Simulation Study of Material Behavior of AISI 304 Stainless Steel in Single Stage Deep Drawing Process Using AFDEX Software

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Abstract-AISI 304 stainless steel will be studied in single phase deep drawing to evaluate its material behavior and the variables affecting the deep drawing process in this study. AISI 304 is one of the most widely used materials for deep drawing purpose because of its wide range of applications and material properties. It also aims to determine the parameters which have effect on deep drawability of AISI 304. Designing/ modelling of dies and workpiece is carried out in SolidEdge V19. Simulation, analysis of this process is accomplished using AFDEX software.The variables in this project are coefficient of friction (0.05, 0.1, and 0.15) and die corner radius (2-8) mm. Punch velocity (230mm/s) and BHF (1265N) are kept consistently. A temperature of 25°C is maintained due to the cold forming type.

Key words: Solid Edge V19, AFDEX, Co-efficient of friction, Die corner Radius, BHF, AISI 304 etc.

I. INTRODUCTION

Sheet metal is often formed in cup or box shapes using the industrial technique known as deep drawing. Sheet metal deep drawing is used to make a variety of products, including pots and pans, containers, sinks, and vehicle components, like panels and gas tanks. Forming flat sheet metal in hollow forms by punching it and letting it flow into the cavity of a mold is known as drawing in the metal industry. Deep drawing is used when depth is one or even more than diameter.

Punches and dies are used to do deep drawing on sheet metal. Punches are used to sketch out the contour of the part's base after it has been drawn. The die cavity is somewhat broader than the punch to accommodate both the punch's passage and clearance. In many ways, this is a configuration that is reminiscent to a sheet metal cutter. Clearance is the gap between die edge as well as punch edge, as in cutting. Dies are used to cut metal from a sheet of metal known as a blank. When sheet metal work is detained flat against die by a blank holder, it is applied pressure to the whole blank surface except for the region directly beneath the punch. Blank holders surround the die. Puncture moves closer to the blank. Metal sheet is rammed into a die cavity after being pierced by an impact punch.

When designing a deep drawing, it's preferable to keep the contour of the drawing as basic as possible. The item will have a flat base during the first stage of sheet metal deep drawing.

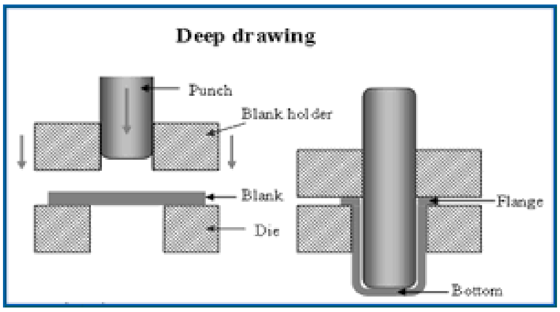


Fig. 1: Deep DrawingMethod

II. LITERATURE SURVEY

Lade Jayahari et.al [1]**Finite element Simulation studies of AISI 304 for deep drawing at several temperatures (2014).**Formability investigation of austenitic stainless steel 304 at different temperatures below warm circumstances is the focus of this article. Material formability is determined by calculating the draw proportion & thickness dispersion of deeply drawn cups at room temperature or 1500C. For 1mm thick Austenitic stainless steel 304 sheets at room temperature, the limiting drawing ratio (LDR) is 2.1, while for 1mm thick sheets at 1500C, the LDR is 2.5, with no additionaldevelopment in the LDR at higher temperatures.

R. Venkat Reddy et.al[2] **Result of SeveralLimits on Wrinkling in Deep Drawing Cylindrical Cups(2012)**. It is the goal of this book to highlight the most important parameters that affectfolding of cylindrical components during the deep drawing method: BHF, punch radiuses, die edges, and coefficient of frictions. There are a variety of elements that may affect the onset and development of wrinkles on a sheet of material, including stress ratios, mechanical qualities, work piece shape, and contact conditions.

KopinathiGowtham et.al [3] **Simulation of Effect of Die Radius on Deep drawing Method (2012).**By adjusting die corner radius & maintaining friction, punch, and blank thickness constant, this work aims to investigate the deep drawing process. Analytical, numerical, and exponential approaches have been used to assess the CATIA-created punch, blank thickness geometry, as well as the finite element simulation process by modifying the die corner radius. An aluminium alloy, AL6061, was employed in this method of simulation, with a beginning diameter of 56mm & drawing speed of 0.9m/sec.

