Journal of Recent Activities in Production
Volume 4 Issue 1

Drawing Analysis of Aluminum Alloy Aa1200 Sheet Metal

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Abstract
Here presents a new technique for deep drawing of cylindrical cups and the aim of this work is investigation of sheet metal forming using a punch with blank-holder. In this technique a cylindrical cup is produced by pushing a circular blank using a flat-headed circular punch through a cylindrical die. Effects of die and punch geometry including, coefficient of friction, blank-holder pressure, punch velocity, drawing load and thickness strain of the cup have been investigated numerically for optimal process design.

***Keyword**: Deep Drawing, FEM, Formability, Tensile Test.*

INTRODUCTION

Sheet metal framing is a standout amongst the most generally utilized procedures as a part of industry. Consistently, the sheet metal framing industry experienced mechanical advances that permitted the generation of complex parts. Be that as it may, the advances in bite the dust plan advanced at a much slower rate, despite everything they depend intensely on experimentation and the encounters of talented specialists. Amid the advancement of the Die, a lessening in the quantity of trials would straightforwardly impact the process duration for improvement. A shorter process duration can be arranged with due usage of programming apparatuses that would anticipate the trial results without really directing the same.

Hear introduces a new technique for deep drawing of conical cups through a die without blank holder. In this technique a conical-cup is produced by pushing a circular blank using a flat-headed circular punch through a cylindrical die. Effects of die and punch geometry including, die fillet radius, die aperture length and punch fillet radius on limiting drawing ratio (LDR), drawing load and thickness strain of the cup have been investigated experimental for optimal process design. The outlook of tool design show in fig 1.

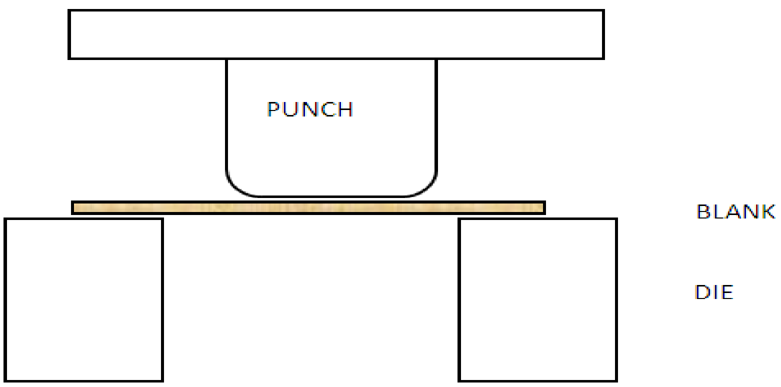

***Figure 1:** Schematic diagram of deep drawing operation using a punch and die with new design.*

Sheet Metal Forming Process

Sheet metal forming processes are the complex interaction between specimen (geometry, tolerance, surface topology, etc.), the forming process (tooling, forming machine, force, lubrication, etc.) and the material (ductility, material parameters, microstructure, corrosion resistance, residual stress, etc.) which exist in forming processes. Most problems in sheet metal forming come from a bad control of holding. This is a conventional type deep drawing process.

