INVESTIGATION OF THE MICROSCOPIC DEFORMATION BEHAVIOR AND SURFACE QUALITY OF AUSTENITIC STAINLESS STEEL PLATE DURING HOLES PIERCING PROCESS

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To my beloved mother and father
Suid Salleh
Asmah Pawanteh

My beloved wife
Siti Aisah Mohmad Ashari

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ABSTRACT

The purpose of this study is to investigate the effect of different clearances on smooth-sheared depth, burr height and surface quality. Austenitic stainless steel sheet metal of 316L with 3 mm thickness as used in this study. Experimental results showed that the burr, smooth sheared region and punch force greatly influenced by the clearance value between the die and punch. The results are in agreement with the previous theoretical and experimental works in the literature. The findings is expected to contribute to the process of developing medical implant device made from 316L stainless steel.

The study involved design and fabrication of a medium precision piercing die set of single station with one hole. Most of the die components were fabricated using the various facilities at KKTM Balik Pulau, Pulau Pinang.The punch was made of SKC50 steel with hardness of 64 HRC with diameter of 5 mm. Four different clearances of 5% (0.15mm), 7% (0.21mm), 10% (0.3mm) and 13% (0.39mm). These die clearances variation were obtained by using circular button die of different die diameter.

ABSTRAK

Kajian ini dilakukan bertujuan mengkaji kesan beberapa kelegaan pemotongan kepada kedalaman permukaan licin, ketinggian burr dan kualiti permukaan kepingan keluli austenitik. Kepingan keluli austenitik 316L dengan ketebalan 3 mm digunakan didalam kajian ini. Keputusan kajian menunjukkan kedalaman permukaan licin, ketinggian burr dan kualiti permukaan amat dipengaruhi oleh kelegaan diantara penebuk dan lubang. Keputusan ini selari dengan keputusan kajian ilmiah yang telah dibuat sebelum ini. Penemuan ini dijangka akan menyumbang dalam pembangunan alat implan yang dibuat daripada 316L .

Kajian ini melibatkan rekabentuk dan fabrikasi sebuah acuan tekan kejituan sederhanadengan satu stesen dan satu lubang. Kebanyakan komponen acuan tekan ini di fabrikasi menggunakan berbagai mesin dan alatan di KKTM Balik Pulau, Pulau Pinang. Penebuk di buat daripada bahan SKC50, dengan kekerasan 64HRC dan berdiameter 5 mm. Empat saiz kelegaan iaitu 5% (0.15mm),7% (0.21mm),10% (0.3mm) dan 13% (0.39 mm) digunakan. Saiz kelegaan ini ditentukan oleh saiz lubang pada lubang acuan tekan ini.

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LIST OF SYMBOLS

D, d - diameter

F - Force

g - Gravity = 9.81 m/s

I - Moment of inersia

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

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CHAPTER I

INTRODUCTION

1.1 Project Background

Sheet metal forming technology has been widely used in many industrial contexts especially in the automotive and electrical industries. Stainless Steel 316L is widely used in various products and is the common material for the manufacture of implant bone plates because it has corrosion resistance and harmless to human body. Bone plates as in figure 1.1 are used to connect fractured bones during healing process. It must be strong enough to withstand the tension in pulling the bones. Presently the bone plates is manufactured using machining operations whereby several jigs and various cutting tool are used in order to minimize the machining lead time and cost, stamping process offer better advantage in terms of manufacturing time as compared to milling and drilling operations. As such an investigation must be made to evaluate and verify the suitability that stamping processes is suitable for Stainless Steel 316L in terms of its deformation behaviour, burr formation and dimensional accuracy The stamping process that under study is hole piercing operation.

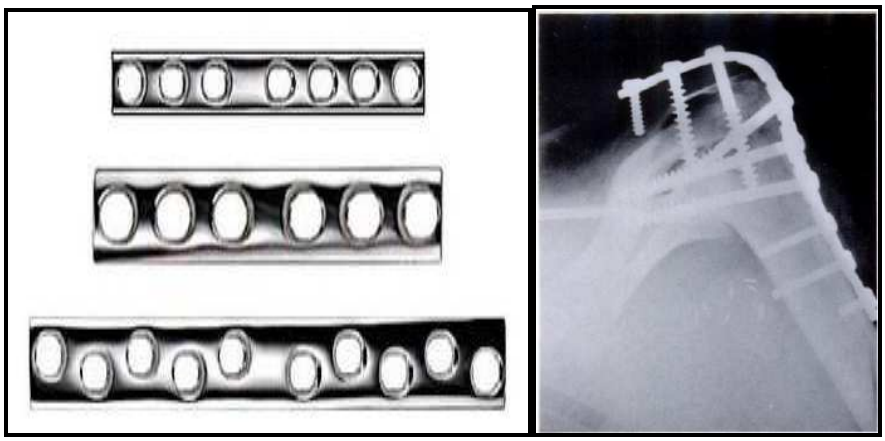

Figure 1.1 Application of bone plate in bone fracture treatment

Currently, the bone plate requires higher quality and lower cost. The sheared surface is one of the major indicators showing the product quality. This study is focused on the sheared wall surface quality in the piercing process. It is well known that burr and crack usually occur in the conventional piercing process. (as showed in figure 1.2) (Sutasn Thipprakmasa *et al*.,2008).

