A STUDY ON EFFECT OF PROCESS PARAMETERS IN SHEET METAL FORMING SIMULATION OF AA5052

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DECLARATION

I declare that this project report entitled “A Study on Effect of Process Parameters In Sheet Metal Forming Simulation of AA5052” is the result of my own work except as cited in the references.

Signature : .....

Name : Tee Shaw Ting

Date : .....

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Structure & Materials).

Signature : .....

Name : Dr. Sivakumar A/L Dhar Malingam

Date : .....

DEDICATION

To my beloved mother and father

ABSTRACT

Deep drawing is an important process in metal forming and manufacturing. Attaining a defect free product with desired mechanical properties is always intense in market. This research will focus in studying the effect of process parameters in AA 5052-O sheet metal forming by finite element method. All simulations were done in LS DYNA 9.71, model surface were meshed in Hypermesh and the result plotted in LS PrePost. The numerical simulation provides a good qualitative coincidence with experimental result under similar conditions. Mesh refinement, coefficient of friction and material properties exhibit great influences in optimizing the verification result. The effect of blank thickness, blank holder force and punch velocity were studied in forming a circular cup for AA5052-O sheet metal. The results reveal that, 1.5mm thickness of blank implied greater drawability with acceptable thinning and higher punch velocity is desirable in industry. However, there is no significant effect in blank holder forces under this condition.

ABSTRAK

Proses pembentukan merupakan satu proses yang amat penting di industri pembuatan. Kajian ini dijalankan untuk mempelajari implikasi proses parameter AA 5052-O dalam proses pembentukan. Kajian ini dijalankan dengan menggunakan cara simulasi. Perisian LS DYNA 9.71 telah digunakan untuk mensimulasikan seluruh proses. Pengesahan keputusan simulasi telah berjaya dengan membandingkan dengan keputusan eksperimen dalam situasi yang sama. Perbaikan mesh, pekali geseran, dan maklumat bahan merupakan khuatir yang penting dalam pengesahan keputusan simulasi. Hasil eksperimen menunjukkan kepingan logam AA 5052-O dengan ketebalan 1.5mm adalah lebih sesuai dalam proses pembentukan. Selain itu, halaju yang tinggi adalan lebih sesuai dalam industri pembentukan.

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FEA	Finite Element Analysis
AL	Aluminium
BHF	Blank Holder Force
ASM	American Society for Materials
FML	Fiber–Metal Laminates
PDE	Partial Differentiate Equation
LDR	Limiting Drawing Ratio
CAD	Computer-Aided Design
FE	Finite Element

CHAPTER 1

INTRODUCTION

1.1 Background of study

Metal stamping is a technique that widely used to manufacture sheet metal. Stamping process uses punches and dies to transform flat metal sheets to desired shape. Sheet metal forming, or stamping, is a process where a material, referred to as the blank, is formed by stretching it between a punch and a die (Abdulla, S. and Tippa, B., 2013). This process produce high volume metal parts therefore the product produced by metal stamping can be seen from household appliances to automotive industries. Also, metal stamping use in producing large machinery parts particularly in automotive industries such as roof header, bonnets, and vehicle door.

Metal stamping involves punching, cutting and shaping processes. To produce a three dimensional shapes, a flat sheet metal is grip by blank holder and a die is inserted then a mechanical press is initiated to form the object. Basically, metal stamping machine is drive by mechanical press and hydraulic press. Hydraulic presses utilize piston with ease of lubricant oil to drive the punch and die. In this case, the force over the length of the stroke will remain constant. Mechanical press operated by stored energy in flywheel. The flywheel running continually until a clutch is betrothed. The driving force produced in mechanical press may vary with the length of stroke. Still many industries used high-speed mechanical press for operation due to the efficiency.

Traditionally, all the metal stamping process need to be tested experimentally using empirical methods, which are costly and time consuming as dies, blank holders and punches need to be manufactured. Finite element analysis (FEA) is the most common technique of simulating sheet metal forming processes to define whether a proposed design will produce parts free from defects such as fracture or wrinkle moreover this is a cost effective way to produce better quality product in a shorter production time (Zein, H. et al. 2014). In addition, it also helps engineers respond to market changes in a faster line of attack and provide simple way to help engineers understand interaction between materials with different surfaces.