Mayavan.T, Karthikeyan.L [4] **Investigational and finite element studies on formability of low carbon steel sheet by deep drawing (2013).**For this study, limiting draw ratio (LDR) & producing limit diagram for different punch strokes are analyzed. The experimental data, such as the cup's thickness distribution & thinning limit, are compared to modeling results. The finite element projected findings matched up well with the experimental data. Results demonstrate that a 50-mm punch stroke with an LDR value of 2.22 was determined to have the optimum shaping characteristics. Abaqus was used to create a finite element analysis model for the project.

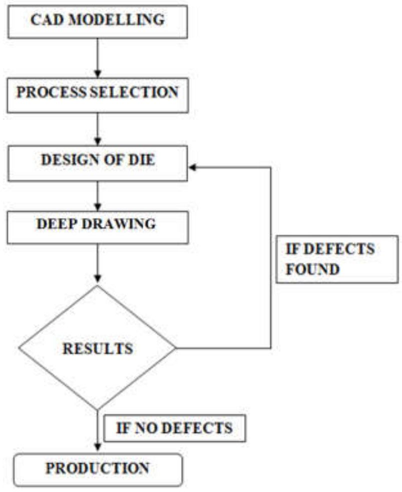
III. SIMULATION

When creating the CAD models for this project, we'll be working by Solid Edge V19. The deep drawing procedure is simulated by STL and AFDEX V16 formats. It will be utilized in this project to develop & simulate metal forging process using metal forming software (AFDEX-2016). With the AFDEX general purpose metal forming simulator, not only are classic processes such as forging, rolling, extrusion, and drawing supported but also new, innovative bulk metal forming processes may be simulated as well. The rigid-thermoviscoplastic finite element technique is the theoretical basis for AFDEX. Metal forming & die structural analysis have flow and heat transfer issues that AFDEX can address.

IV. METHODOLOGY

Phasesfor deep drawing process have been depicted into fig.2. Initially we considered the component to be deep drawn and based on that the CAD models of dies are generated in SolidEdge software. These CAD models are saved in .STL format. Dies are then imported into AFDEX simulation software. The nature of forming is hot and the type of process is without flash. The process parameters are given and the stop criterion is set. In this deep drawing process the variable parameters are co-efficient of friction (0.05, 0.10 and 0.15) and die corner radius (2-8) mm. whereas ram velocity (230mm/s), Binder holding force (1265N) and meshing (auto) are kpt constant. Total 21 iterations were performed and results were tabulated.

Fig2: Steps involved in simulation



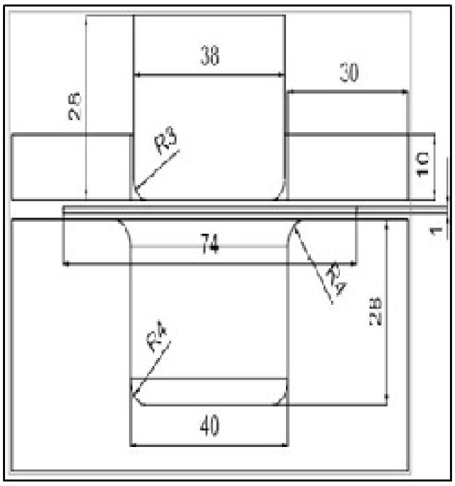


Fig3: Design assembly of cup

Design assembly of cup and dies is shown in fig.3. The assembly consists of upper die, binder, lower die and workpiece. The details of components are tabulated in table 1.

