MODELING AND SIMULATION OF DRAWING PROCESS ON ALUMINIUM AA7075

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

by

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I hereby, declared this report entitled “Modeling and Simulation of Drawing Process on Aluminium AA7075” is the results of my own research except as cited in references.

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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 (Manufacturing Process)(Hons). The member of the supervisory is as follow:

………………………………

(Project Supervisor)

ABSTRAK

Projek ini membentangkan pemodelan dan simulasi proses penarikan ke atas aluminium AA7075. Penarikan ialah satu proses membentuk logam kepingan di mana sekeping logam kepingan dibentuk secara jejari oleh tindakan mekanikal acuan atas. Penarikan acuan memaksa bahan untuk mengalir bersama-sama dengan pergerakan acuan atas, yang menyebabkan ubah bentuk plastik kepada strukturnya. Bahan AA7075 adalah salah satu daripada bahan struktur yang paling penting secara meluas digunakan dalam industri automobil dan aeroangkasa. Penyelidikan yang luas dalam aspek kebolehbentukan yang diperlukan untuk membangunkan komponen yang berguna bentuk kompleks daripada bahan ini. Salah satu cara untuk mengukur kebolehbentukan adalah untuk mencari ciri-ciri pembentukan itu. Dalam kajian ini, kepentingan tiga parameter penting iaitu suhu bahan, suhu acuan dan halaju acuan kepada ciri-ciri proses penarikan ke atas aluminium AA7075 ditentukan. Gabungan kaedah FEA dan kaedah analisis Taguchi telah digunakan untuk menentukan pengaruh parameter proses. Simulasi telah dijalankan seperti pelbagai ortogon berubah bentuk menggunakan perisian Deform 3D. Berdasarkan ubah bentuk yang diramalkan daripada bentuk cawan dan analisis Taguchi dan analisis regresi berganda (MRA) diperhatikan bahawa suhu kepingan logam mempunyai pengaruh terbesar pada kebolehbentukan bahan aluminium.

ABSTRACT

This project presents the modeling and simulation of drawing process on aluminium AA7075. Deep drawing is a sheet metal forming process in which a sheet metal blank is radially drawn into a forming die by the mechanical action of a punch. Drawing dies force the material to flow in conjunction with the movement of the punch, which causes plastic deformation to its structure. The material, AA7075 is one of the most important structural materials extensively used in automobile and aerospace industries. Extensive research on its formability aspects is required to develop useful components of complex shapes out of this material. One of the ways to measure the formability is to find its drawability characteristics. In this study, the significance of three important deep drawing process parameters namely blank temperature, die temperature and punch velocity on the drawing characteristics of aluminium AA7075 sheet was determined. The combination of finite element analysis method and Taguchi analysis was used to determine the influence of process parameters. Simulations were carried out as per orthogonal array using DEFORM 3D software. Based on the predicted deformation of deep drawn cup and analysis of Taguchi and multiple regression analysis (MRA) it was observed that blank temperature has greatest influence on the formability of aluminium material.

DEDICATION

Special dedicate to all persons that help me in completing my final year project especially to my project supervisor Dr. Raja Izamshah bin Raja Abdullah.

To my beloved parents, my family, thank you for your comfort and supported me...

And not forgotten, Thanks to my lecturers and friends…
This report I'm fully dedicate to all of you…

ACKNOWLEDGEMENT

With the highest praise to God and thanks that I manage to complete the Final Year Project successfully. My deepest appreciation to Dr. Raja Izamshah bin Raja Abdullah as my project supervisor for his assistance, inspiring and guiding towards the progress of this project. He had provided not only his personal times to guide me in order to fulfil my report and my project but also provided his knowledge to solve the problem that I confronted.

I would also like to extend my gratitude to all the dedicated Manufacturing Lab technicians and my course mates for continue to guide me and supporting me to finish this final year project.

