UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF EQUIPMENT FOR LOOSEN AND TIGHTEN OF LUG NUTS BY USING GEAR CONCEPTS (SPECIAL LUG WRENCH TOOL)

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Engineering Technology (Maintenance Technology) with Honors

by

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DECLARATION

I hereby, declared this report entitled "Development of Equipment for Loosen and Tighten of Lug Nuts by Using Gear Concepts (Special Lug Wrench Tool)" is the results of my own research except as cited in references.

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Maintenance Technology) with Honours.
The supervisory is as follow:

……

(SHIKH ISMAIL FAIRUS BIN SHIKH ZAKARIA)

ABSTRAK

Biasanya, lelaki tidak mempunyai masalah dalam penukaran tayar kenderaan, tetapi sebaliknya akan menjadi masalah kepada wanita dan orang tua. Menurut kenyataan tersebut, matlamat projek ini adalah untuk menghasilkan satu alat baru (Special Lug Wrench Tool) untuk menjadi penyelesaian kepada masalah pengguna jalan raya apabila berlakunya masalah tayar pancit. Rekabentuk ini akan dicipta semula dari sepanar yang lazim digunakan untuk melonggarkan dan mengetatkan nat memerlukan kekuatan yang tinggi untuk mengendalikannya. Kaedah yang dilakukan untuk rekabentuk alat baru ini adalah berdasarkan daripada konsep gear dan ergonomik, pemodelan 3D dan fabrikasikan produk. Ciri-ciri keselamatan dan operasi yang mudah juga dimasukkan ke dalam projek ini. Di samping itu, rekabentuk alat ini akan direka dalam bentuk yang kecil, supaya alat ini mudah disimpan ke dalam bonet kereta. Besi seperti keluli lembut akan digunakan untuk mendapatkan struktur terbaik untuk produk SLWT ini. Proses pembuatan yang digunakan dalam rekabentuk projek ini melibatkan pemasangan bahagian-bahagian piawaian gear dan kerja-kerja fabrikasi seperti mengisar, melarik, menggerudi, membunga, memotong dan mengimpal. Sebagai hasil akhir, hasil produk dalam projek ini telah berjaya membantu semua orang untuk menukar tayar pancit dengan mudah. Produk ini juga sesuai untuk pengguna jalan raya termasuk kepada golongan lelaki, wanita, warga tua dan remaja.

ABSTRACT

Normally, men has no problem in changing of vehicle tires, but instead will be a problem for women and the elderly people. The aim of this project is to develop a new product (Special Lug Wrench Tool) to solve the road user's problem when flat tire problem raised. The product was innovated from lug wrench tool which was used to loosen and tighten the lug nuts that required a lot of energy or force to operate it. The following methods for this product are design based on the gear concept and ergonomic, 3D solid modelling and fabricate the product. Safety features and easy operation are included into this project. Besides, the product would be small designed, so that it can be easily kept in the car trunk. The metal such as mild steel were used to get the best structure for the SLWT product. The manufacturing process for these projects involves an installation of standard gear parts and fabrication process such as milling, turning, drilling, knurling, cutting and welding. As a final result, the product results in this project successfully help all people to change the flat tire easily. This product also is suitable for any motorist including men, women, elderly and teenagers.

DEDICATION

Specially dedicated to my beloved family and friends…

Dedicated to my lovely family…

Ami Bin Ibrahim

Kalthum Binti Mazelan

Amir Syarifuddin Bin Ami

Amir Aizat Bin Ami

Amirah Afiqah Binti Ami

Amirah Khairunnisa Binti Ami

Dedicated to all my lecturers and friends…

Thank you for the good times,

The days you filled with pleasure.

Thank you for fond memories,

And for feelings I will always treasure…

Thanks for all your love and support…

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LIST OF ABBREVIATION, SYMBOL AND NOMENCLATURE

Mm	-	Millimeter
Nm	-	Newton Meter
N/m^2	-	Pascal
R	-	Teeth of Ring Gear
S	-	Teeth of Sun Gear
P	-	Teeth of Planet Gear
T_r	-	Turn of Ring Gear
T_s	-	Turn of Sun Gear
T_y	-	Turn of Planetary Carrier
P_{out}	-	Output Power
P_{in}	-	Input Power
T_{out}	-	Output Torque
T_{in}	-	Input Torque
F_{in}	-	Input Force
r	-	Radius
EDM	-	Electrical Discharge Machine
SLWT	-	Special Lug Wrench Tool
RTW	-	Ratchet Torque Wrench
PTW	-	Pneumatic Torque Wrench
CIW	-	Cordless Impact Wrench
VAWNR	-	Vehicle All-Wheel-Nuts Remover
MNR	-	Multi Nut Remover
TEHWW	-	The Extension Hydraulic Wheel Wrench
RLNSF	-	Rim Lug Nuts Special Fixture

