

**DESIGN OF A MINI FATIGUE TENSILE  
MACHINE**

**KHAIROL NAIM BIN SHAFEEI**

**SCHOOL OF MANUFACTURING ENGINEERING  
UNIVERSITI MALAYSIA PERLIS  
2015/2016**

© This item is protected by original copyright

# DESIGN OF A MINI FATIGUE TENSILE MACHINE

by

**KHAIROL NAIM BIN SHAFEEI**

Report submitted in partial fulfillment  
of the requirements for the degree  
of Bachelor of Engineering



MAY 2016

## ACKNOWLEDGMENT

Praised to Allah, the Most Gracious and Most Merciful Who has created the mankind with knowledge, wisdom and power. Thanks to Allah for giving a good health, precious time and bright mind to accomplish my project for Bachelor of Manufacturing Engineering. It was a great opportunity to gain more knowledge in an attempt to finish up the project.

I would like to express my deepest gratitude to my supervisor, Dr Muhammad Saifuldin Bin Abdul Manan who had presently given guidance and support throughout the entire project. It would be difficult to complete this project without his guidance and support, especially in the project resources, references and ideas.

Sincere, thanks to the other lecturers, who also helps with their idea and opinion about this project. Outmost thanks to my family who have given support throughout the project. Not forgetting their eternally moral support and understanding of an academic responsibilities.

Last but not least, I would like to express my gratitude to my friends, especially my classmates who had given help technically and mentally during the journey to accomplish this project. Thank you for giving technical advice, moral support and idea to enhance the project. Thank you.

## **APPROVAL AND DECLARATION SHEET**

**This project report titled Design of a Mini Fatigue Tensile Machine was prepared and submitted by KhairolNaim Bin Shafeei(Matrix Number: 121050574) and has been found satisfactory in terms of scope, quality and presentation as partial fulfillment of the requirement for the Bachelor of Engineering (Manufacturing Engineering) in Universiti Malaysia Perlis (UniMAP).**

**Checked and Approved by**

---

**(DR MUHAMMAD SAIFULDIN BIN ABDUL MANAN)  
Project Supervisor**

**School of Manufacturing Engineering  
Universiti Malaysia Perlis**

**December 2015**

## REKA BENTUK SEBUAH MESIN KETEGANGAN KELESUAN MINI

### ABSTRAK

Projek ini adalah di jalankan bagaimana rekabentuk sebuah mesin mini dengan menggunakan kos yang rendah bagi tujuan untuk penggunaan pelajar. Projek ini bertujuan untuk mengkaji tentang kelesuan yang berlaku terhadap spesimen semasa proses penarikan. Rekabentuk akan dihasilkan melalui proses lukisan dengan perisian UGNX. Mesin ini akan melakukan proses pengulangan untuk mendapatkan proses kelesuan terhadap spesimen.

Spesimen ini akan ditarik dengan menggunakan pemegang mesin melalui motor yang menggunakan dayapusingan yang tinggi. Oleh itu, motor merupakan bahagian yang penting untuk proses penarikan terhadap spesimen. Selepas rekabentuk telah dibuat, mesin ini perlu dikaji untuk mendapatkan motor yang mempunyai dayapusingan yang tinggi semasa proses penarikan. Perisian yang akan digunakan untuk mengkaji ialah analisis unsur terhingga. Tambahan pula, analisis telah dilakukan oleh dua bahagian daripada rekabentuk iaitu besi rod dan engkol. Kedua-dua ini akan menghasilkan kawasan kritikal yang telah dikenakannya. Secara teorinya pengiraan akan dikira untuk grafik titaran berdasarkan daya analisis. Melalui rekabentuk yang dihasilkan, mesin ini memberi kefahaman tentang kelesuan yang berlaku pada specimen.

## **DESIGN OF A MINI FATIGUE TENSILE MACHINE**

### **ABSTRACT**

This project is about the design of mini fatigue tensile machine by designing a low cost for the use of students. The project aims to study the tensile that occurs to the specimen during the tensile process. The design of this machine will use UGNX 6.0 as the software machine design. This machine will make the process of repetition to get the fatigue tensile of the specimen. These specimens will be pulled through the machine using the gripper by high torque of motor. Thus, the motor is an important part of the process of tensile to the specimen. After the design has been made, the machine must be studied to obtain high torque of motor that suitable for machine while tensile process. Software that will used to make analyze is Finite Element Analysis. Moreover, analysis had been done by two part of design which is slot and crank. Both of this will be resulted the critical area that had been apply force on it. Theoretically calculation will be calculated to form the graph based on force analysis. Through the design produced, this machine provides an understanding of the fatigue that occur on specimen.

