

# UNIVERSITI MALAYSIA PAHANG

## BORANG PENGESAHAN STATUS TESIS <sup>♦</sup>

**JUDUL: FINITE ELEMENT MODELLING OF OLSEN-ERICHSEN SHEET METAL FORMABILITY TEST**

**SESI PENGAJIAN: 2009/2010**

Saya,

**ISLAHUDDIN IDHA NAWAWI (870214-91-5003)**  
(HURUF BESAR)

mengaku membenarkan tesis (Sarjana Muda / ~~Sarjana~~ / ~~Doktor Falsafah~~)\* ini disimpan di perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Tesis ini adalah hakmilik Universiti Malaysia Pahang (UMP).
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. \*\*Sila tandakan (√)

**SULIT**

(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)

**TERHAD**

(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi / badan di mana penyelidikan dijalankan)

**TIDAK TERHAD**

Disahkan oleh:

\_\_\_\_\_  
(TANDATANGAN PENULIS)

Alamat Tetap:  
**Lot 7648,**  
**Kg Changkat Rambai,**  
**36800, Kg Gajah**  
**Perak Darul Ridzuan.**

Tarikh: **24 NOVEMBER 2009**

\_\_\_\_\_  
(TANDATANGAN PENYELIA)

**AHMAD SYAHRIZAN BIN SULAIMAN**  
(Nama Penyelia)

Tarikh: **24 NOVEMBER 2009**

CATATAN: \* Potong yang tidak berkenaan.

\*\* Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali tempoh tesis ini perlu dikelaskan sebagai SULIT atau TERHAD.

♦ Tesis dimaksudkan sebagai tesis bagi Ijazah Doktor Falsafah dan Sarjana secara Penyelidikan, atau disertasi bagi pengajian secara kerja kursus dan penyelidikan, atau Laporan Projek Sarjana Muda (PSM).

FINITE ELEMENT MODELLING OF ERICHSEN OLSEN SHEET METAL  
FORMABILITY TEST

ISLAHUDDIN IDHA NAWAWI

A report submitted in partial fulfilment of the requirements  
for the award of the degree of  
Bachelor of Mechanical Engineering

Faculty of Mechanical Engineering  
UNIVERSITI MALAYSIA PAHANG

NOVEMBER 2009

## TABLE OF CONTENTS

	<b>Page</b>
<b>SUPERVISOR’S DECLARATION</b>	iii
<b>STUDENT’S DECLARATION</b>	iv
<b>ACKNOWLEDGEMENTS</b>	vi
<b>ABSTRACT</b>	vii
<b>ABSTRAK</b>	viii
<b>TABLE OF CONTENTS</b>	ix
<b>LIST OF TABLES</b>	xii
<b>LIST OF FIGURES</b>	xiii
<b>LIST OF SYMBOLS</b>	xiv
<b>LIST OF ABBREVIATIONS</b>	xv
<b>CHAPTER 1     INTRODUCTION</b>	
1.1     Project Background	1
1.2     Problem Statement	1
1.3     The Objectives of the Research	2
1.4     Scopes of The Project	2
<b>CHAPTER 2     LITERATURE REVIEW</b>	
2.1     Finite Element Analysis	3
2.2     Advantage Using Finite Element Method	5
2.3     Element	5
2.4     Node	6
2.5     Olsen Erichsen Test	7

2.6	Sheet Metal Forming	8
2.7	Deep Drawing	9
2.8	Formability Test	10
2.9	Ductility	11
2.10	Mechanical Properties	12
2.11	Plane Stress	15
2.12	Axisymmetric	16

### **CHAPTER 3      METHODOLOGY**

3.1	Flow Chart	18
3.2	Die Design	19
3.3	Finite Element Method	21
3.4	Mechanical Event Simulation	24
3.5	Type of Element	24
3.6	Element Parameter	26
3.7	Material Properties	28
3.8	Boundary Condition	29
3.9	Performing Analysis	32
3.10	Prescribed Displacement	32
3.11	Surface to Surface Contact	33

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

4.1	Introduction	34
4.2	Result from modelling Algor Simulation	34
4.3	Discussion	44

**CHAPTER 5 CONCLUSION AND RECOMMENDATIONS**

5.1	Introduction	46
5.2	Objectives Achieved	46
5.3	Limitations	46
5.4	Recommendations	47
5.5	Conclusion	47

<b>REFERENCES</b>	48
-------------------	----

**APPENDICES**

A	2D drawing of full die design	50
B	2D drawing of indenter	51
C	2D drawing of ball indenter	52
D	2D drawing of upper die	53
E	2D drawing of lower die	54
F	2D drawing of base indenter	55
G	Gantt chart final year project two	56

