SPRINGBACK BEHAVIOR AND SURFACE QUALITY OF AUSTENITIC STAINLESS STEEL PLATE DURING BENDING PROCESS

MOHD SHAHRIMAN BIN SUTAN

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To my beloved mother and father

Hj. Sutan B. Hj.Abd Hamid

Hjh. Kasmah Bt. Ismail

My beloved wife & daughter

Azrina Bt. Zakaria

Airis Zahrah Soffiya Bt. Mohd Shahriman

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ABSTRACT

This project presents the design development and fabrication of bending dies and spring-back in behaviour and surface quality bending process on a Austenitic Stainless Steel 316 plate by means of stamping machine. A bending die had been designed in 2D and 3D using AutoCad and Solidwork. In order to find spring-back in bending, a ‘‘V’’ shaped die is designed and fabricated. The aims of this study is to investigate how much can 316L stainless steel sheet resile at various angle and to bring forward spring-back graphic to field of knowledge. Spring-back is a common phenomenon in sheet metal forming, caused by the elastic relocation of the internal stresses during unloading. It has been recognized that spring-back is essential for the design of tools used in sheet metal forming operations. Therefore, in this study the subject of bending dies and spring-back in bending process has been investigated rolling direction is one of the factors to control the spring-back. In this study two directions (along & across bending) of the rolling direction were analyzed using optical microscope to check the surface quality. A bending die was fabricated using standard procedure and machining. The special design 316L plates were used as the strip and stamped using Press Machine. Most of the components were fabricated using the various facilities at KKTM Balik Pulau, Pulau Pinang. Hardened Steel punches with various angles (60°, 90° and 110°) were used. The upper surface bending was collected and analysed using microscope. The minimum angle and surface quality of the plates were then recorded.

ABSTRACT

Projek ini membentangkan acuan tekan dan ‘spring-back’ dalam proses lenturan ke atas plat ‘Austenitic Stainless Steel 316’ dengan cara menggunakan mesin tekan. Perbezaan penumbuk keluli keras di mana saiz ketebalan besi 316L yang digunakan adalah 1 mm. Lukisan 2D dan 3D acuan lenturan telah direka menggunakan perisian AutoCad dan Solidwork. Untuk mendapatkan ‘spring-back’ di dalam lenturan, acuan berbentuk, ‘‘V’’ telah direka dengan tujuan untuk mengetahui bahan-bahan logam lembaran keluli boleh berubah dalam pelbagai sudut. ‘Spring-back’ adalah fenomena biasa dalam lembaran logam membentuk, berpunca daripada daya dalaman yang dialihkan. Ianya telah diiktiraf bahawa ‘spring-back’ adalah perlu untuk digunakan dalam lembaran logam bagi operasi membentuk. Oleh itu dalam kajian ini subjek acuan lenturan dan ‘spring-back’ dalam proses melengkung telah dikaji. Arah gelekan merupakan salah satu factor untuk mengawal ‘spring-back’. Dalam kajian ini dua arah iaitu sepanjang lenturan dan melalui lenturan telah dianalisis menggunakan mikroskop untuk memeriksa kualiti permukaan plat tersebut. Dalam proses ini, acuan lenturan akan dihasilkan mengikut prosedur standard dan pemesinan. Plat 316L dengan reka bentuk khas telah digunakan sebagai kepingan dan ditekan menggunakan mesin penekan. Kebanyakan komponen telah dihasilkan menggunakan pelbagai mesin dan alatan yang terdapat di KKTM Balik Pulau, Pulau Pinang. Penumbuk keluli keras menggunakan tiga sudut iaitu (60°, 90° and 110°) telah digunakan. Lentur permukaan atas dikumpulkan dan dianalisis menggunakan optical mikroskop. Sudut dan permukaan minimum kualiti plat kemudiannya direkodkan.