## TABLE OF CONTENTS

	<b>Pages</b>
<b>ACKNOWLEDGEMENT</b>	<b>i</b>
<b>APPROVAL AND DECLARATION SHEET</b>	<b>ii</b>
<b>ABSTRAK</b>	<b>iii</b>
<b>ABSTRACT</b>	<b>iv</b>
<b>TABLE OF CONTENTS</b>	<b>v</b>
<b>LIST OF FIGURES</b>	<b>ix</b>
<b>LIST OF TABLES</b>	<b>xii</b>
<b>LIST OF ABBREVIATIONS OR NOMENCLATURE</b>	<b>xiv</b>
 <b>CHAPTER 1: INTRODUCTION</b>	
1.1 Background of Project	1
1.2 Problem Statement	3
1.3 Objectives	3
1.4 Project Scope	3
1.5 Project Planning	4
1.6 Gantt Chart	4
1.7 Significant of Project	4
1.8 Summary of Chapter	4
 <b>CHAPTER 2: LITERATURE REVIEW</b>	
2.1 Conceptual Review	7
2.2 Fatigue Tensile	8
2.3 Fatigue Tensile machine	10
2.4 Mechanism of Fatigue Tensile Machine	13

2.4.1	Gripper Mechanism	14
2.4.2	Summary	17
2.4.3	Motor Mechanism	17
2.4.4	Summary	19
2.4.5	Bearing Slider	20
2.4.6	Summary	22
2.5	Existing Product	22
2.6	Finite Element Analysis	25

### **CHAPTER 3: METHODOLOGY**

3.1	Introduction	27
3.2	Concept Design Theory	29
3.3	Design and Concept Selection	29
3.3.1	Criteria of the project	30
3.3.2	Sketching Concept	31
3.3.3	Pugh method	35
3.3.4	Concept Selection	36
3.4	Machine Component	36
3.4.1	Stepper Motor	37
3.4.2	Mechanical Screw Grip	38
3.4.3	Bearing	39
3.4.4	Plate	40
3.4.5	Shaft	41
3.4.6	LGB Rail Slider	42
3.5	Finite element analysis of crank slider mechanism	43

### **CHAPTER 4: RESULTS AND DISCUSSION**

4.1	Introduction	45
4.2	Animation using CATIA software	46
4.2.1	Kinematic Analysis	48
4.2.2	Force Analysis	49
4.3	Analysis using CATIA software	54



4.3.1	Crank analysis	56
4.3.2	Crank Improvement Analysis	59
4.3.3	Pin analysis	61
4.3.4	Pin Improvement Analysis	64
4.4	Product Costing	66
4.5	Summary	67
 <b>CHAPTER 5: CONCLUSION AND RECOMMENDATION</b>		
5.1	Conclusion	68
5.2	Recommendations	69
 <b>REFERENCES</b>		
		71
 <b>APPENDICES</b>		
		73

© This item is protected by original copyright

## LIST OF FIGURES

<b>Figures No.</b>		<b>Page</b>
2.1	Schematic Illustrating Cyclic Loading Parameters [4]	8
2.2	Direct Force Fatigue Testing Machine[4]	10
2.3	Micro Fatigue Test [2]	11
2.4	Tensile Strength and Fatigue Tensile [5]	12
2.5	Crack Initiation, Crack Growth, Final Failure [2]	13
2.6	Sequence of Event Observed by Fatigue Cycles [2]	13
2.7	Screw Grips [7]	14
2.8	Wedge Screw Grips [8]	15
2.9	Pincer Grips [9]	16
2.10	NEMA 34 Rotary Stepper Motor [11]	17
2.11	NEMA 23 Rotary Stepper Motor [12]	18
2.12	Drawer Slider [13]	20
2.13	Linear Roller Bearing [14]	21
2.14	910 Servohydraulic Fatigue Test Machine [15]	23
2.15	810 Family Electrodynamic Fatigue Test Machines [16]	24
2.16	Expert 4000 Mini Machine [17]	25
2.17	FEM simulation of the damage of San Francisco Oakland Bay Bridge caused by the 1989 Loma Prieta earthquake	26
3.1	Flow Chart	28
3.2	Concept 1	31

