and driven by either air or electric motors or even manually, the first model had a lifting capacity of 10 tons with raises of 2” or 4”. Since then the product has evolved to push, pull, lift, lower and position loads of anything from a few kilos to hundreds of tones. One of the biggest single screw jacks made to date is a special Power Jacks E-Series unit that is rated for 350 tones –even in earthquake conditions for the nuclear industry. More recent developments have concentrated on improved efficiency and durability, resulting in changes in both lead screw and gearbox design options for screw jacks

The main goal is to design and develop a customized which will not lift loads in the usual way where load is lifted because of the vertical action of the screw which will lift the load directly, instead the load will be lifted indirectly.

when a gearbox is to be removed for servicing its casing is very brittle since it is entirely made of aluminum alloy cast it is very difficult to remove manually hence a customized tool can be used to lift and remove the gearbox casing.

In this design the tool will lift loads indirectly where the load to be lifted in this case a gearbox casing is fastened to the supporting structures of the tool and the threads of the main screw is Left Hand Thread that means it rotates opposite to the regular Right Hand Thread which will in turn tightens which will produce compressive force which in-turn lifts the gearbox casing.

3. METHODOLOGY



3.1 OPERATIONAL CONSIDERATIONS:

Screw jacks are mechanical devices consisting of a heavy bottom metallic base or stand through which a screw mechanism is allowed to slide up and down through a circular path over a central axis. The load that is to be lifted is place dover the top “head" of the screw mechanism. The lifting movement or operation is made functional by applying an external physical force (using human hands) through a radial motion.

A careful inspection of the screw movement (unwinding) through a single thread shows that the elevating movement follows the principle of an inclined plane.

Primarily two major factors are involved with the functioning of a screw jack, viz. the *weight* lifted and the *effort* applied.

Let’s try to understand and derive a relation between the above two parameters responsible for the operation of a screw jack.

3.2 USING THE CONCEPT OF SCREW JACK TO LIFT LOADS

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 uses a simple theory of gears to get its power. As the screw section is turned, two ends of the jack move closer together. Because the gears of the screw are pushing up the arms, the amount of force being applied is multiplied. It takes a very small amount of force to turn the crank handle, yet that action causes the brace arms to slide across and together. As this happens the arms extend upward. The car's gravitational weight is not enough to prevent the jack from opening or to stop the screw from turning, since it is not applying force directly to it.

3.3 DESIGN OF THE MODEL

3.3.1 DESIGN OF SCREW:

Normal diameter = 36mm

Square thread (normal) p = 6mm

$D_i = 30mm$

$D_o = 36mm$

$D_{mean} = 33mm$

$D_c = Do - 1.226869p$

$D_c = 28.64mm$

$\sigma_c = P/A$

$= 50/((\pi/4) * 28.64^2)$

$\sigma_c = 0.00776\ N/mm^2$

Torque required for screw

$T = ((P * D_{mean})/2) * (l + \pi\mu D_{mean})/(\pi D_{mean} - \mu l)$

$T = 300.46\ Nmm$

$\tau = T/((\pi/16) * D_c^3)$

$\tau = 0.0651\ N/mm2$

$\sigma_{1,2} = \sigma_c/2 + 1/2\sqrt{\sigma c^2 + \tau^2}$

$\sigma_{1,2} = 0.0388 \pm 0.0758$

$\sigma_1 = 0.1146$

$\sigma_2 = -0$

$\tau_{max} = 1/2\sqrt{\sigma c^2 + \tau^2}$

$\tau_{max} = 0.0758\ N/mm^2$

Tensile strength

$P = \pi/4 * (D_o^2 - D_i^2)\ \sigma_t$

$50 = \pi/4 * (36^2 - 30^2)\ \sigma_t$

$\sigma_t = 0.1473\ N/mm2$

$A = \pi D * t_1$

$\pi/4 * (36^2 - 30^2) = \pi * 36 * t_1$

$t_1 = 3mm$

$w = A * \tau$

$= \pi D * t_1 * \tau$

$w = 22.41N$

For self-locking

$\mu > tan \lambda$

$tan \lambda$= L/ πD_p

= 6/ $\pi 33$

$tan \lambda$ = 0.057871

λ=3.31°

0.3>0.057871

∴ It is self-locking

3.3.2 PREPARATION OF MODEL:

Body: The 2D draft below shows the dimensions of the body which also acts as the supporting structure of the model