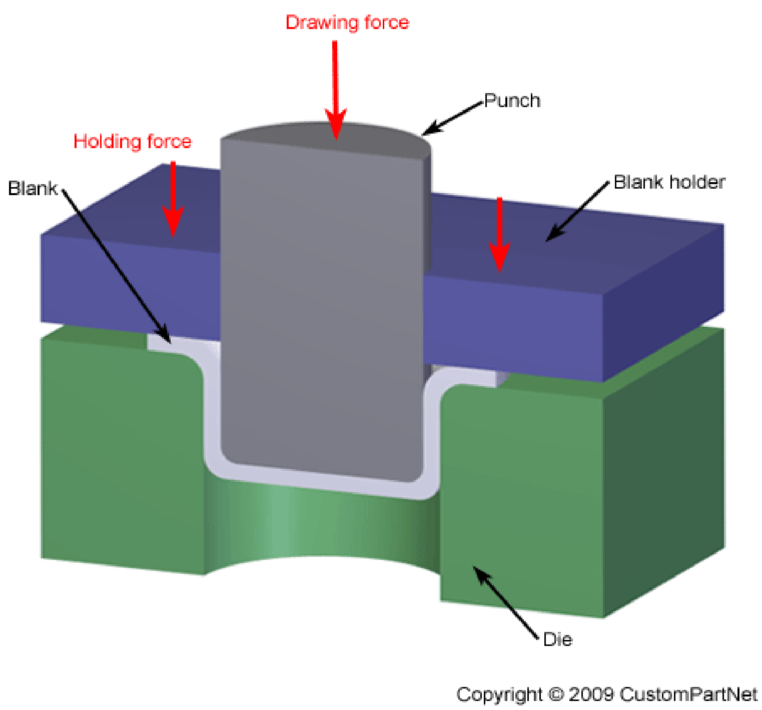

Figure 2: *The typical deep drawing operation of a sheet metal using a punch and die*

EXPERIMENTAL STUDY

Preface

Simple basic experiments are designed with different die and blank geometries. They are conducted with changing parameters in order to form a test matrix. Experimental results are then compared with this matrix examining the success of the finite element model. This work, the deep drawing process is simulated with ANSYS 14.0 Software. The die and punch is assumed to be rigid made with die steel and for the deformable Stainless Steel blank, the elasto-plastic analysis is carried out. This method the different process parameters such as coefficient of friction, punch pressure, blank-holder pressure are studied. Blank material is stainless steel and finite element technique is used for the simulation. The study includes many aspects that affect the final product.

Materials

Material Properties of Blank

Aluminum with the thickness of 1.5 mm is used in this research work. This material is refereed because of good formability specification and deep usage in the automotive industry. Material mechanical properties of the blank are given

Table 1: *Mechanical propertiesAA1200*

E	ν	n
65 GPa	0.29	0.41

Where, n is the strain hardening exponent, E is the Young's modulus, ν is Poisson's ratio,

σ is the Yield Stress of the blank material. Figure 3.8 shows the stainless steel sheet which was used in experiment.

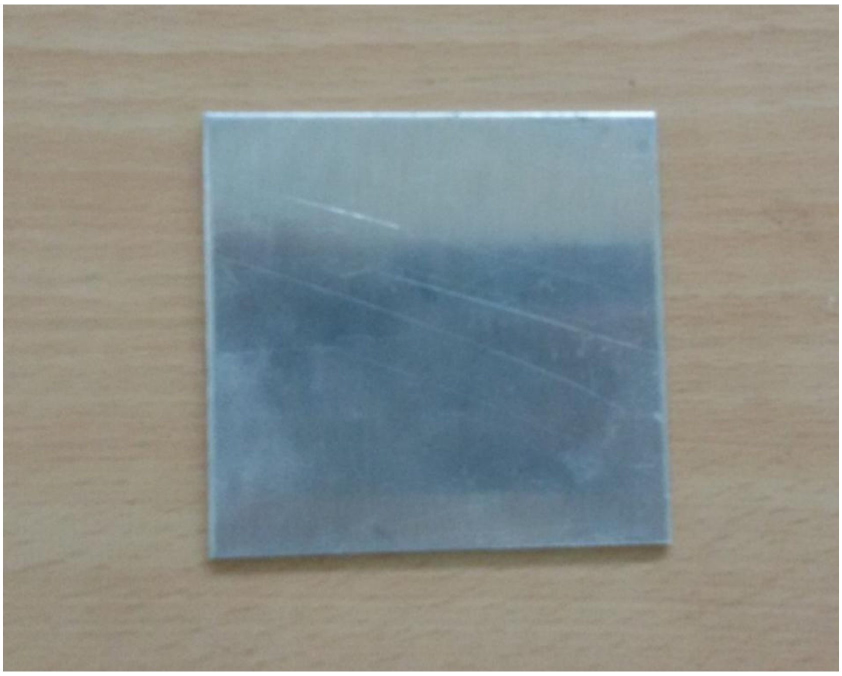

Figure 3: *Aluminum Sheet for Cupping Test*

Methodology

In this study, the methodology adopted consists of a number of steps and sub steps. Starting from the creation of a 3-D axisymmetric model and then describing input parameters such as material properties (E, ν, ρ and ε) and process parameters (coefficient of friction, blank thickness and dimension of tools (design)). The FE model was made using ANSYS software. The mechanical boundary conditions were then executed on the model. And run the process. With all the process and geometrical parameter performed the experiment in hydraulic machine, the formed final product analyse and the result data taken. Finally, the experimental results compare through previous research work. After this cup analysis required for the structural study of behaviour of formed cup material.