CHAPTER 1

INTRODUCTION

1.1 Introduction

Automobiles or vehicles are powered by an internal engine and consisting of four wheel. Vehicle such as a car usually have similar function and concept of motion to a motorcycle which means they move on the road using a rolling tire. The wheel is connected to a drive shaft which is connecting to the combustion engine. A set of lug nuts are typically used to secure a wheel to threaded wheel studs thereby to a vehicle's axles (Tseng et al., 2005).

However, replacing a new or spare tire vehicle when tire was punctured or flattened is a difficult task especially nowadays tire was fitted using an impact wrench with high torque. The high force required to loosen the lug nuts in manually and sometime required extension bar attached to the lug wrench to overcome the load. This situation consume lot of time and expose to injury especially when someone stand on the lug wrench to push or loosen the lug nuts. In these cases, how about when happen when it comes to women and elderly people. Therefore it is crucial to have special tool or device that can perform easily for women and elderly people for low energy or force required to loosen and tighten the lug nuts.

A new tool will be reinvented by applying a computer approach of design and manufacturing for the problem solution. This project also will be more focusing on the integrating 3D design (SolidWorks) and then will produce the actual product by installing standard gear parts and fabricating process such as milling, turning, drilling, knurling, cutting and welding. The design of the project will be focused on the objective which uses low force to loosen and tighten the lug nuts to facilitate the

people who want to change the flat tire. “Special Lug Wrench Tool” (SLWT) is a name of device project to solve the road user’s problem when faced with flat tire and it is design was created to facilitate especially for women and elderly people. Hence, this project was intended to help all people change the flat tire easily. This device is suitable for any motorist including men, women, elderly and teenagers. The design uses a gear concept to transfer and reduces the force to be applied.

1.2 Problem Statement

As stated by Cho et al. (2012) almost all cars are using pneumatic tire type which is inflated with air and it’s provided more superiority to performance in driving such as the cornering, handling and rolling over obstacles, and sure thing for riding comfort. Nevertheless, there are still have two main problems that may result in the total failure from occurrence of puncture and may lead to an accident if the blowout at high speeds. Furthermore, there is the occurrence of friction between the tires and surfaces of road generally if looked from the point of applied science, and then the surface of the tires will wear and cause to damage. The factor such as heat, road conditions, pressure of tire and mechanical issues are will be influence to the wear causes of the tires. All of these factors may lead to the flat tire cases (Farudzi and Azib, 2014).

The flat tire is an incident faced by most car and the worst case scenario when it happened at highway road where are far away from the workshop. Moreover, a thread of lug nuts will be wears more quickly when tires are flattened. The tire can only be used to 15 percent fewer miles for every 20 percent that in flattened. Besides, the tire will overheat more quickly and cause more damage (Junankar et al., 2015). Therefore, the only solution to these problem is require the replacement to damaged tire with a spare tire. If these problem occurs, all drivers are should know a basic knowledge to the procedure of tire replacement. Minimal skill is required in order to change the flat tire. A tire replacement tools such as the cross lug wrench or L-shaped nut remover and scissor jack are supplied by manufacturer in almost all vehicle nowadays (Abdullah et al., 2013).

However, it is difficult to loosen and tighten the lug nuts cause of limitation on force to change the flat tire especially for women or elderly people. Furthermore, when all lug nut are applied by pneumatic gun especially after the car has been repaired from workshop and might be more difficult to loosen it. Hence, new concept ideas for SLWT by using the transmitting power was applied into this project to facilitate the people who want to change the flat tire.

1.3 Objective

Based on the problems as mentioned above, the objectives to this project are:

1. To design the product by using a gear concept to loosen and tighten the lug nuts with reinvented the product for low force required, safety, ergonomic and easy operation.
2. To test the analysis stress with an engineering software.
3. To produce the actual product.