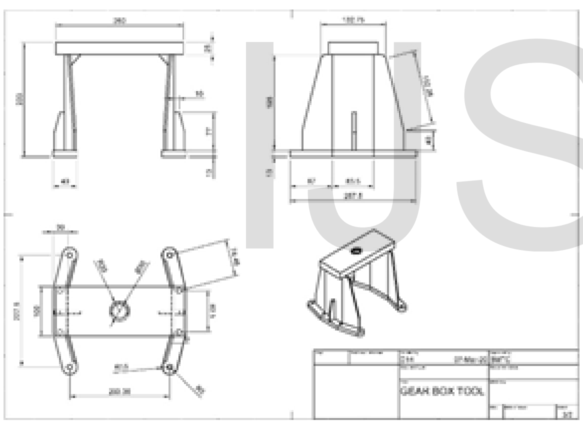


Fig. 1 2D Draft of the Body of the model

Screw: The 2D draft below shows the dimensions of the screw which is the major component which will carry most of the load and due to the action of the screw the load will be lifted.

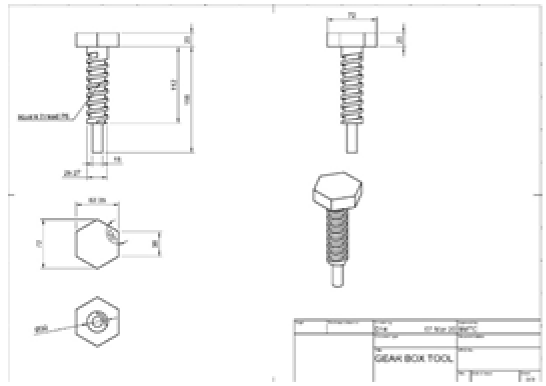


Fig.2 2D Draft of the Screw of the model

Holder: This component is specifically designed to hold the shafts of the gearbox during the lifting action during which it will be coupled to the shafts which in-turn provides support and restricts the motion of the screw which will convert the applied torque to compressive force which will lift the gearbox casing

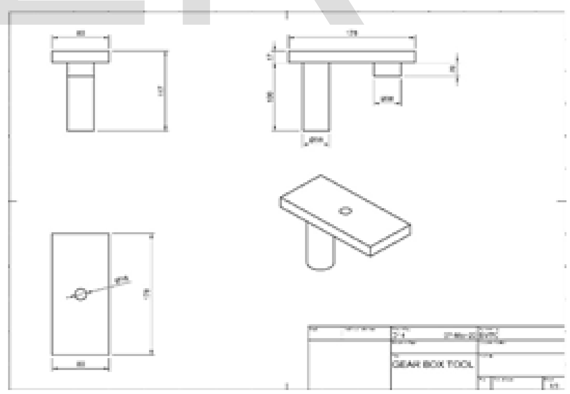


Fig. 3 2D Draft of the Holder of the model

A 3D CAD model of customized tool is developed from the calculations carried out in the previous phase using the software Fusion 360

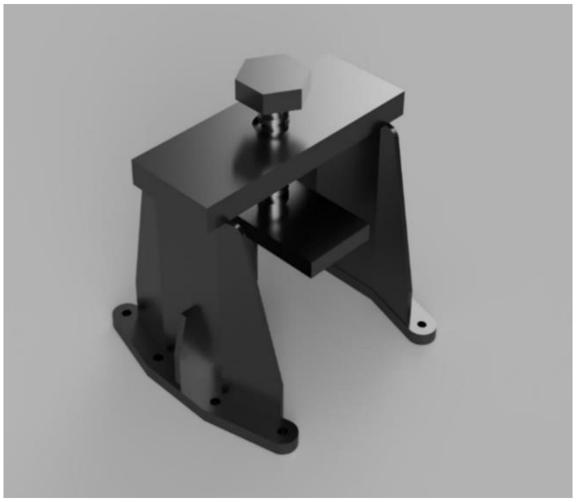


Fig. 4 Isometric view of model

3.3.3ANALYSIS:

