UNIVERSITI TEKNIKAL MALAYSIA MELAKA

STUDY ON IMPACT OF SEVERAL TYPES OF METALS IN SIMULTANEOUS TIRE WRENCH

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

by

MOHAMAD SYAHAQIL BIN ABD TALIB

B071510815

920724055149

FACULTY OF MECHANICAL AND MANUFACTURING ENGINEERING TECHNOLOGY

2018

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

Tajuk: Study On Impact Of Several Types Of Metals In Simultaneous Tire Wrench

Sesi Pengajian: **Semester 1 2018/2019**

Saya **Mohamad Syahaqil bin Abd Talib** mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (X)

☐	SULIT*	Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972.
☐	TERHAD*	Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan.
☒	TIDAK TERHAD	

Yang benar,	Disahkan oleh penyelia:
....	....
MOHAMAD SYAHAQIL BIN ABD TALIB	EN KHAIRIL AMRI BIN KAMARUZZAMAN
Alamat Tetap:	Cop Rasmi Penyelia
NO 24, JALAN MERAK MAS 15,	
TAMAN MERAK,	
75450 BUKIT KATIL, MELAKA	
Tarikh:	Tarikh:

*Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I hereby, declared this report entitled Study on Impact of Several Types of Metals In Simultaneous Tire Wrench is the results of my own research except as cited in references.

Signature: ……………………………………
Author : MOHAMAD SYAHAQIL BIN ABD TALIB
Date:

APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Maintenance) with Honours. The member of the supervisory is as follow:

Signature: ……………………………………………….

Supervisor : MR. KHAIRIL AMRI BIN KAMARUZZAMAN

Signature: ……………………………………………….

Co-supervisor: DR. ABDUL MUNIR HIDAYAT SYAH LUBIS

ABSTRAK

Kejadian tayar pancit semasa memandu adalah dikira sebagai satu kejadian kecemasan. Ini kerana, tayar merupakan agen penggerak yang mengawal posisi serta pergerakan sesebuah kenderaan. Kejadian tayar pancit ini juga boleh mengakibatkan kemalangan kecil sehinggakan meragut nyawa pemandu. Di dalam kajian ini, berbagai eksperimen dijalankan terhadap dua bahan yang dipilih iaitu aluminium dan *stainless steel*. Objektif utama kajian ini adalah (i) menjalankan beberapa ujian mekanikal keatas bahan-bahan terpilih, (ii) menjalankan ujian simulasi menggunakan CATIA V5, (iii) dan menyarankan bahan yang terbaik untuk membuat pembuka tayar pada masa hadapan. Di dalam ujian mekanikal, ianya termasuklah ujian kilasan, ujian *hardness index number*, dan ujian hentaman. Kesemua ujian ini dijalankan adalah untuk mengkaji dan mempelajari tingkah laku serta karakter sesebuah bahan itu apabila diuji secara mekanikal dimana ianya mewakili situasi sebenar penggunaannya. Bagi ujian kilasan, *hardness index number*, dan ujian hentaman, kesemua keputusan yang diperolehi menunjukkan bahawa *stainless steel* adalah lebih baik berbanding aluminium didalam perbandingan ini. Ujian simulasi kekuatan juga dijalankan menggunakan perisian CATIA V5. Didalam simulasi ini, jumlah tenaga *strain* yang diperolehi untuk aluminium adalah 4.129 J, dan bagi *stainless steel* pula, adalah 1.491 J. Ini membuktikan bahawa aluminium adalah bahan yang baik dari segi penyebaran tekanan dibandingkan dengan *stainless steel.* Dan sebagai keputusan akhir, *stainless steel* adalah merupakan bahan yang disarankan bagi projek ini oleh kerana kelebihan yang dapat dikaji didalam kajian ini.

ABSTRACT

Flat tire during driving can be consider as an emergency situation. This is because tire acted as a moving and also movement-controller agent for vehicles. This flat tire also can cause an accident and sometimes it even involves death. In this research, experiments are conducted on aluminum and stainless steel. The main objectives of this research are (i) to run a mechanical test onto several types of materials, (ii) to run a simulation test using CATIA V5, (iii) and to recommend the best material selection for future tire wrench. Under mechanical test, it consists of torsion test, hardness index number test and impact test. These test are conducted onto both materials due to analyze and studies its behavior and also characteristic when mechanically tested as its represents in real use. As for torsion test, hardness index number, and impact test, all results obtained revealed that stainless steel are better than aluminum in this comparison. Strength analysis also are performed using CATIA V5. Inside this simulation, amount of strain energy are obtained where aluminum has a value of 4.129 J, while stainless steel has 1.492 J. This thus indicated that aluminum are better at distributional stresses compared to stainless steel. And as final decision, stainless steel are the recommended material for this project due to advantages its offered from this research.