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D, d - diameter

F - Force

g - Gravity = 9.81 m/s

I - Moment of Inertia

l - Length

m - Mass

N - Rotational velocity

P - Pressure

Q - Volumetric flow-rate

r - Radius

T - Torque

V - Velocity

w - Angular velocity

x - Displacement

z - Height

θ - Angle

ρ - Density

α_f - Final sheet angle

R_f – Radius

α_i – Die angle

R_i – Die Radius

t – Thickness

TS – Tensile Strength

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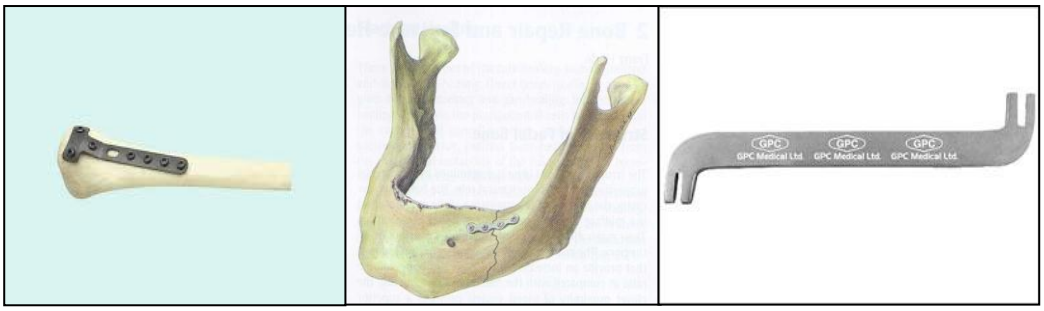
CHAPTER 1

INTRODUCTION

1.1 Project Background

Sheet metal stamping plays a major role in many industries today. Sheet metals have a wide range of application in industry and commonly used for automobiles, household goods, electronics and medical devices (Ozgu Tekaslan *et al*. 2008). Spring-back can be minimized by means of die design however it cannot be eliminated totally. To reduce spring-back, compression to minimum is one of the most important problems in die design **(**Ozgu Tekaslan *et al.* 2006). As part components get smaller and tolerances get tighter, the dimensional accuracy of a stamped part becomes a crucial factor in determining the overall quality of the part. In most, if not all, sheet metal forming processes, spring-back is the major problem faced (Y.E. Ling *et al*. 2005).

Stainless steel 316L (SS316L) is widely use in various products and is the common material for the manufacture especially implant bone plate because of corrosion resistance, heat resistance, heat treatment, welding and machining. Bone plates (Figures 1.1) are surgical tools, which are used to assist in the healing of broken and fractured bones.



Figures 1.1 Bone plate (www.gpc-medical.com)

At present, the bone plates are produced by CNC Milling machining, whereby several jigs, fixture and cutting processes are used to produce the bone plates. In order to minimize the machining time and cost, stamping process is much faster to produce the bone plates compared to milling and drilling.

Before that, an investigation must be made to observe and verify that stamping processes are suitable for SS316L in terms of its upper surface & back surface, and in order to minimize the spring-back amount after stamping processes.

1.2 Problem Statement

Some of the issues related to bending or stamping process are highlighted as follows:

1. What is the optimum bending angle and dwell time setting to minimize spring-back issue in achieving the desired angle?
2. The spring-back problems such as increased tolerances and variability in the subsequent forming operations, in assembly, and in the final part. These effects typically degrade the appearance and quality of the products being manufactured - Robert H. Wagoner *et.al.* (2013)
3. Data from previous studies on bending especially on material type 316L is still limited. Mostly used material type include *Stainless Steel, Brass, Cooper, Galvanized & Aluminium – Zafer Tekıner (2003)*

Recently, in medical industry many companies are trying to form the bone plate in single stamping operation while keeping the material costs and the scrap down by using 316L plate. The driver for usage is 316L in the medical industry results from customers demand, high accident rate, lower price than titanium plat and effective production.

Spring-back causes the following problems in sheet-metal forming:

1) The assembly of the sheet metal components becomes problematic thereby increasing the assembly time and reducing the productivity.
2) Rolling direction affects the spring-back as the strength of the sheet-metal is different in various directions i.e. 316L sheet metal.
3) In medical industry different punch corner radius is used for different bending operations which in turn affects the spring-back in components.
4) A wide range of thickness are used in sheet-metal components which again affects the spring-back.

However, spring-back characteristic of SS316L has not been investigated widely and very little information is available about its behaviour during bending operations.

2.12 Research Question

1. What is the minimum angle after done bending process?
2. What is the measured angle for the spring-back after bending process?
3. Are there any crack occurs on that angle?

1.4 Project Objective

In the view of above mentioned facts the spring-back has been analysed in V-bending process with the following objectives:

1. To design and fabricate bending dies with various angle when bending SS 316L.
2. To study the effect of bending parameters on the spring-back and bending rolling direction of SS 316L plate.

1.5 Project Scope

1. Design bending die using AutoCAD and Solid Work.
2. Stamping process (bending) using Hydraulic Press Machine will be employed.
3. To studied spring-back at angle 60°, 90°& 110° and dwell time (5s, 10s & 15s) in bending process.
4. Austenitic Stainless Steel 316L plate will be used as strip material (0.5mm).
5. Harden Steel punches will be used as bending punches.
6. To analyse bending plate based on along and across the rolling direction using optical microscope.

1.6 Significance of findings

The significance of this project is to find out whether sheet metal stamping (bending) can be applied to a Austenitic Stainless Steel 316L plate with the desired quality to be used in the bone plates manufacturing industry.

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