This methodology has mainly 3 steps.

1. Analysis of material of blank and tool with Formability tests.
2. Taguchi method
3. Fem analysis.

Finite Element Analysis

In this methodology the all experimental work is validated by previous work and FEM simulation.A complete Finite Element Analysis involves of three stages: I) Pre-Processing, I) FiniteElement Solver and III) Results-Processing. This software involves of two parts to perform a full analysis:

- Fully interactive pre- and post-processing graphical user interface
- Performs the finite element analysis

General purpose of finite element analysis system which includes a diversity of analysis conveniences. It is products can be use to explain variety of linear and non-linear stress, dynamics, composite and thermal engineering study problem. Relate to real engineering problems FEM is capable to model and stimulate the structure by accumulating all of the simple expression into a set of simultaneous equations with the degree of freedom at each node. The arrangements of nodes and lines were finally well-defined the finite elements models. Sheet metal forming processes are the difficult interaction between specimen (geometry, tolerances, surface topology, etc.), the forming process (tooling, forming machine, forces, lubrication, etc.) and the material (ductility, material parameters, micro structure, corrosion resistance, residual stresses etc.), which happen in forming processes. The processes deep drawing, and V-Die bending that are under analysis in this paper. The reason why the interactions in sheet metal forming processes are so difficult is that a change in one area creates variations in the other areas and that the interfaces are highly non-linear. Initially, the sheet is discretised into consistently regular finite elements mesh. Applying incremental displacement all through the iteration steps was carried out along forming process. Subsequently the parts of the mesh are refined. To define the contact points between the forming tools and the sheet metal in demand to make sure smooth flows of material, a appropriate concern have been carried out regards to punch and die radius. Additionally, large plastic strains had to be showed using specially advanced material laws with correspond stain hardening. As the model is symmetry hence only half of the model is formed and simulate for time saving. The mesh generated and boundary conditions of model were shown in Figures 3.3. The deformed mesh (represent by red colour) and original mesh (represent by blue colour) shows the deformation of metal sheet as shown

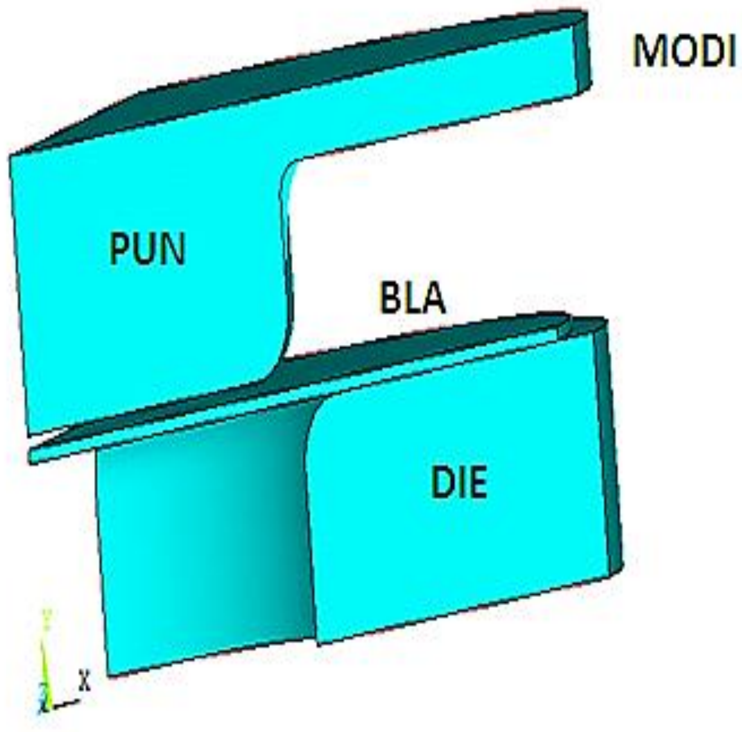

Figure 4: *Geometry and Mesh Generation of Model*

Experimental Set up

Experiments were carried out on a 40 tonne capacity hydraulic press UTM machine, display with a mechatronic device. Load vs. displacement is plotted and displayed on screen and saved on an excel work sheet. Figure 3.6 show the set up of deep drawing process.