DEDICATION

I would like to thank my beloved parents for all the supports and motivations they gave me during my studies here at Universiti Teknikal Malaysia Melaka (UTeM). I also would like to thank my supervisor and co-supervisor alongside with my fellow friends who has shared their thoughts, knowledge and also their contributions when I am in need. Not to forget, my sincere thanks to the Faculty of Mechanical and Manufacturing Engineering Technology for giving me this opportunity to conduct tests and write this honour thesis.

To whom individuals I may not mention above, which their contribution also helps and supports me, I would like to extend my sincere thanks to all of them.

ACKNOWLEDGEMENTS

Alhamdulillah, all praises to Allah, God Almighty as He bestow His blessing and guidance which helped and eased the process for me to complete this project successfully. I would like to express my deepest appreciation to all those who provided me the possibility to complete this report. A special gratitude I give to my final year project supervisor, Mr Khairil Amri bin Kamaruzzaman, and also my co-supervisor, Dr Abdul Munir Hidayat Syah Lubis, who contribution in stimulating suggestions and encouragement, helped me to coordinate my project especially in writing this report.

Furthermore I would also like to acknowledge with much appreciation the crucial role of the staffs of faculty laboratory assistance, Mr Norhisham bin Abdul Malik, Mr Zuraini bin Zachariah and Mr Wan Shahib Igal bin Wan Hashim, who gave the permissions to use all required equipment and the necessary materials to complete the task "Study On Impact of Several Types of Metals In Simultaneous Tire Wrench".

Last but not least, I also would like to acknowledge my colleague, Muhammad Syafiq bin Sulaiman, who always supported me and guided me during completing this research.

