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Design and Fabrication of Low Cost Four Wheeler Nut Runner

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Abstract: *Tyre failure is a common phenomenon in all types of two or four wheelers. In case of four wheelers removal of the damaged tyre from the wheel for replacement with a new one is a tedious process and time consuming. Varieties of tools are available in market for this purpose. However, they are either expensive or work with some sort of power. This paper aims at designing and fabricating a cost effective gadget for removal and tightening the wheel nuts of a car with minimum mechanical effort. The gadget is tested on a mostly used car and found suitable for field applications*

Key Words: *Spur gears, planetary gears, module, pinion, shaft, pcd, nut remover and tightner,*

I. Introduction

Transportation is one of the important needs in day-to-day life, among which car usage plays an important role. However, most of the times an individual faces problem with tyre punctures that require its removal from the vehicle for replacement. This is done with the help of a simple or standard cross wrench that is supplied by the car manufacturer. They are provided with heads having slots of different sizes to suit the type of nut to be handled. It is also required to lift the body of the car slightly above the ground using a jack to enable free removal of the tyre from the wheel. All the four nuts at the periphery of the wheel need to be removed one-by-one and re-fixed. This makes the entire process laborious and time consuming.

The above problem has been addressed by various automobile manufacturing units by designing and developing pneumatic power driven tools [1] that are being used at the servicing centers. Impact wrench is another version of such tools works with a compressor and power source. An air hose line is required to connect the compressor to the impact wrench for providing much larger torque as compared to traditional methods. It also requires proper lubrication for the bearing to minimize wear and tear effects. Thus the system requires a proper maintenance and is not suitable for general applications.

A special tool, 'VAWNR' has been designed and fabricated for removing all the four wheel nuts simultaneously with little energy consumption and time consuming[2]. Tests have been carried out by means of both mechanical lever and impact type wrenches on a standard pcd of 100 mm. The mechanical lever type was found to be less time consuming and effort. The present work aims at improving the design and fabrication methodologies involved in this approach that will make it more efficient and user friendly

II. Methodology

It has been proposed to design a simple tool for the purpose of removing and tightening the four nuts used to hold the tyre of a four wheeler on to the wheel, fabricate and test for its applicability in real sense. Some of the critical components have been fabricated in-house employing readily available materials. Proper care has been exercised in the process so that the required accuracies were met and their assembly results in a perfect gadget as proposed.

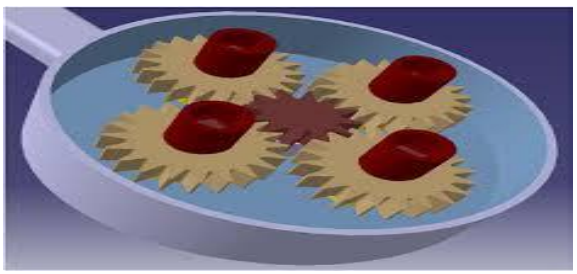

Fig-1 Schematic view of the wheel nut runner

2.1 Components And Materials Used

Major components used in this tool development are gears, shafts, bottom plate, bearings, keys, flat/spring washers and wrench socket. Gears are arranged in planetary mode (Fig. 1) so that motion of driver gear gets transferred to the driven gears. They are made of grey cast iron. The driver gear is driven by means of a lever mechanism (Fig. 2). Shafts are used to transfer torque from gears to the wrench. Bottom plate of mild steel is used to hold the gear assembly tight withstanding various forces acting on the system. Bearings are essential to reduce frictional losses. Flat washers made of medium carbon and spring washers of stainless steel are used for proper positioning of wrench sockets and gears in the system

2.2 Design Philosophy

The tool is designed as a small box housing five gears arranged in a planetary gear system. All the gears are spur gears in nature. The driver gear is positioned at the centre of the system and meshed properly with the other four driven gears. The shaft attached to the central drive gear is subjected to torque by physically operating a lever attached to it in the assembly drawing (Fig. 1). This in turn rotates the drive gear and the driven gears as well simultaneously, in the required direction. As the shafts attached to driven gears also rotate, they deliver power for removing or tightening the nuts. The tightening or loosening of nuts is done by positioning the sockets fixed in the heads of all the four shafts of driven gears.

Design of the tool was based on a most commonly used 100mm pcd in most of the cars of Indian make. Diameters of the gear (D_g) and the pinion (D_p) have been calculated and selected for suiting this configuration. Diameters of 48mm and 52mm were found suitable for the gear and pinion respectively. Respective tooth dimensions for gear and pinion were found to be 24mm and 26mm.

The module for this combination has been calculated according to the formula,

$$\text{Module, } M = (D_p/T_p)$$

Where, 'M' represents the module, 'T_p' and 'D_p' the teeth and diameters of pinion. This resultant of module value is 2.

With the above values the total diameter 'D' of the tool was found to be 100mm according the expression

$$\text{Diameter, } D = (M \times T_p + M \times T_g)$$

2.3 Manufacturing Processes

The tool consists of a plate that forms the base for the whole setup. A plate was of 175mm diameter and 15mm thickness of mild steel was machined down to 12mm thickness. Through holes of 42mm diameter with a central distance of 50mm were drilled in a jig boring machine. Radial ball bearings Dia20/42 x 12 mm were fixed tight fit into these holes.

Mild steel rod was turned in a lathe machine for making shafts of 20mm diameter on one side over a length of 50mm and 14.5mm diameter over the rest of 25mm length. Keyways were cut in the shaft with 20mm diameter using a slotting machine to insert rectangular sunk keys of 8mm×4mm dimensions over which the gears were tightly fixed. Provision for fixing the wrench socket heads was made at the end of the shafts with diameter of 14.5mm.

