Development of Conceptual Vehicle All-Wheel-Nuts Remover

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Abstract – As the standard of living in Malaysia has increased, most of the families have at least one vehicle, typically, car, to move easily and quickly. With the increment of the number of cars in the road, the number of cars' problem due to tyre failure has increased. Often, the car is provided with tyre wheel nuts remover and jack for instance spare tyre replacement. Nevertheless, due to the difficulty in applying the required torque to remove the nuts, most of the time, driver rely on the tow truck and available nearest mechanic to solve the problem. This always happen to the elderly or female drivers. Based on the capability of torque application by these drivers, a vehicle all-wheel-nuts remover is designed. The remover is designed to be ergonomic to be used, easy maintenance, easy storage, easy to handle and able to remove all nuts at once. The design of the remover is based on standard pitch circle diameter (PCD) of 100 mm and 4 numbers of nuts for most of the cars available.

Keywords – All-Wheel-Nuts remover, Torque multiplier, Automotive maintenance kit, Tyre failure.

I. INTRODUCTION

Car is not a symbol of luxurious anymore. It is a need for every family. People need car due to several reasons. Some of them are, to get to a destination, to travel conveniently, to do daily job and to move things to a greater distance. The problem occurs the most during car operation is the problem with tyre puncture [1][2]. The flat tyre needed to be replaced with spare tyre. Therefore, drivers need to know basic knowledge of tyre replacement procedure if such problem occurs. In order to change the flat tyre, one requires minimal skills. Virtually every car has a tyre replacement tools such as the L-shaped nut remover and jack supplied by the manufacturer [3][4].

The tool used to remove the wheel nuts should be designed for ergonomic, easy to handle and requires small space for storage. The tool is also function as wheel nuts tightener. Nonetheless, it is difficult for women and the elderly drivers due to high required torque to remove the wheel nuts. In addition, if the nuts are successfully removed, the problem to retighten the nuts will follow. If the required torque is not applied in tightening the nuts, the nuts will lose, and this will jeopardize the driver's safety.

Impact wrench used to remove wheel nuts is also consuming time in automotive maintenance industry. For these reasons, to avoid time wasting and a lot of energy used to change the tyre, a special tool is designed and fabricated to allow driver or mechanic to remove four wheel nuts at once with little energy consumption. The design is based on standard PCD of 100 mm for most of the cars available [5].

II. METHODOLOGY

The conceptual design of the vehicle all-wheel-nuts remover (VAWNR) tool is performed by commercial computer aided design (CAD) software as shown by Figure 1.
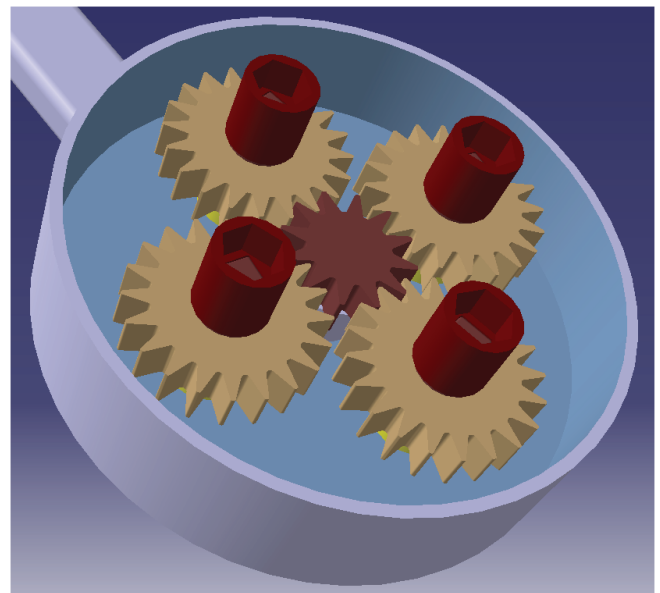

Fig. 1. VAWNR tool conceptual design.

Several static load analyses are also performed in order to find the safety factor of the design. Theoretical calculation analysis is carried out with the purpose of validation. The force required for removing four numbers of nuts is,

$$F = 4\tau / (lR_G) \qquad (1)$$

Where F is the applied force, τ is the torque required to remove one nut, l is the length of level and R_G is the gear ratio of central gear and driven gears of the tool.