TABLE OF CONTENTS

TABLE OF CONTENTS x

LIST OF TABLES xv

LIST OF FIGURES xvii

LIST OF SYMBOLS xxi

LIST OF ABBREVIATIONS xxii

CHAPTER 1

INTRODUCTION 1

1.1 Introduction 1

1.2 Problem Statement 2

1.3 Objectives 2

1.4 Scope 3

CHAPTER 2

LITERATURE REVIEW 4

2.1 Ferrous Metal 4

2.1.1 Cast Iron 4

2.1.2 Mild Steel 7

2.1.3 High Carbon Steel *(For ball bearing)* 14

2.1.4 Stainless Steel 17

2.2 Non-Ferrous Metal 24

2.2.1 Aluminum 24

2.3 Mechanical Test and Simulation 31

2.3.1 CATIA V5 32

2.3.2 Torsion Test 33

2.4 Tools 35

2.4.1 Spanner 35

2.4.2 Lug Wrench 36

2.4.3 Screwdriver 37

2.4.4 Ratchet 37

2.4.5 Air-gun 38

2.5 Gear 39

2.5.1 Gear Manufacturing Method 40

2.5.1.1 Casting 40

2.5.1.2 Stamping 41

2.5.1.3 Injection Molding 41

2.5.1.4 Forging 42

2.5.2 Gears Nomenclature 42

2.5.3 Spur Gear 44

2.5.4 Helical Gear 45

2.5.5 Bevel Gear 45

2.5.6 Gear Defect 46

2.5.6.1 Wear 47

CHAPTER 3

METHODOLOGY 49

3.1 Introduction 50

3.2 Data Collection 50

3.2.1 Observation 50

3.2.2 Statistical Data 51

3.2.3 Reflect from Journal /Books 51

3.2.4 Response From Potential Consumers 51

3.3 Fabrication /Installation 52

3.3.1 Cutting 52

3.3.2 Lathe Machine 54

3.3.3 Milling machine 56

3.3.4 Metal Inert Gas (MIG) Welding 58

3.4 Analysis and Testing 59

3.4.1 Rockwell Hardness Test (HRC) 59

3.4.2 Charpy Impact Test 62

3.4.3 Torsion Test 65

3.4.4 Tensile Test 66

3.5 Material Selection 66

CHAPTER 4

RESULTS AND DISCUSSION 67

4.1 Torsion Test 67

4.1.1 Specimen: Aluminum 1 67

4.1.2 Specimen: Aluminium 2 70

4.1.3 Specimen: Aluminium 3 73

4.1.4 Specimen: Stainless Steel 1 76

4.1.5 Specimen: Stainless Steel 2 80

4.1.6 Specimen: Stainless Steel 3 83

4.2 Hardness Test 86

4.3 Impact Test Results 89

4.4 Simulations Using CATIA V5 91

4.4.1 Aluminum Specimen 91

4.4.2 Stainless Steel Specimen 91

4.5 Torsion Test 93

4.5.1 Calculation 93

4.5.1.1 Turning Process 93

4.5.1.2 Milling Process 93

4.5.2 Introduction 94

4.5.3 Aluminum Specimen 95

4.5.4 Stainless Steel Specimen 98

4.6 Hardness Test 102

4.7 Impact Test 105

4.8 CATIA V5 Simulation 108

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS 110

Recommendations 111

REFERENCES 113

LIST OF TABLES

TABLE	TITLE	PAGE
Table 2.1:	Results from the experiments conducted between GCI and DCI	6
Table 2.2:	Comparison of results for compression test	7
Table 2.3:	Comparison of chemical compositions Low Carbon (LC), and Low-Alloy (LA)	9
Table 2.4:	Properties of selected stainless steel relatives to various ferrous and non-ferrous alloys	19
Table 2.5:	Chemical composition for Austenitic stainless steel	21
Table 2.6:	Melting point for selected stainless steels	22
Table 2.7:	Modulus elasticity as a function for various stainless steel grades	23
Table 2.8:	Classification of wrought aluminum alloys	27
Table 2.9:	Strength ranges of various wrought aluminum alloys	27
Table 3.1:	Procedure for Band Saw machine	52
Table 3.2:	Procedure for turning process	54
Table 3.3:	Procedure for milling process	57
Table 3.4:	Scale, Indenter, Testing Force and Application Range of Rockwell Hardness Test	60
Table 3.5:	Procedure of Hardness Number testing	60
Table 3.6:	Procedure of Impact testing	63
Table 3.7:	Procedure of Torsion testing	64
Table 4.1:	Reading obtained after test (Aluminum 1)	67

Table 4.2:	Reading obtained after test (Aluminum 2)	70
Table 4.3:	Reading obtained after test (Aluminum 3)	73
Table 4.4:	Reading obtained after test (Stainless Steel 1)	76
Table 4.5:	Reading obtained after test (Stainless Steel 2)	79
Table 4.6:	Reading obtained after test (Stainless Steel 3)	82
Table 4.7:	Results for hardness number	85
Table 4.8:	Results for impact test	88
Table 4.9	Result for Aluminum Testing Simulation	90
Table 4.10:	Result for Stainless Steel Testing Simulation	91

LIST OF FIGURES

FIGURE	TITLE	PAGE
Figure 2.1:	Distribution of stresses for GCI and DCI	6
Figure 2.2:	Resulted cracks after compression test	7
Figure 2.3:	Heat treatment scheme of investigation plain low-carbon steel	10
Figure 2.4:	As-received material (Low Carbon Steel)	11
Figure 2.5:	50% cold-rolled material (Low Carbon Steel)	11
Figure 2.6:	Material after intercritical annealed at 750°C (Low Carbon Steel)	11
Figure 2.7:	Material after intercritical annealed at 800°C (Low Carbon Steel)	12
Figure 2.8:	Material after intercritical annealed at 850°C (Low Carbon Steel)	12
Figure 2.9:	Stress-strain curves of plain low carbon steel, 50% cold-rolled and intercritical annealed at various temperature	13
Figure 2.10:	Schematic drawing of the FSW process and miniaturized Charpy test specimen	15
Figure 2.11:	Schematic drawing of the location of the optical microscopic observation (red dots)	16
Figure 2.12:	Optical microscopic of FSW after cut	16
Figure 2.13:	Family Relationship for standard austentic stainless steel	20
Figure 2.14:	Family relationship for wrought aluminum alloys	26
Figure 2.15:	Specimen used (Tested Aluminum Bar)	28