Table 1: Particulars of Component

Component	Cup
Material Used	AISI 304
Forming Type	Cold
Number of draws	1
Initial Billet Temperature	25^0C

A. CAD Modeling

This is an important stage where the model of the component is prepared using Solid edge. The cross-sectional and isometric view of the dies and blank is shown in the figure below

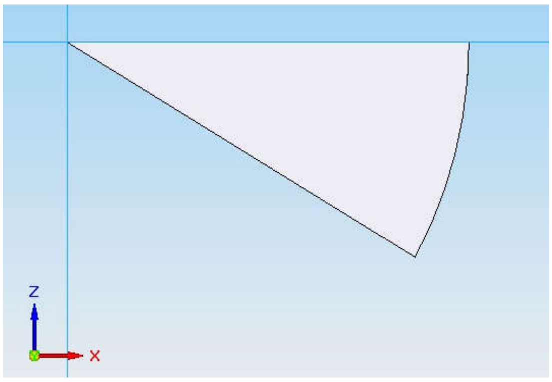


Fig 4: Blank

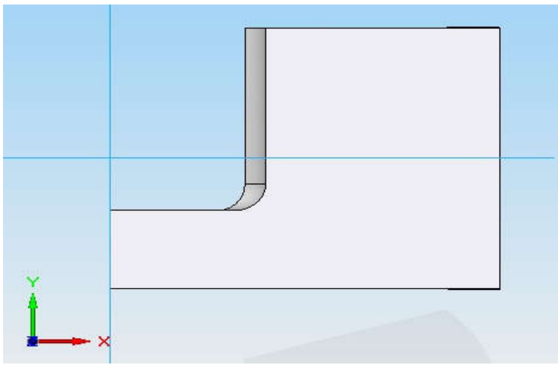


Fig5: Lower Die

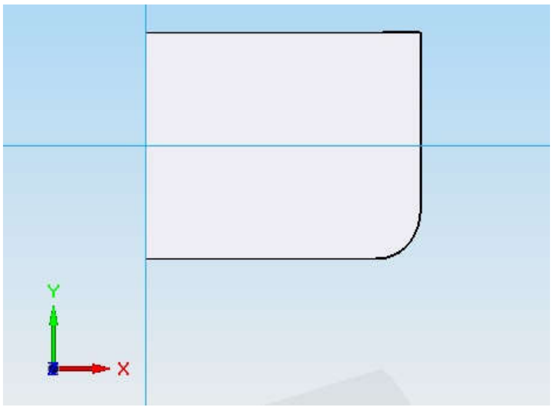


Fig6: Upper Die

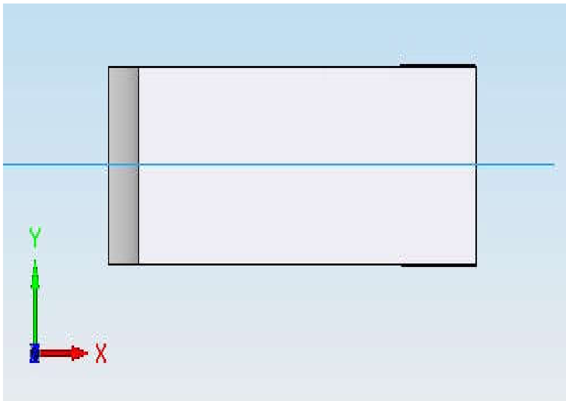


Fig7: Binder

Table 2: AA 6061 Material Properties

Ultimate tensile strength	505Mpa
Modulus of elasticity	193Gpa
Poisson's ratio	0.265
Yield tensile strength	205Mpa
Hardness, Brinell	201
Density	8g/cc

V. RESULTS

Table 3: Damage values for various Ram velocity

SL. NO.	Co-efficient of Friction (μ)	Die Corner Radius	Damage Value
1	0.05	2	5.89008E-001
2		3	3.55332E-001
3		4	3.23480E-001
4		5	2.78191E-001
5		6	2.63095E-001
6		7	2.52708E-001
7		8	2.36616E-001
8	0.10	2	4.71616E-001
9		3	3.98472E-001
10		4	3.20442E-001
11		5	2.96434E-001
12		6	2.55663E-001
13		7	2.65966E-001
14		8	2.35929E-001
15	0.15	2	5.95502E-001
16		3	3.77201E-001
17		4	3.28264E-001
18		5	2.97951E-001
19		6	2.63372E-001
20		7	2.66571E-001
21		8	2.48311E-001

Total 21 iterations were performed and the damage values were tabulated in the table 3. Following figures represents the damage value and load value of three iterations with minimum values.