1.4 Scope of Work

To fulfilling the objectives for this project, several scopes have been determined:

1. Designing the product concept based on the planetary gear type and designed for standard lug nuts.
2. Testing the new develop product according to the torque measurement by torque wrench and analysis the stress generated using SolidWorks simulation.
3. Produce the product by installing standard gear parts and fabricating process such as milling, turning, drilling, knurling, cutting and welding.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In automotive industry, tire replacement tools such as the car jack, lug wrench, torque wrench and impact gun serves to open and tighten the lug nut on a car wheel. Lug nut serves to hold the wheel on the axle so that the wheel rims are in tight. Lug wrench allows the user to provide power to the socket to tighten and loosen the nuts wheel. Typically many manufacturers include lug wrench as one of the basic tools in the vehicle. It is usually placed in the rear of the car bonnet.

2.2 The Problem for Loose the Lug Nuts

Nearly 90 minutes by Zaheen (2012) claimed that mechanic take time to loosen and tighten the lug nuts on studs properly. Therefore, it take longer time as an estimation to complete these task. A new design for wheel and fasteners has been asked to the manufacturers to the solution for this problem, so that when the lug nuts are properly installed, no re torqueing would be required.

Lug nuts, also known as wheel nuts are the large bolts which are located on the wheel of most land vehicles. They are screwed tightly to the bolts that extend out from the axle. Their job is to keep the tire on the vehicle. Lug nuts can be very difficult to be removed if over torqued or not treated with anti-seize spray before screwed in place. However, the people can paying the mechanic to do these task if they had problem to loosen and tighten the lug nuts which lack of tools or improper tools. Hence, the study of previous method or tire replacement tools that used before will be carried out to develop a new design of product as an innovation to these

problems. Figure 2.1, 2.2 and 2.3 shown which a high force is required to loosen the lug nuts, a woman that difficulty in change the flat tire and an elderly need the helper to change the flat tire.

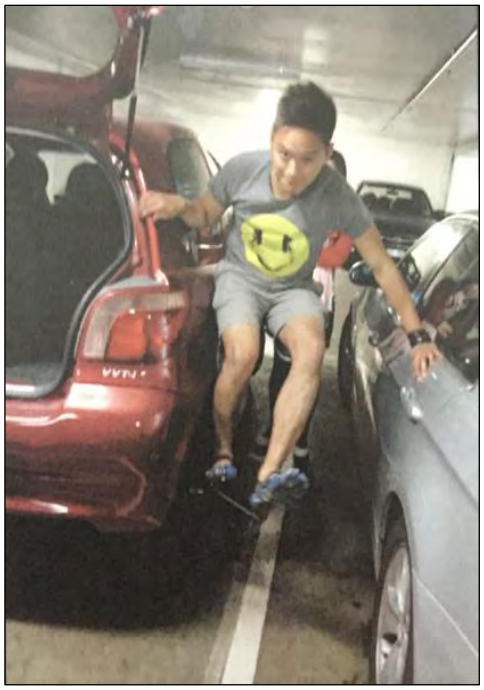

Figure 2.1: High force is required (Zaheen, 2012)

Figure 2.2: A woman in difficulty to change the flat tire (Zaheen, 2012)

Figure 2.3: An elderly need the helper to change the flat tire (Zaheen, 2012)

2.3 Previous Method or Tire Replacement Tools

There are various kinds of innovation product to the tire replacement tools nowadays. The size of the lug nuts also are available in various sizes like a 17mm, 19mm and 21mm and their nut head is hexagonal shaped. Despite that, this project is focusing on various studies to learn more about standard tire replacement tools that was developed before. The products that was designed previous also will be study in this project.

2.3.1 Car Jack

According to Noor et al. (2008) car jack in automotive industry is a tool to raise the vehicle in order to facilitate the maintenance activity. The basic car jack which manually operated are most familiar to the people and it's included as standard tire replacement tool or equipment for most of the new cars.

There are various types of car jack in automotive such as screw jack, toggle jack and hydraulic jack. The toggle and screw jack are similar concept of principle

which uses power screw to raise the load. The toggle jack has connection member which are arranged to a specific degree of freedom. And for the type of hydraulic jack, it is uses a fluid to raise the load by achieving the fluid in cylinder from pumping or increasing the pressure (Daniel, 2017). Even so the standard type of car jack that typically was supplied by manufacturers is the screw jack or scissor jack as shown in Figure 2.4.