**LIST OF TABLES**

<b>Table No.</b>		<b>Page</b>
2.1	Degree of Freedom for generic element type	6
3.1	Material Properties of Brass, Red	22
3.2	Material Properties of Aluminum 5052-T4	22
3.3	Material Properties of steel Magnesium Alloy AZ63A	22
3.4	The table of variables for the simulation modeling in this project	30
3.5	The table of constant value for the simulation modeling in this project	31
4.1	Material Properties of Specimen	40

**LIST OF FIGURES**

<b>Figure No.</b>		<b>Page</b>
2.1	Finite Element Analysis	4
2.2	Schematic Diagram of Erichsen Test	7
2.3	Deep Drawing Sequence	10
2.4	Stress-Strain Curve	14
3.1	Design of die in Auto CAD of Erichsen Test	17
3.2	Mesh density and Mesh size	19
3.3	Figure of drawing with mesh	20
3.4	Figure of boundary condition of sheet metal and its state	25
3.5	Figure of boundary condition of punch and its state	26
3.6	Figure of boundary condition of blank holder and its state	26
3.7	Figure of boundary condition upper die and its state	27
3.8	Figure of full boundary condition	27
3.9	Figure of prescribed displacement	28
3.10	Figure of Load curve for punch	29
3.11	Figure for load curve setting	29
4.1	Aluminum 5052 –T4	32
4.2	Magnesium (AZ63A)	32
4.3	Brass, red	33
4.4	Graph for the Elastic Plane Stress	33

4.5	Aluminium 5052 –T4	34
4.6	Brass, red	35
4.7	Magnesium (AZ63A)	35
4.8	Graph for the Plastic Plane Stress	36
4.9	Aluminium 5052 –T4	37
4.10	Brass, red	37
4.11	Magnesium (AZ63A)	38
4.12	Graph for the Elastic Axisymmetric	38
4.13	Aluminium 5052 –T4	39
4.14	Brass, red	40
4.15	Magnesium (AZ63A)	40
4.16	Graph for the Plastic Axisymmetric	41



**LIST OF SYMBOLS**

$\varepsilon$	Strain
$\Delta\sigma$	Stress range
$\sigma_m$	Yield stress of deformed material
$\sigma_t$	Tensile stress
$N$	Newton
$\varepsilon$	Strain
$\sigma$	Stress
$F$	Force
$A$	Area
$E$	Modulus of Elasticity
$k$	kilo

**LIST OF ABBREVIATIONS**

cm	centimetre
OET	Olsen-Erichsen Test
FEM	Finite Element Method
m <sup>2</sup>	Metre square
OET	Olsen-Erichsen Test
FEA	Finite Element Analysis
DOF	Degree of Freedom

## **ABSTRACT**

The main objective of this project is to assess the characteristic and formability of sheet metal to withstand plastic deformation without rupture using finite element method or to be more specific using ALGOR software with Olsen-Erichsen Test. Olsen-Erichsen Test is the one of the most popular technique since it is the method that used long before compare with other method. In this test there is a variable that being manipulate which are the element definition and type of material like aluminium, magnesium and brass. Meanwhile the variable that constant is the size dimension. After the drawing drawn in ALGOR software fill in the information needed to run the simulation and the data needed is collected. Through the data, the graph of displacement deformation between axis Z and Y is plotted. The data is analyse and found that magnesium is the most ductile followed by aluminium and brass. From the research data, it can be verify using the information in table of material properties to check the result from simulation is right or not.

## ABSTRAK

Objectif utama dalam kajian ini adalah untuk menganggar sifat dan kebolehan bahan kepingan logam dalam menampung perubahan bentuk plastik sebelum bahan tersebut mengalami kerosakan dengan menggunakan kaedah finite element atau dengan lebih tepat lagi menggunakan aplikasi perisian ALGOR melalui Ujian Olsen-Erichsen. Ujian Olsen-Erichsen ini adalah antara kaedah yang sangat terkenal kerana merupakan salah satu kaedah yang paling awal digunakan berbanding kaedah yang lain. Di dalam ujian ini terdapat pemboleh ubah yang di manipulasikan iaitu definisi elemen dan juga jenis bahan yang berlainan iaitu aluminium, magnesium dan juga tembaga. Manakala pemboleh ubah yang di malarkan ialah dimensi saiz bentuk bahan. Setelah lukisan dibuat di dalam perisian Algor, isikan maklumat yang diperlukan untuk menjalankan simulasi dan data yang diperlukan disimpan. Melalui data tersebut graf perubahan bentuk antara paksi Z dan Y dihasilkan. Data dianalisis dan didapati magnesium paling mudah berubah bentuk diikuti oleh aluminium dan tembaga. Daripada data kajian, ia boleh disahkan menggunakan maklumat dalam jadual sifat bahan menentukan keputusan data kajian simulasi adalah benar atau tidak.