Figure 2.16: Position strain occurred the highest 29

Figure 2.17: Position where stresses occurred the most 29

Figure 2.18: Damage value (C) obtained after the specimen breaks 30

Figure 2.19: Highest temperature recorded and its position 30

Figure 2.20: Stress-Strain diagram obtained from the final results 31

Figure 2.21: Sample of 2D and 3D drawing from CATIA V5 32

Figure 2.22: Sample of simulation testing using CATIA V5 33

Figure 2.23: Illustrate of torsion test where θ the angle of twist produced by torque (T) 34

Figure 2.24: Spanner 36

Figure 2.25: '+' shaped lug wrench 36

Figure 2.26: Screwdrivers 37

Figure 2.27: Ratchets 38

Figure 2.28: Air-gun Tool 39

Figure 2.29: Sample of gear mold 40

Figure 2.30: Stamping Process 41

Figure 2.31: Sample of injection molding machine/process 42

Figure 2.32: Basic parts of gear 44

Figure 2.33: Spur Gear 44

Figure 2.34: Helical Gear 45

Figure 2.35: Straight bevel gear 46

Figure 2.36: Adhesive wear 48

Figure 2.37: Type and example of abrasive wear 48

Figure 3.1:	Electrical Power Saw Machine	52
Figure 3.2:	Lathe machine	54
Figure 3.3:	Milling machine	56
Figure 3.4:	MIG welding simulation	58
Figure 3.5:	Rockwell Hardness Test	59
Figure 3.6:	Ductile to Brittle Transition	63
Figure 4.1:	Torque (Nm) VS Twisting Angle (°) for Aluminum 1	68
Figure 4.2:	Aluminum 1 (after testing)	69
Figure 4.3:	Torque (Nm) VS Twisting Angle (°) for Aluminum 2	71
Figure 4.4:	Aluminum 2 (after testing)	72
Figure 4.5:	Bending occurred at the broken part of specimen (AL 2)	72
Figure 4.6:	Torque (Nm) VS Twisting Angle (°) for Aluminum 3	74
Figure 4.7:	Aluminum 3 (after testing)	75
Figure 4.8:	Torque (Nm) VS Twisting Angle (°) for Stainless Steel 1	77
Figure 4.9:	Stainless Steel 1 (after testing)	78
Figure 4.10:	Torque (Nm) VS Twisting Angle (°) for Stainless Steel 2	80
Figure 4.11:	Stainless Steel 2 (after testing)	81
Figure 4.12:	Torque (Nm) VS Twisting Angle (°) for Stainless Steel 3	83
Figure 4.13:	Stainless Steel 3 (after testing)	84
Figure 4.14:	Sample of material after conducted hardness test	85
Figure 4.15:	HRA (Diamond Indenter)	85
Figure 4.16:	HRB (Ball Indenter)	86
Figure 4.17:	Graph plotted from data collected for hardness test	87

Figure 4.18:	Before (Aluminum 1)	88
Figure 4.19:	After (Aluminum 1)	88
Figure 4.20:	Before (Aluminum 2)	88
Figure 4.21:	After (Aluminum 2)	88
Figure 4.22:	Before (Aluminum 3)	88
Figure 4.23:	After (Aluminum 3)	88
Figure 4.24:	Before (Stainless Steel 1)	89
Figure 4.25:	After (Stainless Steel 1)	89
Figure 4.26:	Before (Stainless Steel 2)	89
Figure 4.27:	After (Stainless Steel 2)	89
Figure 4.28:	Before (Stainless Steel 3)	89
Figure 4.29:	After (Stainless Steel 3)	89
Figure 4.30:	Simulation testing on aluminum specimen	90
Figure 4.31:	Simulation testing on stainless steel specimen	90

LIST OF SYMBOLS

mm	-	Length
E	-	Young's Modulus
t	-	Thickness
***d*, Ø**	-	Diameter
R	-	Radius
wt%	-	Weight Percentage
RPM	-	Revolution Per Minute
MPa, GPa	-	Pressure
F	-	Force
τ	-	Shear Stress
T	-	Torque
C	-	Outer Radius of Shaft
J	-	Moment Of Inertia of the Cross Section
θ	-	Angle
V	-	Voltage
e	-	Depth of the Indenter Penetration
N	-	Newton