In the fabrication of VAWNR tool, two processes are performed; milling and fitting. Since the gears are not available in the market, custom designed gears need precision milling and fitting processes. Once the tool is ready, an experiment is performed with the intention to find the time required to remove the nuts. This result is then compared with the time required using ordinary L-shaped wrench. Experiment using impact wrench is also performed.

III.   ANALYSIS AND RESULTS

The analysis of the VAWNR tool is performed with designated parameters (Table 1). Fig. 2 illustrates the force contour of the central gear from static load analysis.

Table 1. Design parameters.

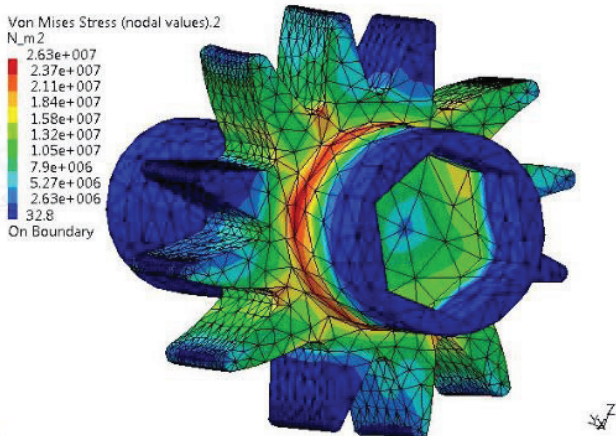| Parameters	Symbol	Value	Unit
Central gear number of teeth	N_C	16	
Driven gears number of teeth	N_D	24	
Applied torque	τ	140	Nm

Fig. 2. Von Mises stress contour analysis.

IV.   FABRICATION

Fig. 3 shows the shape of the gears after milling process. The housings of the tool are made of low carbon steel (Fig. 4). A standard shaft for socket holder is cut and welded on the driven gears (Fig. 5 and 6). Grease is used to reduce wear, tear and heat of friction from mating gears (Fig. 7). Once the tool is assembled, a layer of paint is applied to finish the surface and protect from corrosion (Fig. 8).

Fig. 3. Fabricated gears.

(a)   Base

(b)   Cover

Fig. 4. Tool housings.

Fig. 5. Shaft.

Fig. 6. Joint location for welding.

Fig. 7. Grease application.

Fig. 8. Finish product.

V. EXPERIMENT

Experiments are conducted on the wheel of Proton Wira 1.5 car. An impact wrench is used with the support of 5.5 hp air compressor. The time taken to remove all nuts is recorded. Fig. 9 shows the experiment of removing wheel nut using L-shaped wrench. Fig. 10 shows the application of VAWNR in removing all wheel nuts at once using lever. Impact wrench is used to remove the nut one by one (Fig. 11). Fig. 12 shows impact wrench is used with VAWNR to remove all wheel nuts. The time taken to remove wheel nuts using VAWNR and lever is almost the same as using L-shaped wrench. However, the torque applied is reduced 33%. Using VAWNR with impact wrench, removing four nuts at once is faster than removing one nut at a time. The reduction in time taken is about 53%. The data is tabulated in Table 2.

Fig. 9. Removing one wheel nut using L-shaped wrench.

Fig. 10. Removing all wheel nuts using VAWNR and lever.

Fig. 11. Removing one wheel nut using impact wrench.

Fig. 12. Removing all wheel nuts using VAWNR and impact wrench.

Table 2. Experimental results.

Tool	Time (s)	Torque (Nm)
L-shaped wrench	110	560
VAWNR and lever	102	375.2
Impact wrench	19.67	560
VAWNR and wrench	9.33	1304

VI. CONCLUSION

In this research, the conceptual design of VAWNR tool is proposed. The static load analysis is performed. The fabrication of VAWNR tool is completed by milling, welding and fitting processes. The VAWNR tool is successfully manufactured and fully functional either tested manually using lever or by using impact wrench. From the results of analyses and experiments, the tool is possible to be improved and prototyped for mass production. For future development and improvement of the VAWNR tool, light and strong material is expected to be available and applied.

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