UNIVERSITI TEKNIKAL MALAYSIA MELAKA

INVESTIGATION ON SPRINGBACK CHARACTERISTIC ON VARIOUS SPEEDS OF ALUMINUM ALLOYS SHEET 6061

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

By

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DECLARATION

I hereby, declared this report entitled “Investigation on Springback Characteristic on Various Speeds of Aluminum Alloys Sheet 6061” is the results of my own research except as cited in references.

Signature : …….

Author’s Name : WAN NURAINI BTE MOHD JAMIL

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Engineering Materials) with Honors. The member of the supervisory committee is as follow:

……..……

(Principal Supervisor)

(MOHAMAD HAIDIR BIN MASLAN)

ABSTRAK

Aluminium gabungan ini banyak digunakan dalam industri perkilangan memproses pembentukan. Namun, lembaran aluminium gabungan memiliki kelemahan terhadap fenomena sbangkit kembali dalam pembentukan lembaran logam. Pembengkokan adalah salah satu jenis lembaran logam membentuk yang menciptakan bangkit kembali yang akan mengarah pada dimensi tidak tepat dari bahagian. Tujuan dari projek ini adalah untuk menyiasat perilaku bangkit kembali dan ciri-ciri dalam rangka untuk mengawal dan meminimumkan masalah ini. Dalam projek ini, bahan yang digunakan adalah paduan aluminium siri 6061. Proses bending U-berbentuk akan membongkok ke 90 ° selama percubaan. Tujuan dari uji bending adalah untuk menentukan pengaruh kelajuan pukulan pada fenomena springback semasa proses pembentukan lembaran logam. Sudut jumlah springback dapat diukur dengan menggunakan koordinat pengukuran di empat daerah dengan menggunakan kelajuan yang berbeza. Uji mekanik dilakukan uji kekerasan sesuai dengan standard ASTM setelah uji lentur dan tarik. Kelajuan pukulan lebih rendah akan mengurangkan pemulihan elastik. Sudut membongkok dekat sampai 90 derajat di kelajuan pukulan di bawah 5mm/s. Selain itu, uji tarik membuktikan bahawa kelajuan pukulan yang lebih tinggi akan memberikan pemulihan elastik yang lebih besar. Pemulihan elastik menjadi lebih besar pada kelajuan 10 mm/s berbanding dengan kelajuan 3mm/s dan 0.5mm/s. Kemudian, nilai kekerasan meningkat dengan jumlah yang lebih besar musim semi kembali. Deformasi plastik yang lebih besar akan memberikan sumbangan terhadap pemulihan elastik sebagai nilai kekerasan meningkat. Selain itu, tekan luar bongkok mempunyai kekerasan

yang lebih besar berbanding dengan tarik dalam bongkok. Melalui kajian ini, perbaikan proses pemeriksaan bending bisa untuk mengurangkan jumlah springback.

ABSTRACT

Aluminum alloy is widely used in manufacturing processing industry for sheet metal forming. However, aluminum alloy sheet have the drawbacks against the springback phenomena in sheet metal forming. Bending is one types of sheet metal forming that create springback or residual plastic strain during the operation which will lead to the inaccurate dimension of the part. The objective of this project is to investigate the springback behaviour and characteristic in order to control and minimize this problem. In this project, the material used is aluminum alloy 6061 series. The U-shaped bending process will be bending into 90° during the experiment. The aim of this bending test is to determine the effect of punch speeds on springback phenomenon during sheet metal forming process. The angle of springback amount can be measured by using the coordinate measuring machine in four characteristic tooling regions. The springback characteristic will be observed in the tensile test by using different speeds. The mechanical test of hardness test is performed according to ASTM standard after the bending and tensile test. The lower punch speed will reduced the elastic recovery. The bending angles are near to 90 degree at the punch speeds below 5mm/s. Other than that, tensile test proved that higher punch speed will give greater elastic recovery. The elastic recovery becomes greater at speed of 10mm/s compared to the speeds of 3mm/s and 0.5mm/s. Then, hardness value is increased with the greater amount of spring back. The greater

plastic deformations will contribute to the elastic recovery as the hardness value increasing. Besides, compressive stress of outer bending has higher hardness compared to the tensile stress of inner bending. Through this study, the improvement of the bending process can be inspecting in order to reduce the springback amount.

DEDICATION

To my beloved father, mother, sister and friends.

Thank you for the undivided loves and supports.

ACKNOWLEDGEMENT

Alhamdulillah, by the grace of Allah who has provided me with a good health I can complete my report as a perfect condition in time.

Firstly, I would like to express my sincere gratitude to my supervisor, En Haidir for supporting me, constructive comment, and advice in preparing my report. I am very appreciating for the guideline, information and ideas to complete this project.