Finite element analysis is a numerical method used to solve multiphysics problems. Finite element analysis offers a mean to find the approximate solution for the engineering and mathematical physic problems. The general procedure of finite element can be categorized to three major steps which is preprocessing, solving and post processing. Preprocessing process involve discretize of geometry, define material properties and apply boundary condition. In solving process, each interval divided will be assigned simple approximate functions, and the suitable linear equations are formulated and finally the equation is solved. The result is then obtains and visualize in post-processing step. Figure 1.1 shows the cup forming in finite element simulation and empirical method.

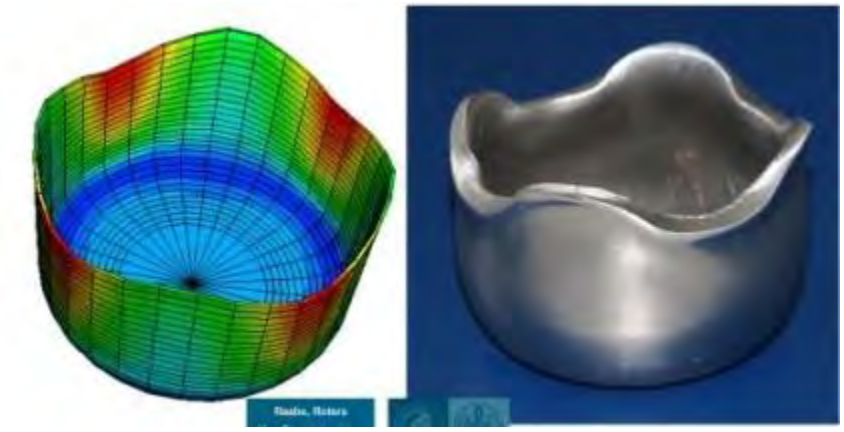

Figure 1.1: Sheet forming in finite element simulation and empirical method.

(Raabe, n.d.)

Experimental design is an important aspect in metal stamping process; it used to identify important factors that affect the process. Design of experiment show the variant information under hypothesized conditions to reflect the variation. The effect of variations can cause large influence to the quality of final stamping. Formability plot shows the wrinkles, cracks, unpredictable spring back of the sheet and other important aspects for the metal thinning after it is formed. This research embodies on the effect of material and process variation for circular cup metal forming process. There are many causes that may lead to occurrence of defects in metal stamping process, however this project only emphasize the thickness of the blank, variation of blank holder force and variation of ram velocities.

1.2 Problem statement

Sheet metal forming is among the most imperative metalworking processes in industries. The products produced under sheet metal forming are variety which did not constraint by shapes and sizes, it can range from simple bending to double curvatures, deep drawing and high complexity geometry designs. In past decade, metal forming tools are designed fully depend on experiences gained through acquaintance, and often needs a protracted and expensive trial and error process. This method leads to high cost of production, which cut down the profit of manufacturers. Consequently, simulations become the current trend to simulate the forming process in finite element method. Simulation makes it conceivable to spot errors and problems, such as wrinkles or splits in parts, on the computer at preliminary stage in forming processes. Thus, the production of real tools to run practical tests is not necessary.

1.3 Objectives

The objectives of this research are:

I. To validate sheet metal forming simulation;

II. To investigate the effect of process parameters in forming process.

1.4 Scope of project

The scopes of this research are:

I. The research is focus on the formability of AA5052-O as blank material;

II. A deep drawing simulation for circular cup is conducted using finite element method;

III. All the simulations is conducted using Explicit Dynamic Software;

IV. The effect of blank thickness, blank holder force and punch velocity in the deep drawing process is discussed.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Literature review shows critical and comprehensive review which relate to topic of project report. In research project, literature must be analyzed in sequence and synthesized logically. All information used must be up to date and related to the topic of interest. Literature not only just summarizes all the related previous research individually but should compare and relate all theories and findings.