At this juncture, it is only logical for me to pay tribute to my family. Their undivided love and support are the beacons that have continued to motivate me through the harshest of situations and I believe it will also spur me on to greater achievement in the future.

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3D	-	3 Dimensional
Fb	-	Blankholder force
Y	-	Yield stress
D_o	-	Blank diameter
Dp	-	Punch diameter
Rd	-	Corner radii of die
UTS	-	Ultimate tensile strength (blank material)
Fmax	-	Drawing force maximum
N	-	Newton
Cm	-	Centimeter
LDR	-	Limiting draw ratio
mm	-	Millimeter
PSM	-	Projek Sarjana Muda
UTeM	-	Universiti Teknikal Malaysia Melaka
MRA	-	Multiple Regression Analysis

CHAPTER 1
INTRODUCTION

1.1 Background

Drawing is a compression-tension forming process. There is great interest in the process because there is a continuous demand on the industry to produce lightweight and high strength components. Design in sheet metal forming, even after many years of practice, still have certain unsolved challenges. This is due to the large number of parameters involved in deep drawing and their interdependence. These are material properties, machine parameters such as tool and die geometry, work piece geometry and working conditions. Research and development in sheet metal forming processes requires lengthy and expensive prototype testing and experimentation in arriving at a competitive product. Thus, Finite Element Method (FEM) had been introduced to overcome those problems.

This project focused on modelling and simulation of drawing process on aluminium AA7075. This process consists of the plastic deformation of an initial at blank subjected to the action of a rigid punch and die while constrained on the periphery by a blank holder. Conventional design processes for sheet metal forming are usually based on an empirical approach. However, due to the requirement of high precision and reliability in shaped parts, these methods are far away from a final and reliable solution. Nowadays, Finite Element Method (FEM) is being gradually adopted by industry to envisage the formability properties of sheet metal especially for the drawing process. The aim of this study is to evaluate and simulate the influence of parameter by means of a FEM analysis of a metal casing drawing process. In this project, a detail analysis will be given on the three dimensional shapes of drawing process.

Figure 1.1: Complex part of drawing process – Automotive plate

(Source: < http://www.comecstampi.com/en-sheet-metal-dies/deep-drawing-dies.htm>)

1.2 Problem Statement

In deep-drawing, the material is clamped with certain blank holding force which is between the blank holder and die. This will cause the flange to wrinkle during drawing. Wrinkling can be reduced or eliminated if a blank holding is loaded by a correct amount of force. A high blank holding force increases the punch force and causes the cup wall to tear. Forming speed or known as punch velocity also plays role in the formability, thus correct amount of the punch velocity should be identified.

There are some areas with defect on the blank which occur due to insufficient or excessive stress and strain either on the die or the material during the drawing process, identifying the heating approach will reduces or eliminate the defects.

To measure the formability and its drawability characteristics in Finite Element Analysis Software where in the past journals experimental work is conducted which consumes both time and cost. Minimizing the process steps or redrawing steps will also lead to saving time.

1.3 Objectives

In order to fulfil the aim of the project, the following objectives are proposed based on FEA capability and reliability in predicting the drawing process:

(a) To investigate the effect of drawing parameters (determination of punch velocity, blank temperature and die temperature) by numerical simulation deep drawing process of aluminium AA7075.
(b) To develop mathematical model using Multiple Regression Analysis (MRA) to predict stress and strain value of the aluminium AA7075.
(c) To simulate deep drawing process using Finite Element Analysis Software thus reduces the experimental work.

The outcome of this project will be useful for industries that manufacturing parts using drawing process as this will be the early stage of decision making process.

1.4 Scopes

In order to meet the objectives listed, the scopes of this project have been defined. They are:

(a) Design and envisage the formability properties of sheet aluminium AA7075 using FEM software (Deform3D).
(b) The design of the deep-drawing die is based on tubular or cylindrical product only.
(c) The value of the strain and stress to achieve a good drawing product are the most important goals in this research project.