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Special thanks to all the lovely members of my family without the encouragement and overwhelming support, this project would not have been possible. I also would like to thank for my friends in the faculty manufacturing engineering for their help and support.

Finally, I hope this report will be valuable and benefit to future student.

Thank you, Wassalam.

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Ri - Initial Bend Radius

øi - Initial Bend Angle

a1 - Initial Profile Angle

Rf - Final Bend Radius

øf - Final Bend Angle

a2 - Final Profile Angle

ε - Engineering Strain

l_o - Initial Gauge Length

l_i - Instantaneous Gauge Length.

ε_t - True Strain

A_i - Instantaneous Cross Sectional Area

A_o - Initial Cross Sectional Area

σ - Stress

σ - True Stress

S - Second

F - Force

Ln - Bend Allowance of the Neutral line

ρ - Electrical Resistivity of the Material

μ	-	Coefficient of Friction
θ	-	Angle
Ks	-	Spring Back Factor
T	-	Thickness of the Material
εpl	-	Difference between the Plastic
εe	-	Elasticde Formation
εt	-	Permanent Deformation Plastic
R_i	-	Radius of Curvature

R	-	Resistance of a Wire
μ	-	Coefficient of Friction
ρ	-	Radius of Curvature
θ	-	Angle
n	-	Number of Panels, Strain hardening Exponent
c	-	Die Gap
E	-	Young's modulus
L	-	Contact Length
R_d	-	Die Radius
t	-	Sheet Thickness
R_f	-	Radius of Curvature After Spring Back
α	-	Bend Angle
Ro	-	Original Radius of Curvature
W	-	Width of die
l	-	Length
d	-	Diameter
m	-	Meter
s	-	Second
°C	-	Degree Celcius
%	-	Percentage
N	-	Newton

LIST OF ABBREVIATION

mm	-	Milimeter
ASTM	-	American Standard Test Method
kN	-	KiloNewton
YS	-	Initial Yield Stress
BHF	-	Blank Holder Force

HSS	-	High Strength Steel
CMM	-	Coordinate Measuring Machine
GPa	-	GigaPascal
Mpa	-	MegaPascal
RT	-	Room Temperature

CHAPTER 1

INTRODUCTION

1.1 Background Study

Sheet metal forming is very functional and useful in manufacturing industry. The bending process is one of the examples in sheet metal forming. Bending process occur when the material change it shape and characteristic. The material is stressed beyond the yield strength but below the ultimate tensile strength (Maziar Ramezani and Zaidi Mohd Ripin, 2009). Otherwise, metal is stretched outside of the bend radius and compressed inside of the bend radius during the bending process cause the metal near the neutral axis stress to value below the elastic limit and metal far away from the neutral axis stress beyond the yield stress (Sen Jiang, M.S., 1997). Springback can be defined as the shape is change in bending process after removal the external loads. It is caused by when the stored energy release during the removal of the external loads (Carden, *et al*., 2002). The springback is also affected by the unloading stress and strain response of the material (Yoshida *et al.*, 2002). Other than that, springback of sheet bending process would create severe residual stresses in tool design (George E. Totten, 2002). In other words, when the bending is removed the elastic turns to its origin but it restricted by the plastic deformation zone. This characteristic can be defined as the springback phenomena.

1.2 Problem Statement

Springback occur during the bending process lead to the inaccurate dimensions. This will problem to assemble of component in the manufacturing industry. Springback cause the deviation from the desired shape because of the influenced by the elastic modulus, yield strength of materials and the bending ratio radius of curvature/sheet thickness (Sen Jiang, M.S., 1997). Beside, previous research show the springback phenomena effect by the materials parameter, tooling geometry and process parameter on the spring back amount (Hong Seok Kim and Muammer Koc, 2008; Moon, Y.H., *et al*., 2002). Hence, it is important to control and minimize the springback phenomena in order to increase the standard quality in the manufacturing industry. Besides, it can reduces the reject part from the production line and achieve better process control. Furthermore, the economic will be effect in terms of delayed production and reject of the production. According to the Moon, Y.H., *et al*., (2002) the springback amount influenced by the tool temperature when increasing of the die temperature will lower the spring back amount due to lowered flow stress at elevated temperature. Otherwise, the influences of the parameters such as punch speed, friction coefficients, various temperature, and blank holder forces can affect the springback phenomena (Hong Seok Kim and Muammer Koc, 2008). In this project, the parameter of punch speed is using to investigate the springback characteristic by bending process in order to reduce the spring back amount. Other than that, the characteristic of springback will investigated from the tensile test.