Using Ansys workbench software the 3D model geometry is imported to geometry section of the workbench and the model is then checked for any structural errors and it is meshed as shown below

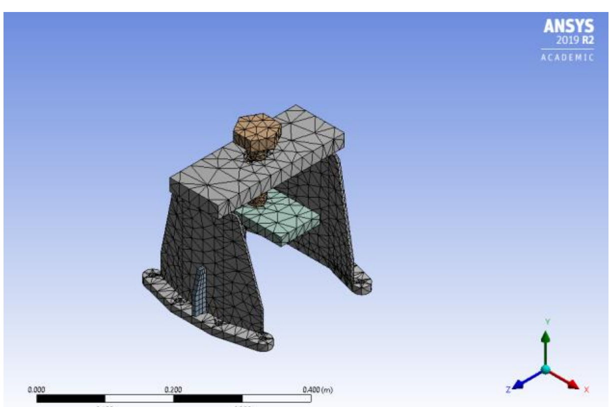
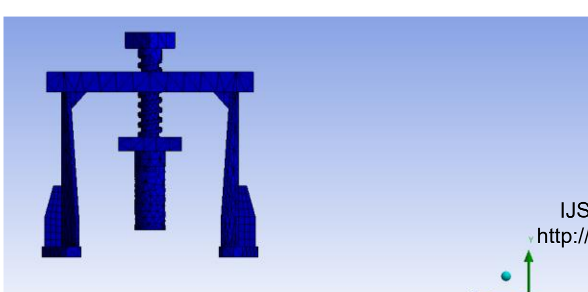


Fig. 5 Isometric view of the meshed 3D model assembly



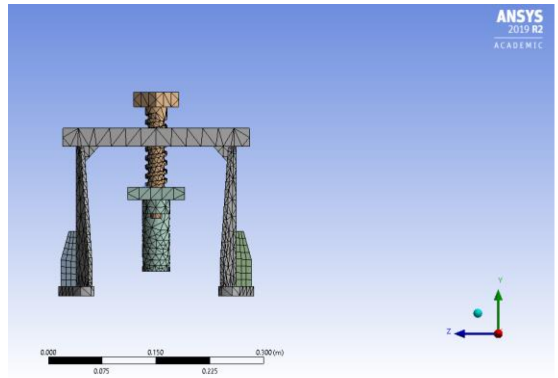


Fig. 6 Front view of the meshed 3D model assembly

After the assembly is meshed the model is subjected to loads as specified below

Screw will be subjected to torque of 3000 rpm, and it is free only in rotational Y direction and constrained in all the other directions.

Body is constrained in all directions except linear Y direction.

Holder will be fixed and constrained in all the directions.

Since the screw cannot freely move down it will put compressive load on the threads which in-turn makes the body to move in linear Y direction.

Thus, this analysis proves that there is no need to conduct structural analysis since the whole assembly will undergo rigid body motion. All the loads will be acting on the screw itself. Hence there is no deformation.

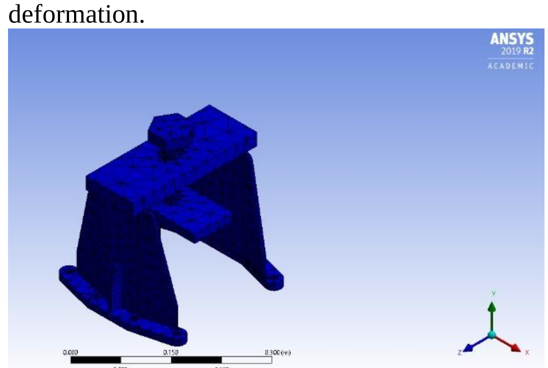


Fig. 7 Isometric view of deformed body

Fig. 8 Front view of deformed body

4. FABRICATION PROCESS

- MATERIAL SELECTION AND CUTTING
- DRILLING
- WELDING
- THREAD CUTTING

5. CONCLUSION:

The objectives of this work are achieved the geometric model and 3D CAD model is created by using CAD software, FUSION 360.

All the parts are assembled and the model is tested on the gearbox to remove the casing and the model works as intended in this work.

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