Figure 5: *Tonnes Hydraulic Testing Machine*

The drawing of cup and tensile test performed by this machine the all necessary result data are collected by computer which connected though machine. This machine is a mechatronic machine; the controlling system is mechanical with electronic system.

The another machine called Erichson cupping machine is use to performed formality test of material this machine is mechanical based machine or manually operating machine.
This machine is capable to deform up to 2mm thickness only and it is operated manually, in the machine the punch travel equivalent to Erichson number. In this testing use different thickness of sheet and plot the graph between punch travel up to crack initiation of different sheet to the different thickness of sheet as shown in graph 4.1 and 4.2.

Blank size calculation
For final dimensions of drawn shape to be correct, starting blank diameter D_b must be correct. Solve the diameter of blank by setting initial sheet metal volume = final product volume. For the cup profile radius the punch nose radius is taken 3 times of the sheet metal thickness.

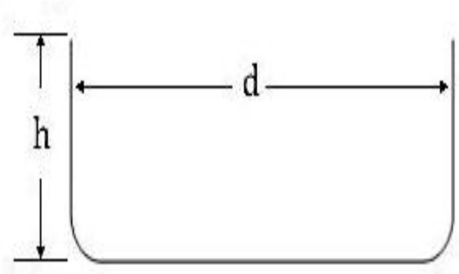

Figure 6: Final product of deep drawing

Where,
h = height of cup (in mm),
d = diameter of cup (in mm).
The size of the blank is

$D_b = \sqrt{(d_1^2 + 4d_2h)}$--(eq. 1)

$D_b = \sqrt{(50^2 + 4 \times 50 \times 28)} = 90$ mm

Where,
D_b = Blank diameter (in mm)

Manufacturing technology - Drawing clearance
In drawing sides of punch and die separated by a clearance (c) is given by –
c = 1.1 (t) = 1.1 x 1.5 = 1.65 mm (one side)
Where,
t = Sheet thickness (in mm)
I. Dejmal et al. [7] recommended a wider range of die curvature: ‘from two to ten times the blank thickness’. According to

this concept, the die curvature (die nose radius) is 7 times of the sheet metal thickness.

Above calculation (by eq. 1) shown that, the diameter of cup is 50 mm and height is 28 mm therefore, the diameter of die cavity should be 50 mm and punch diameter is 46 mm.

Blank holder force

Wrinkling can be reduced if a blank holder is loaded by maximum punch pressure. Higher holding forces do not allow material to be pulled into the die, causing under stretching of blank and tearing. Smaller holding forces cause wrinkling of flange. The formula for calculation of blank holder force is given below:

$$F_h = 0.015Y\pi\{D_b^2 - (D_p + 2.2t + 2R_d))^2\}$$

$$F_h = 0.015(195)(\pi)\{(90^2) - (46 + 2.2 \times 1.5 + 2(10)^2))^2\}$$

$$F_h = 72.14 \text{ kN}$$

If we converted into pressure, than –

$$\text{pressure} = \frac{\text{Force}}{\text{Area}} = \frac{72141.33}{(\pi \times 45^2)} = 11.33 \text{ (say 11 MPa)}$$

Where,
F_h = Holding force in drawing (in N),
Y = Yield strength of the sheet metal (in N/mm^2),
t = Sheet thickness (in mm),
R_d = die corner radius (in mm),
D_b = Blank diameter (in mm),
D_p = Punch diameter (in mm)

Parameters

Table 2: *Geometrical parameters*

Tools	Dimensions
Punch diameter	80mm
Die outer diameter	80mm
Die inner diameter	55mm
Depth in dia	12mm

CONCLUSIONS

Some findings of the project are summarized as follows:

- Blank - holder with punch was given a better results compare to conventional deep drawing process. And with this present geometry conical cups successfully formed without any failure. The finite element simulation provides a satisfactory prediction of thickness variations results with Taguchi approach.
- The results from this work open the platform of determination of optimum blank holder pressure for enhance quality products.
- The optimal parameter combination includes blank holder pressure 20MPa, velocity of punch 0.3 mm/sec and coefficient of friction 0.005.
- Punch Pressure is maximum at maximum blank-holder pressure with 0.3 mm/sec punch velocity.
- Punch pressure was ranged from 20 MPa to 30MPa for various experiments.
- FEM simulation results showed that, the maximum 1st principal stress on deep drawn cup varies from 156 MPa to 166MPa and plastic strain varies from 0.59 to 0.61.

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