CHAPTER 2

LITERATURE REVIEW

2.1 Fundamentals of deep-drawing

Deep drawing is a sheet metal forming process in which a sheet metal blank is radially drawn into a forming die by the mechanical action of a punch. It is thus a shape transformation process with material retention. The process is considered "deep" drawing when the depth of the drawn part exceeds its diameter. Although the process generally is called deep drawing, it is also used to make parts that are shallow or have moderate depth. This is achieved by redrawing the part through a series of dies. In the basic deep drawing process, a sheet metal blank is placed over a die opening and is held in place with a blankholder or hold down ring (Figure 2.1). The punch travels downward and forces the blank into the die cavity, forming a cup. The important variables in deep drawing are the properties of the sheet metal, the ratio of the blank diameter, D_o; the punch diameter, D_p; the clearance, c, between punch and die, the punch radius, R_p; the die corner radius, R_d; the blank holder force and friction and lubrication between all contacting surfaces.

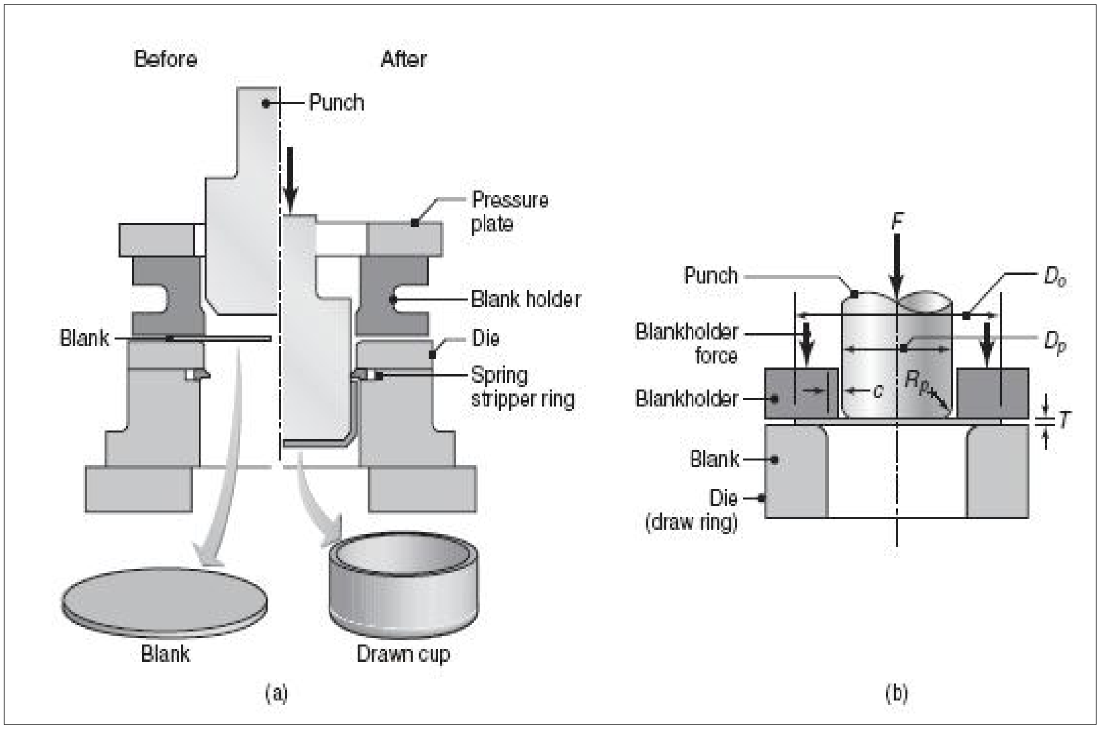

Figure 2.1: (a) Schematic illustration of the deep drawing process on a circular sheet metal blank. (b) The process variables in deep drawing. (Kalpakjian, Serope; Schmid, Steven, 2010).