LIST OF ABBREVIATIONS

STW	-	Simultaneous Tire Wrench
PCD	-	Pitch Circle Diameter
GCI, FG	-	Grey Cast Iron
DCI, SG	-	Ductile Cast Iron
ANSYS	-	Analysis System (3D design software)
MIG	-	Metal Inert Gas (Welding)
LC	-	Low Carbon
LA	-	Low Alloy
Bal.	-	Balance
TEM	-	Transmission Electron Microscopy
FSW	-	Friction Stir Welding
ASS	-	Austenitic Stainless Steel
FCC	-	Face-Centered Cubic
ASTM	-	American Society for Testing Materials
ISO	-	International Organization for Standardization
DT	-	Destructive Test
SS	-	Stainless Steel
AL	-	Aluminum
JTKP	-	Department of Manufacturing Engineering
JTKM	-	Department of Mechanical Engineering
2D	-	Two Dimensional
3D	-	Three Dimensional

CHAPTER 1

INTRODUCTION

1.1 Introduction

Tire wrench or lug wrench has been used to loosen or tightened the nuts at the hub of the vehicles since the day that an automobile was firstly produced. It is one of the most important things when it comes to an emergency such as flat tire which requires them to unscrewed the nut and change it with the spare tire. The nuts of the tire is responsible to keep the wheels stays onto its position while rotating at low or even high speed. It also one of the major parts at a vehicles as it ensures the safety and comfortability to the driver. Lots of tools can be used to loosen or tighten the nuts, such as lug wrench, air gun with socket sets, and also regular wrench. By using this tools, it is a time-taken process as it requires the mechanic or the driver to unscrew the nuts one by one manually. Sometimes, the material of the tools also affected the whole process of changing the tire. As known, higher grade materials is costly. The initiative taken by some of the driver is to buy lower grade tools as it would not expected to be used daily or regularly without knowing that lower grade material has a higher chances to wear or broken depends on frequency usage rate. By introducing the Simultaneous Tire Wrench, it could help the mechanics to reduce time taken to loosen or tighten the nuts by unscrewed all of it in the same time with the same amount of forces. This wrench also comes with suitable material which can be increases its lifespan and strength.

1.2 Problem Statement

All of the car uses nut to lock the wheels onto its place. The problems occur in this situation is the tools use to unscrewed or lock tight the nut is a time-taken process. This is due to steps taken which unscrewed it by one piece of the nut at a time. Time is a valuable and important thing for some mechanics. This is due to lots of customers came to repair or change their tire. To add, some of the tools were manufactured with low grade material such as aluminum to reduce manufacturing cost which can easily break or wear during changing the tire process. Generally known, aluminum is lightweight, soft and yet low in strength. This could lead to serious problem when it comes to an emergency situation. For example the tire caught flat in the middle of the night on the side of the road. While rotating the manual tire wrench, suddenly it breaks and no options left beside to call for a towing which can be more costly. Besides that, manual tire wrench requires the users to apply huge amount of forces to unscrew it. This could be a burdensome to the users when it comes to changing the tire. With all the problems stated above, a special tool is manufactured to overcome the problems and to facilitate all the users. This tool provides a time-saver process and also requires less human effort when it comes to changing the tire process.

1.3 Objectives

From this experiments, there are three main objectives issued due to complete this project;

1. To run a mechanical test onto several types of materials
2. To run a simulation test using CATIA V5
3. To recommend the best material selection for future tire wrench

1.4 Scope

The scope of this project are cars that manufactured with Pitch Circle Diameter (PCD) 100 mm. PCD means the distance between each nut that holds the wheels. For example, Malaysian car manufacturer, Perodua Viva, Kancil or Axia. All of the cars that are tested has four holes for nut and bolt. Other than that, this project also taken place at nearby workshops that has the same tools used in changing the tire process such as tire shops. Here, test are done to a certain type of cars and data or results also can be collected. Besides that, this project are introduced to nearby learning institutions where students could learn the mechanisms used in this project and demonstrations could be presented. This attract the student's interest in learning about mechanical and how it is done. For example, students are demonstrated on how this project works with such a simple gear mechanisms and yet still offers several benefits to industries nor consumers.