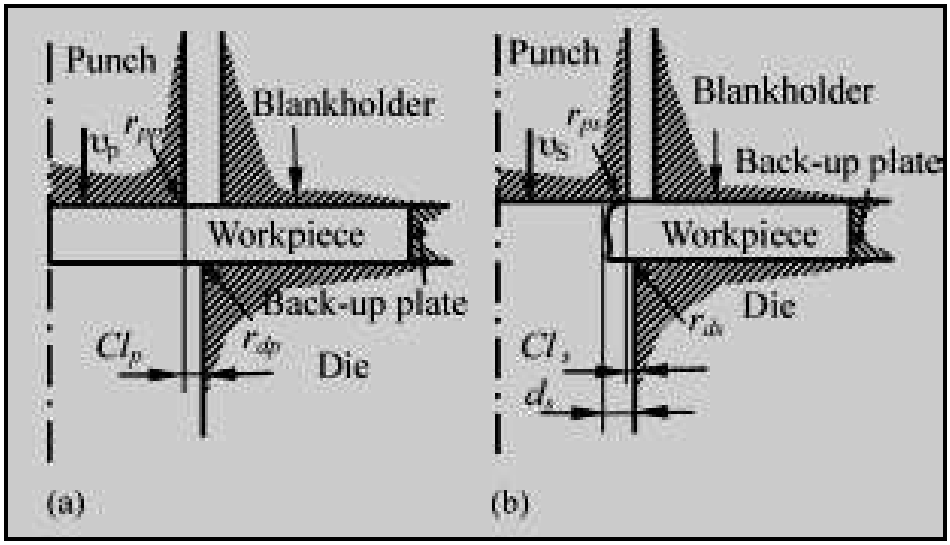

Fig. 1.2 Conventional pierce-shaving process:
(a) piercing step and (b) shaving step.

1.2 Problem Statement

Problems in Piercing Steel 316L can be divided into two segments which are the burr formation on the holes wall and the form accuracy of the holes after piercing.

1.2.1 Burr formation

Burr formation normally depends on the cutting clearance between punch and die opening. Optimum cutting clearance will produce minimum burr. Steel 316L has a high tensile strength which creates high resistance during shearing process. The deformation behaviour of the holes are normally divided into three segments with standard percentage which are plastic deformation, penetration and fracture as shown in figure 1.3.

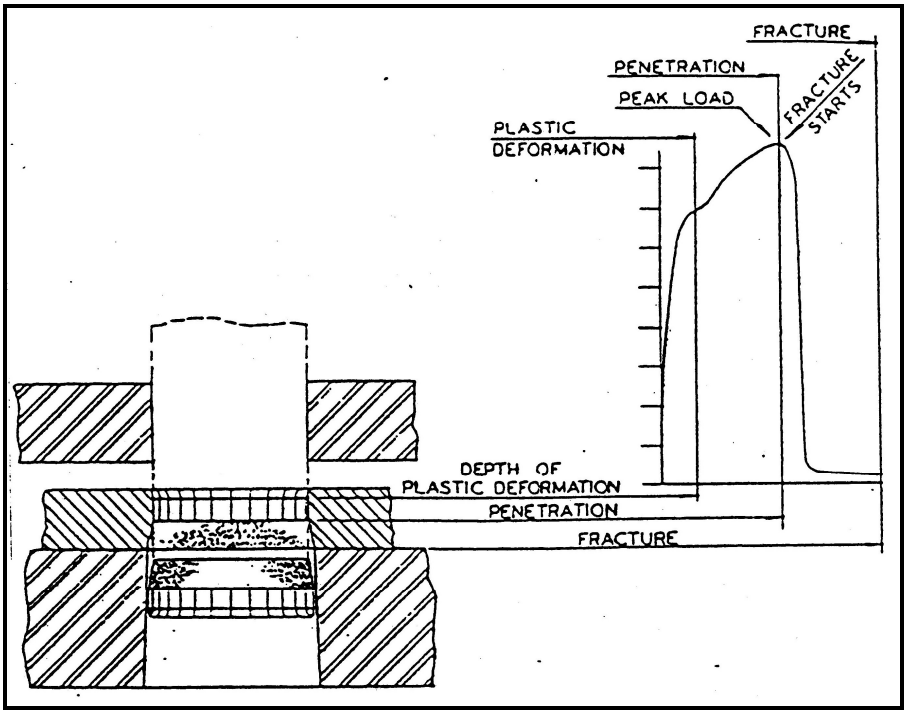

Figure1.3 Burr formation during piercing in three stages and respected load

However due to the high tensile strength of austenitic stainless steel the desired burr formation after piercing may not occur.

1.2.2 Dimensional Accuracy

Surface deformation at the top and bottom of the stamped plate effect the dimensional accuracy of the product. The force from the punch that penetrates the steel plate from top side will affect the top and bottom surface.

1.3 Research Questions

i. What is the burr height on the plate holes area after the piercing process?
ii. Are there any crack occurs on the hole wall?
iii. What are the hole sizes variation after piercing operation?

1.4 Project Objectives

The objectives of this project are

i. To design and fabricate a piercing die set.
ii. To investigate the effect of cutting clearances on the microscopic deformation behaviour of a pierced hole.
iii. To quantify the dimensional accuracy of the pierced holes.
iv. To evaluate the cutting clearances effect on stress and index failure using computer aided engineering analysis.

1.5 Project Scope

i. Pro Engineer stress analysis software will be used to analyze the piercing effect of 4 cutting clearances on the die openings.
ii. To design and fabricate the piercing die set using the available facilities at KKTM Balik Pulau.
iii. To apply the piercing operation using standard punches and dies via hydraulic press machine.
iv. 3 mm thickness austenitic stainless steel 316L plate will be used as strip material.
v. To collect samples and observes with profile projector and optical microscope.

1.6 Significance of the findings

The findings of this study will enable researchers to evaluate the potential of replacing machining by stamping operation in the manufacture of bone plates or other medical devices.