Figure 2.4: Standard scissor jack that was supplied

2.3.2 Lug Wrench

The lug wrench is commonly used to loosening and tightening the lug nuts. This tool have two type of shaped which may be in L-shaped or X-shaped. Typically manufacturer supplied of lug wrench in L-shaped which by combination of socket wrench and prying tip as depicted in Figure 2.5. The type of this lug wrench has lack of ability to measure and limiting the force required but it is inexpensive. Hence, to assembling the tires is harder part because an improper procedure to ensure the tightening of the lug nuts. In addition, if the force that applied is too excessive it will cause the lug nuts or strip threads is harder to remove when disassembling process. Besides non-uniform torque between the various of lug nuts or excessive torque may causes of brake rotor to be warping if the car is equipped with disc brakes. Thus an improvement as innovation to the lug wrench, a ratchet socket wrench is developed (Baby et al., 2015).

Figure 2.5: L-shape lug wrench

2.3.2.1 Ratchet Torque Wrench (RTW)

On the authority of Chang et al. (2016) most of RTW have a round head or a gourd-shaped head as illustrated in Figure 2.6. A pawl and a gear are respectively held by the handle which has two intersecting circular recesses. The function of pawl is allowing the gear to rotate at set distances in only one direction. After that, the handle can spin freely, whereas in the opposite direction, the pawl catches the gear, thus allowing the application of force (torque) from the handle into the socket for the tightening of lug nuts. Nevertheless, if the pawl and gear did not fit well, then the gear would slip or skip. This means, performance of the device largely determines between the fit of the pawl and gear. It will may lead to gear tooth failure if critical mismatch limit the amount of force that applied to the device, which directly influences to the overall quality of RTW.

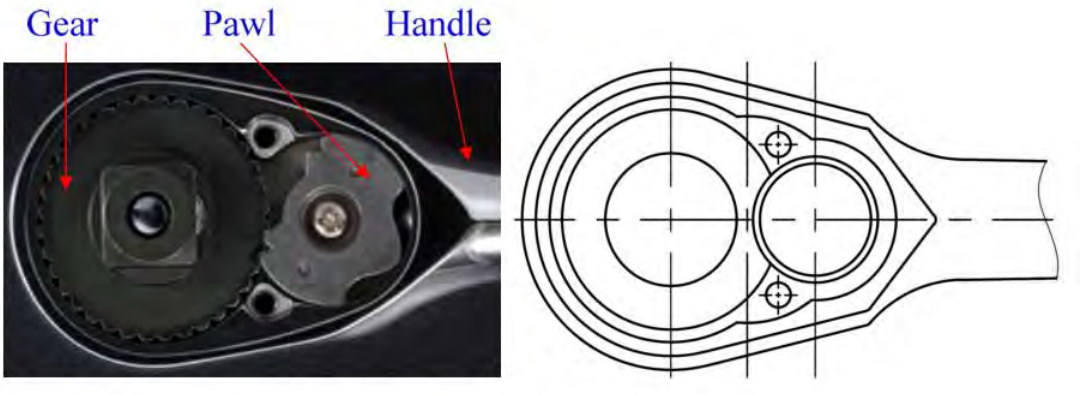

Figure 2.6: RTW with a gourd-shaped head (Chang et al., 2016)

2.3.3 Socket Wrench

Socket wrench in Figure 2.7 show the spanner heads can be changed to suit the size of the socket to be used to open a different nut or fastener on a place. The most common form is known as the ratchet teeth are composed of unidirectional mechanism that built it. Thus it can be turned around to use the rear movement and can be used in narrow spaces.

Figure 2.7: Socket wrench

2.3.4 Impact Wrench

An impact wrench as shown in Figure 2.8 is sometimes confused with pneumatic torque, even though looks similar, but in truth a totally different tool (Farudzi and Azib, 2014). The impact wrench is designed from socket wrench power tool to transfer high torque output with minimal exertion by the user, by collecting the energy in rotating mass, and then transferring it immediately to the output shaft. Most common of power source for impact wrenches are air that compressed, furnish a design with low cost and the great power-to-weight ratio. It is almost always used a simple vane motor, typically from four till seven vanes, and various of lubrication systems, but the most common used is an oiled air, while the rest may consist special oil passages routed to the part should require and a separate, sealed oil for the hammer assembly. The hammer will drive directly from the motor in most of impact wrenches, only low torque when the fastener is required to giving it in fast action (Baby et al., 2015).