2.2 Metal forming

Metal forming process defines as one of the most important manufacturing process in industry especially in metal working. The basic working principle of metal forming is applying force to deform the raw material. Generally in metal forming process, the stress exerted to the material should be greater than yield stress to let the materials undergoes plastic deformation to permanently deform the shape of the component and transformed into desired shape of the design. However, the stress applied must be controlled to less than ultimate stress of the materials to prevent failure. Therefore, forming process need fine control over material properties, because in order to obtain anticipated shape and size of

formed component, the ability of the material to flow plastically in solid state without deterioration of its properties should be controlled (Shah et al., 2014).

There are two major processes comprised in metal forming process which is bulk deformation process, and sheet metal working process. The surface area to volume ratio for bulk deformation is lower compare to sheet metal working that show higher surface area to volume ratio. The most common process that undergoes bulk deformation is forging, rolling, extrusion, and drawing. Conversely, sheet metal working processes include shearing, bending and deep drawing. Shearing usually used for punching hole, it cut the workpiece to desire shape. Basically shearing did not involve plastic deformation of the components but still commonly use in metal forming. Bending process deform workpiece by referring to some desired axis. Bending widely use in metal forming industry to manufacture channel, bracket, V-shape along a straight axis. In deep drawing process, a flat sheet metal is deformed when a punch is forced into a die cavity. The process classify as deep drawing only when the depth of the drawn part is greater than its diameter. Figure 2.1 shows illustration of sheet metal working process.

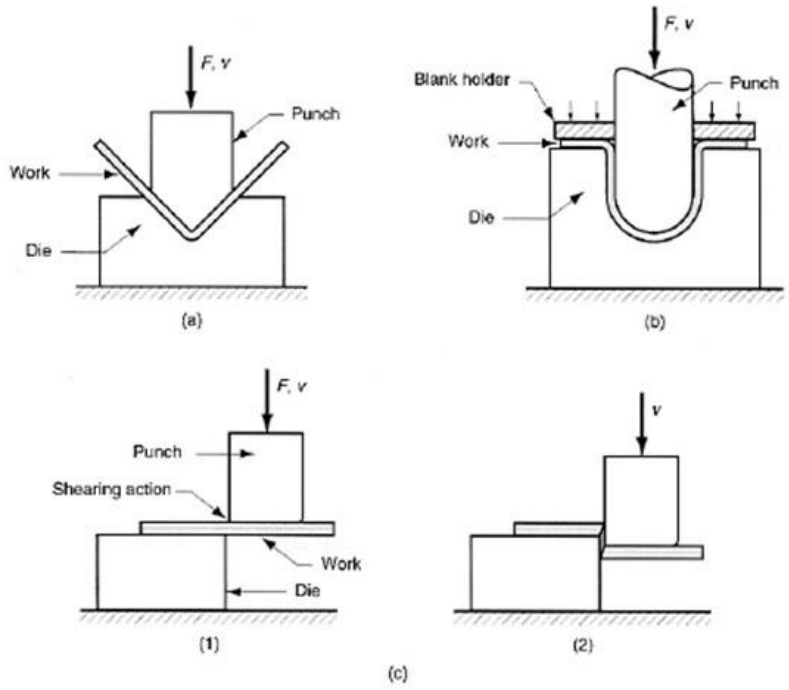

Figure 2.1: Sheet metal working (a) Bending; (b) Drawing; (c) Shearing; (1) as punch first contact sheet and (2) after cutting (Kenzie, 2015).

The deep drawing technology was first developed in 1700s, later numerous relevant studies and researches are done; develop as the commonly used forming process in all industrial applications now. A basic deep drawing process is to transform a flat sheet metal into a three dimensional cup, shell or box shape. However complex contour can be formed in deep drawing process too but as the complexity goes up, and the manufacturing difficulties increase. Sheet metal stamping process may operate by several types of press or machines, but three elementary components are essential: blank, sheet metal from which the part is to be made; punch; and die. Punch is forced to deform the flat sheet metal to anticipated shape for the base of the part then die cavity matches the punch and slightly broader as clearance to allow its passage. In result, the sheet metal is deformed follow the shape designed. A simple deep drawing process is shown in Figure 2.2. Initially, the work

piece or blank is placed on the die opening; blank holder is used to surround the blank that applies pressure to the blank ensure it work flat against the die and avoid sticking of blank and punch on return stock. A double action will experience by the equipment which from punch and blank holder.