3.3	Concept 2.	32
3.4	Concept 3	33
3.5	Concept 4	34
3.6	Concept 4	36
3.7	Stepper Motor [11]	37
3.8	Screw Vise Grip [18]	38
3.9	Bearing [19]	39
3.10	Plate [20]	40
3.11	Shaft [22]	41
3.12	LGB Rail [13]	42
3.13	Example of part to analysis	43
3.14	Assembly Drawing	44
3.15	Explode Drawing	44
4.1	Free Body Diagram	48
4.2	X-component, force acting on crank for each angle	49
4.3	X-component, displacement between slider	51
4.4	X-component, acceleration on slider	53
4.5	X-component, velocity of slider	53
4.6	Octree Tetrahedron	55
4.7	Linear Tetra and Parabolic Tetra	55
4.8	Deformed Mesh	57
4.9	Von Misses Stress	57
4.10	Crank	60
4.11	Von Misses Stress	61
4.12	Deformed Mesh	62

4.13	Von Misses Stress	63
4.14	Pin	65
4.15	Von Misses stress	66

© This item is protected by original copyright

## LIST OF TABLES

<b>Tables No.</b>		<b>Page</b>
1.1	Gant Chart for FYP 1	6
2.1	Chemical composition of SAE 4340 steel[5].	11
2.2	Heat treatment procedures of SAE 4340 steel	11
2.3	Specification of Screw Grips	15
2.4	Specification of Wedge Screw Grips	15
2.5	Specification of Pincer Grips	16
2.6	Motor Specification [11]	18
2.7	Motor Specification [12]	19
2.8	Specification of Drawer Slider	20
2.9	Specifications of LGB Rail Slider	21
2.10	Specifications of 910 Servohydraulic Fatigue Test Machine	23
2.11	Specification of 810 Family Electrodynamic Fatigue Test Machines	24
2.12	Specifications of Expert 4000 Mini Machine	25
3.1	Criteria of Concept 1	31
3.2	Criteriaof Concept 2	32
3.3	Criteria of Concept 3	33
3.4	Criteria of Concept 4	34
3.5	Pugh Method	35
3.6	Motor Insertion	37

3.7	Grip Insertion	38
3.8	Bearing Insertion	39
3.9	Plate Insertion	40
3.10	Shaft Insertion	41
3.11	LGB65 Rail Insertion	42
4.1	Typical Tensile Strength of Some Materials	45
4.2	Motion of Gripper	46
4.3	Result of force acting on crank	50
4.4	Result of displacement between slider	51
4.5	Result of acceleration on slider	52
4.6	Result of Slider Velocity	54
4.7	Material of Crank	56
4.8	Factor of Safety	56
4.9	Structural Analysis of Crank	58
4.10	Von Misses Stress Value	60
4.11	Material of Pin	61
4.12	Factor of Safety	62
4.13	Structural Analysis of Pin	63
4.14	Von Misses Stress Value	65
4.15	Part Design	67

## LIST OF ABBREVIATIONS AND NOMENCLATURE

$\sigma_m$	=	Mean stress (N/mm <sup>2</sup> )
$\sigma_r$	=	Stress range (N/mm <sup>2</sup> )
$\sigma_a$	=	Stress Amplitude(N/mm <sup>2</sup> )
<b>R</b>	=	Stress Ratio
<b>N<sub>f</sub></b>	=	Fatigue Life
<b>N<sub>i</sub></b>	=	Initial Cycle To Crack
<b>N<sub>p</sub></b>	=	Crack Start To Spread
<b>SAE</b>	=	Standard Organization Alloy
<b>kHz</b>	=	kiloHertz
<b>C</b>	=	Carbon
<b>Mn</b>	=	Manganese
<b>Si</b>	=	Silicon
<b>Cr</b>	=	Chromium
<b>Ni</b>	=	Nickel
<b>Mo</b>	=	Molybdenum
<b>Cu</b>	=	Copper
<b>As</b>	=	Arsenic
<b>L</b>	=	length
<b>EBSD</b>	=	Electron Backscattered Diffraction
<b>P-MR</b>	=	Palmgren-Miner rule
<b>kN</b>	=	kiloNewton
<b>NEMA</b>	=	National Electrical Manufactures Association
<b>M</b>	=	Motor
<b>UGNX 6.0</b>	=	Unigraphics
<b>FEA</b>	=	Finite Element Analysis
<b>CATIA</b>	=	Computer Aided Three Dimensional Interactive Application