## **CHAPTER 1**

### **INTRODUCTION**

#### **1.1 PROJECT BACKGROUND**

The Olsen-Erichsen test is a method of measuring the ductility and drawing properties of strip or sheet metal which involves determination of the width and depth of impression. It is the oldest formability method of measuring the ductility and drawing properties of sheet metal. The test simulating a deep drawing operation is made by a cupping test in which a piece of sheet metal, restrained except at the center, is deformed by a cone-shaped spherical-end plunger until fracture occurs. The height of the cup in millimeters at fracture is a measure of the ductility. This test is sometimes used to detect stretcher straining and indicates the surface finish after drawing,

#### **1.2 PROBLEM STATEMENT**

The products made by sheet-forming processes consist of a large variety of shapes and sizes, ranging from simple bends to double curvatures with shallow or deep recesses. In many cases while deforming the sheet metal, the component tends to fractures at certain point. The causes of failure are parameters related to forming process. One of the main

problems with the planning of sheet metal forming is the testing of formability in sheet metals and to forecast the results. So analysis in Olsen-Erichsen Test is done to analyze the criteria of sheet metal.

### **1.3 OBJECTIVE**

The focus of this research is to assess the characteristic and formability of sheet metal due to elasticity and plasticity and also performing the simulation of Olsen-Erichsen Test. Using finite element method this study will estimate the ductility of the sheet metal.

### **1.4 PROJECT SCOPES**

This research is focus on the effect of deformation displacement for different material after given nodal prescribed displacement. The scopes of this project are:

#### **1.4.1** To perform a simulation for forming process of OET:

This simulation test covers the procedure for conducting the ball punch deformation test for Brass, Aluminum and Magnesium sheet metal intended for forming application.

#### **1.4.2** To assess characteristic & formability of sheet metal:

Estimate the ductility of sheet metal of Brass, Aluminum and Magnesium sheet metal sheet metal from OET using the material properties table.

## References:

- [1] David V. Hutton, *Fundamental of Finite Element Analysis*, Mc Graw Hill, 2004
- [2] [http://en.wikipedia.org/wiki/Finite\\_element\\_method](http://en.wikipedia.org/wiki/Finite_element_method)
- [3] Algor Help File
- [4] [http://me.aut.ac.ir/staff/solidmechanics/alizadeh/Erichsen%20Cupping%20Test\\_files/image003.jpg](http://me.aut.ac.ir/staff/solidmechanics/alizadeh/Erichsen%20Cupping%20Test_files/image003.jpg)
- [5] Charles Wick, Raymond F. Veilleux, *Tool and Manufacturing Engineers Handbook Forming*, Volume 2, Forming, Fourth Edition, SME, 1984
- [6] Henry E. Theis, *Handbook of Metalforming Process*, 1999, page 40
- [7] <http://metals.about.com/library/bldef-Olsen-Ductility-Test.htm>, 17 October 2009
- [8] <http://www.answers.com/topic/sheet-metal-forming>, 14 August 2009
- [9] Serope Kalpakjian, *Manufacturing Engineering And Technology*, Prentice Hall, 2006
- [10] <http://www.custompartnet.com/wu/images/sheet-metal/deep-drawing-sequence.png>
- [11] William F. Smith, Javed Hashemi, *Foundation of material Science and engineering*, Mc Graw Hill 2006
- [12] M. Akrouf, M. Ben Amar, C. Chaker, F. Dammak (2008) Numerical And Experimental Study Of The Erichsen Test For Metal Stamping, APEM Journal
- [13] Karl-heinrich Grote, Erik K. Antonsson, (2009) Springer Handbook of Mechanical Engineering, Page 589
- [14] Chu C.C. (2003). Elastic plastic springback of sheet metals subjected to complex plane strain bending histories", Solids structures, Vol. 22
- [15] S. A. Jenabali, A. Nazarboland, E. Mansouri, S. Abbasi, (2006) Investigation of formability of low carbon steel, Iranian Journal of Science & Technology, Vol. 30
- [16] Raymond Aurelius Higgins, (2006) Materials for engineers and technicians, Page 39

- [17] George E. Totten, Kiyoshi Funatani, Lin Xie, (2004), Handbook of metallurgical process design, Page 44
  
- [18] Yokai, M., and Alexander, J. M., "*A Further Investigation of the Erichsen Test*," Sheet Metal Industries, July 1967, pp. 466-475
  
- [19] [Shiro Kobayashi](#), [Soo-Ik Oh](#), Taylan Altan, *Metal Forming And The Finite Element Method*, Oxford University Press, USA (March 9, 1989)
  
- [20] Mechanics of Material: Stress, [http://www.efunda.com/formulae/formula\\_index.Cfm](http://www.efunda.com/formulae/formula_index.Cfm), 19 November 2009.
  
- [21] Roger T. Fenner, *Finite Element Methods for Engineer*, Imperial College Press, London, The Macmillan Press Ltd, 1997, Page 148