Deep drawing process can be divided into:

(a) Deep drawing in a single draw or in one step – is the forming of a plane sheet section (blank) into an open hollow shape (see Figure 2.2).

(b) Redrawing – is the forming of an open hollow shape into one with a smaller cross-section (see Figure 2.3).

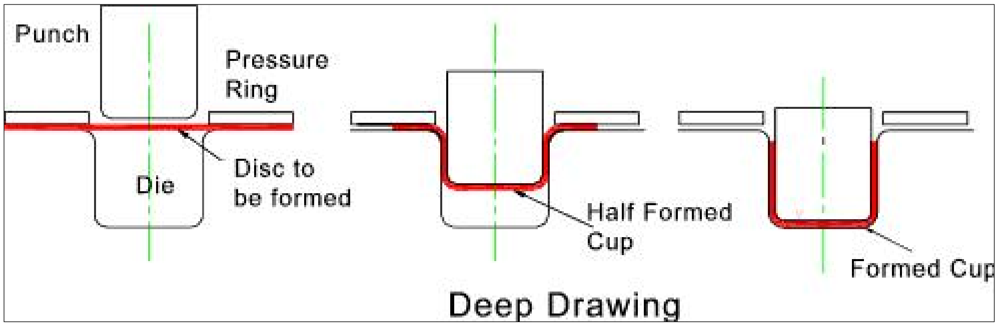

Figure 2.2: Deep drawing in a single draw (Fadzlley, 2011).

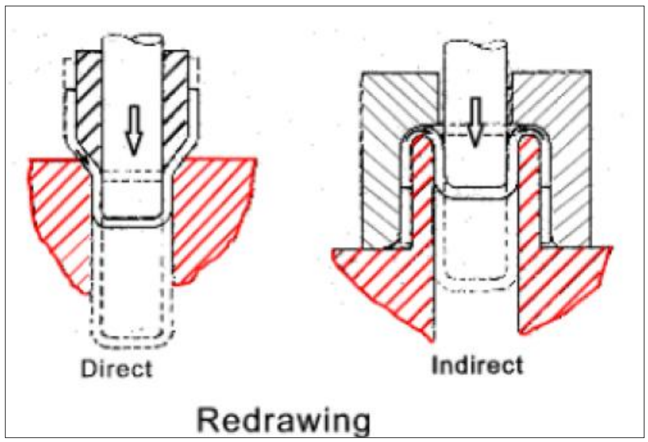

Figure 2.3: Redrawing (Fadzlley, 2011).

Suitable radii in the punch bottom to side edge, as well as the approach to the die opening, are necessary to allow the metal sheet to be formed without tearing. In most deep-drawing operations, the part has a solid bottom to form a container and a retained flange that is trimmed later in the processing. In some cases, the cup shape is fully drawn into the female die cavity, and a straight-wall cup shape is ejected through the die opening. To control the flange area and to prevent wrinkling, a hold-down force is applied to the blank to keep it in contact with the upper surface of the die. A suitable sub-press or a double-action press is required. Presses can be either hydraulic or mechanical devices, but hydraulic presses are preferred because of better control of the rate of punch travel.

Any metal that can be processed into sheet form by a cold-rolling process should be sufficiently ductile to be capable of deep drawing. Both hot- and cold-rolled sheet products are used in deep-drawing processes. The cold-work effects introduced during processing of the sheet products for deep-drawing applications must be removed and the as-delivered coils should be free of any aging. This would imply that aluminum-killed drawing quality steel, for example, would be preferred over rimmed steel. After the deep-drawing operation, ductility can be returned to that of the original sheet by in-process annealing, if necessary. In many cases, however, metal that has been deep drawn in a first operation can be further reduced in cup diameter by additional drawing operations, without the need for intermediate annealing.

The properties considered to be important in sheet products designed for deep drawing include:

(a) Composition - with a minimum amount of inclusions and residual elements contributing to better drawability.