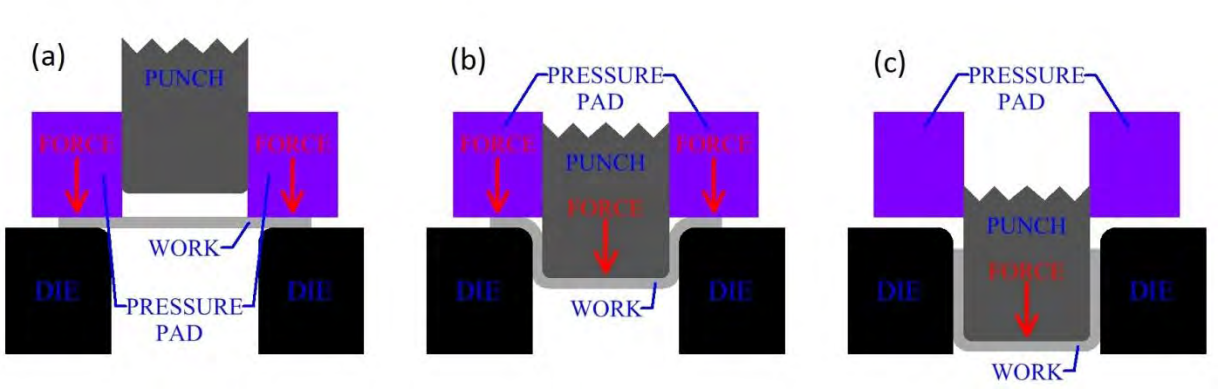

Figure 2.2: Simple Deep Drawing Process (a) Initial position of tools; (b) Punch moving down to deform the work; (c) The work is fully deformed (Sivaraman, 2016).

The basic concept for deep drawing process is that the drawing depth of the cup is higher than half of the cup diameter, if the depth of cup is smaller than the diameter of the cup it can be denoted as shallow drawing (Shah et al., 2014). Tool steels and iron commonly use as materials in making die and punch. However, the materials of making punch and die can also range from plastics to carbide. Engineering processes that prevails every step in deep drawing process are one of the imperative aspects that should be considered. There are several significant procedures during different stages in deep drawing process as reported by Johnson and Mellor (1962):

1. Radial drawing between die and blank holder;

2. Bending and sliding over the die corner;

3. Broadening between die wall and punch;

4. Bending and sliding over the punch corner;

5. Elongation and sliding over the punch nose.

In metal forming process the mechanical properties of materials such as flow stress and anisotropic describe the ability of the sheet materials to deform to produce desired shape. Anisotropic describe that when the properties of a material differ with different crystallographic orientations. Cold rolled sheet metal show crystallographic texture experienced in the process. After rolling process, the grains are usually distorted and elongated in one or more direction. Therefore sheet metal poses significant anisotropy mechanical behavior. In particular, plastic anisotropic give substantial effect in deep drawing process since large deformation will take place. Anisotropy coefficient, or Lankford coefficient R, are common parameter used to describe the anisotropy behavior. Equation (2.1) shows Lankford coefficient R, can be defined through uniaxial tensile test on rectangular sheet specimens.

$$R = \frac{\varepsilon_w}{\varepsilon_t} \tag{2.1}$$

where $\varepsilon_w$and ε_t are the plastic strain along the width direction and the thickness direction of the specimen respectively (Iordache et al., 2009). Limiting Drawing Ratio (LDR) is used to express the deep drawn formability, which is the largest value of the ratio between initial blank diameters and punch diameter with no necking and failure occur in the process. LDR