A hole of 10mm diameter was made in the central shaft for allowing a 70mm long rod to pass through. The rod was used to apply torque and rotate the central gear. This enables the mating gears also to rotate simultaneously.

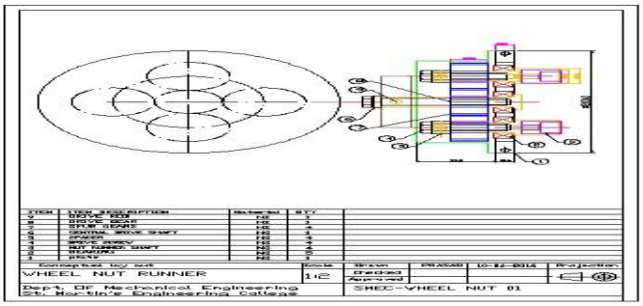

Fig-2- Wheel Nut Runner Assembly Drawing

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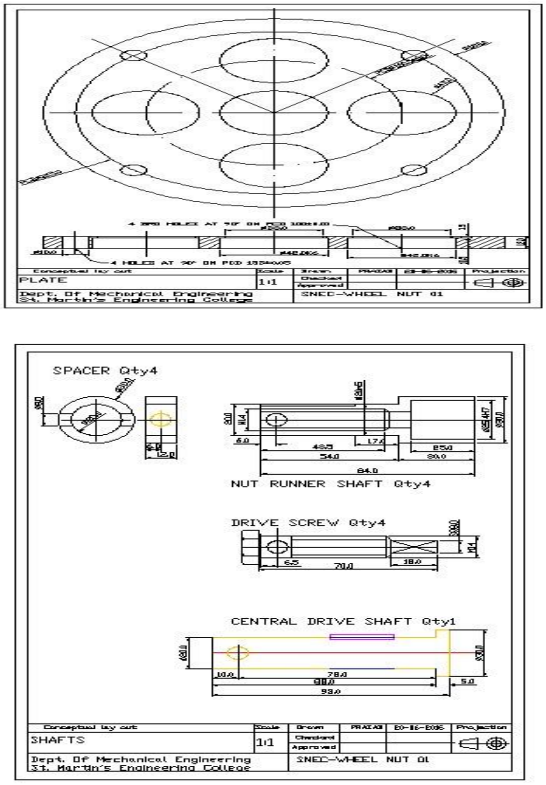

Fig-3- Wheel Nut Runner Part Drawing

Performance of bearing/solid-lubricant systems have been developed (6, 7 and 8). In this way, patented self-contained solid-lubricated all-steel and hybrid-ceramic ball and roller bearings are now available for environments that do not contribute to their lubrication, such as in air or vacuum.

2.4 Assembly

Figure 1 shows the drawing of the overall tool assembly. The planetary gear assembly was mounted on one side of the plate. Shafts were then fixed to the gear assembly one after the other form the other side of the plate

III. Experimental Details, Results And Discussion

The tool was tested on a Swift car of Maruthi Suzuki having PCD of 100mm. Time taken for unclamping and clamping the nuts are recorded.

Figure 3 shows the tool mounted onto the rim of the wheel for removal and re-fixing of the wheel.

Fig-4 Wheel nut runner on testing

Further refinement in the design of the tool will be beneficial to fabricate a light and more efficient gadget in future that would make this a most promising device in open market.
Torsional force applied for different individual strength capabilities:
T = (F x L) Nm,
where F is the force applied (in N) on a lever arm of L (in m)
L = 75 cm = 0.75m `
Assuming T = 140 Nm
F = 140/0.75 = 187 N
Each nut experiences a force of 47 N

Table-1

SNo.	Middle aged	Aged	Female
F	300N	200N	150N
T	225 Nm	150 Nm	113Nm
Tg	51 Nm	34 Nm	26 Nm

3.1 Illustrations:
Assume that a middle aged person can apply a force of 300N
Thus, Torque T = (300*0.75) = 225Nm
The sun and planetary gear system of the tool experiences this much torque.
Thus, T = 225Nm, L = 0.75m, R = 0.92
F applied to each nut will be = (4* 225) / (0.75*0.92) = 1304 N
Gear ratio plays an import role to determine the force require to unscrew the nuts.
As the gear ratio decreases the force required to turn the screw decreases. The relation between the gear ratio and arm length are required for force and torque calculations
Gear Ratio: R = 24/26 = 0-.92
F = 4T/(LR) = (4 x 140) / (0.75 x 0.92) = 811 N
T = FLR/4 = 300x0.75x 0.92 / 4 = 51 Nm

IV. Conclusions

1. The time consuming for removing all the nuts is found to be about 90 seconds that was less as compared to the values reported in other similar devices (about 102 seconds).
2. The torque applied on the tool is about 7N, 10N, and 12N in case of normal middle aged, and aged male persons, and females. In any case it was found to be less as compared to other data reported in literature (about 375 Nm).
3. The tool is cost effective, and involves simple design and fabrication procedures. It does not require any power source for its operation.
4. It is handy, and can be operated by any ordinary person without any physical assistance.
5. Gear ratio plays import role to determine the effort. And different gear combinations can be evaluated

V. Future scope:

1. The tool can be made light weight with composite material, corrosive resistance
2. Automation with pneumatic/hydraulic can be developed

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