(b) Mechanical properties - of which the elongations as measured in a tension test, the plastic-strain ratio, *r* and the strain hardening exponent, *n* are of primary importance. The strength of the final part as measured by yield strength must also be considered, but this is more a function of the application than forming by deep drawing.

(c) Physical properties - including dimensions, modulus of elasticity, and any special requirements for maintaining shape after forming. Once a metal has been deep drawn into a suitable form, it can be further processed to develop additional shape. The first shape is usually a round cylinder, or a modification of this is a square box with rounded corners, for example. This latter shape is related to the cylinder in that the four corners are essentially quarter segments with straight walls between each segment.

2.1.1 Deep draw progression

A flat blank is formed into a cup by forcing a punch against the center portion of a blank that rests on the die ring. The progressive stages of metal flow in drawing a cup from a flat blank are shown schematically in Figure 2.4.

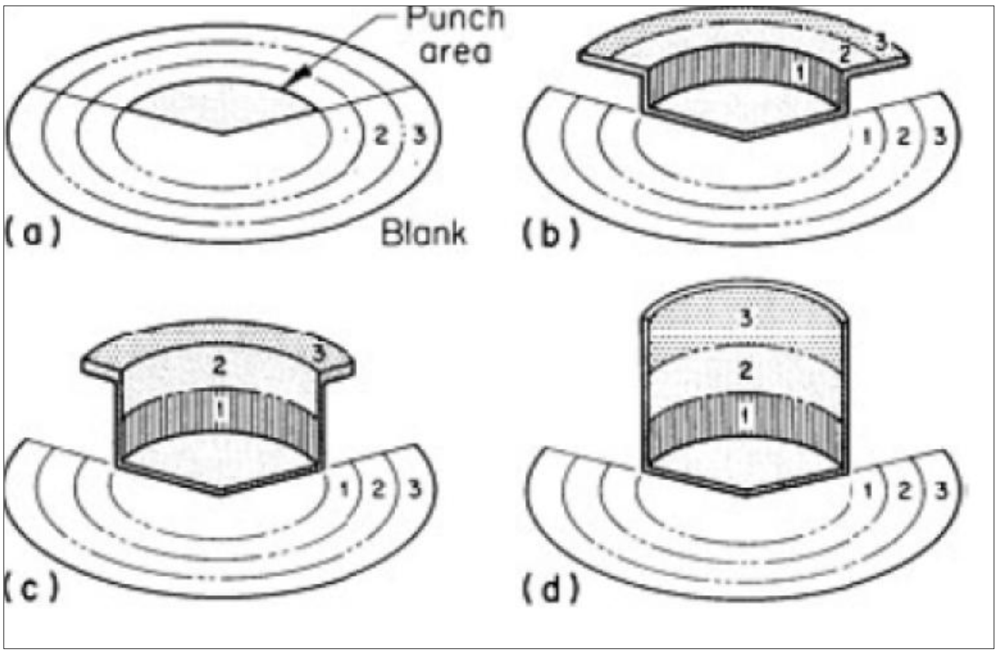

Figure 2.4: Progression of metal flow in drawing a cup from a flat blank (Fadzlley, 2011).

During the first stage, the punch contacts the blank (a), and metal section 1 is bent and wrapped around the punch nose (b). Simultaneously and in sequence, the outer sections of the blank (2 and 3, a) move radially toward the center of the blank until the remainder of the blank has bent around the punch nose and a straight-wall cup is formed (c and d). During drawing, the center of the blank (punch area, a) is essentially unchanged as it forms the bottom of the drawn cup. The areas that become the sidewall of the cup (1, 2, and 3, d) change from the shape of annular segments to longer parallel-side cylindrical elements as they are drawn over the die radius. Metal flow can occur until all the metal has been drawn over the die radius, or a flange can be retained by (Sniekers et al, 1990).