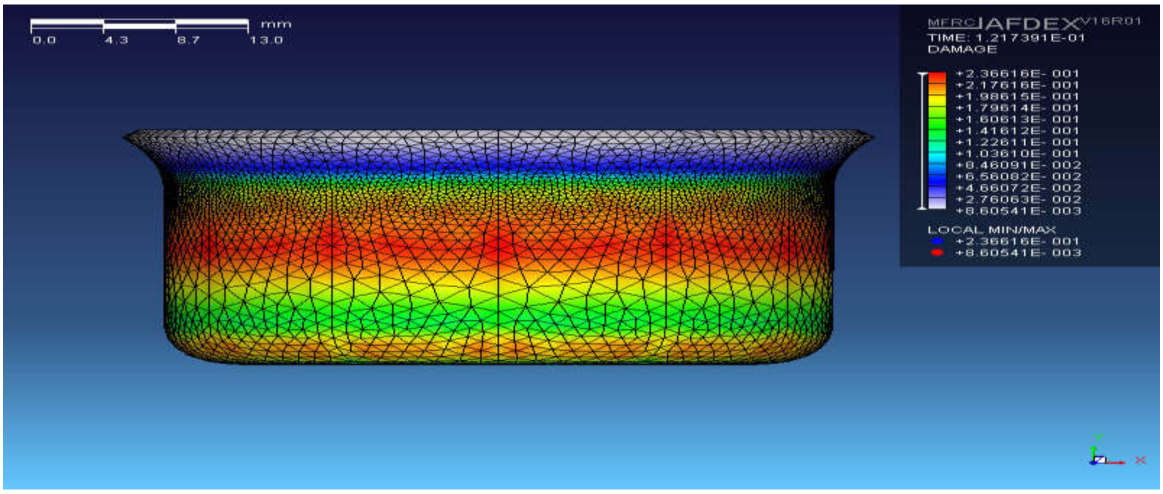


Fig. 8: Damage value of cup drawn with Co-efficient of friction 0.05, die corner radius 8mm.

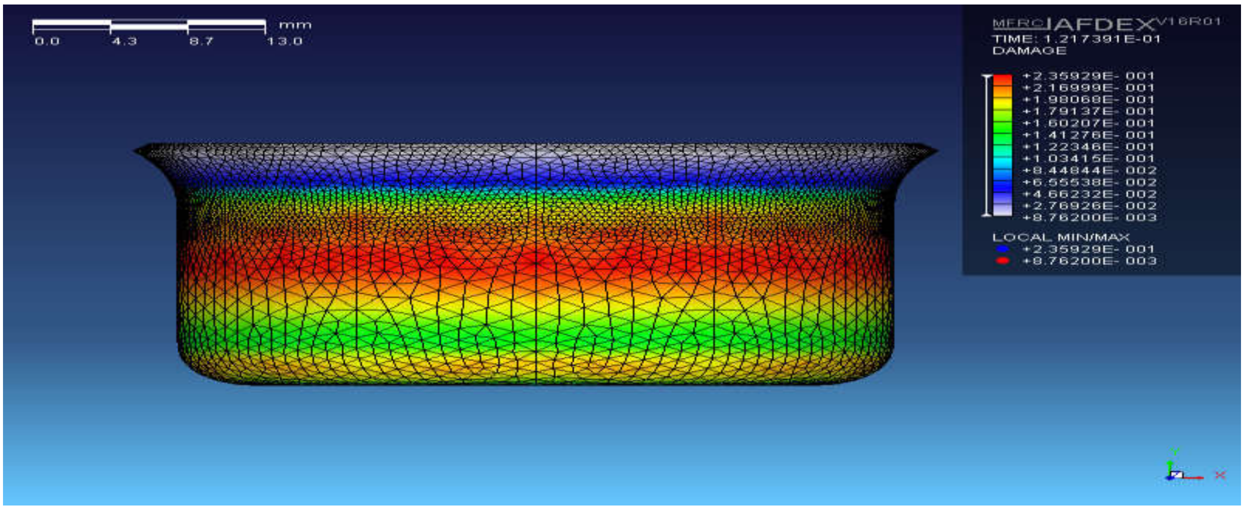


Fig9: Damage value of cup drawn with Co-efficient of friction 0.10, die corner radius 8mm.

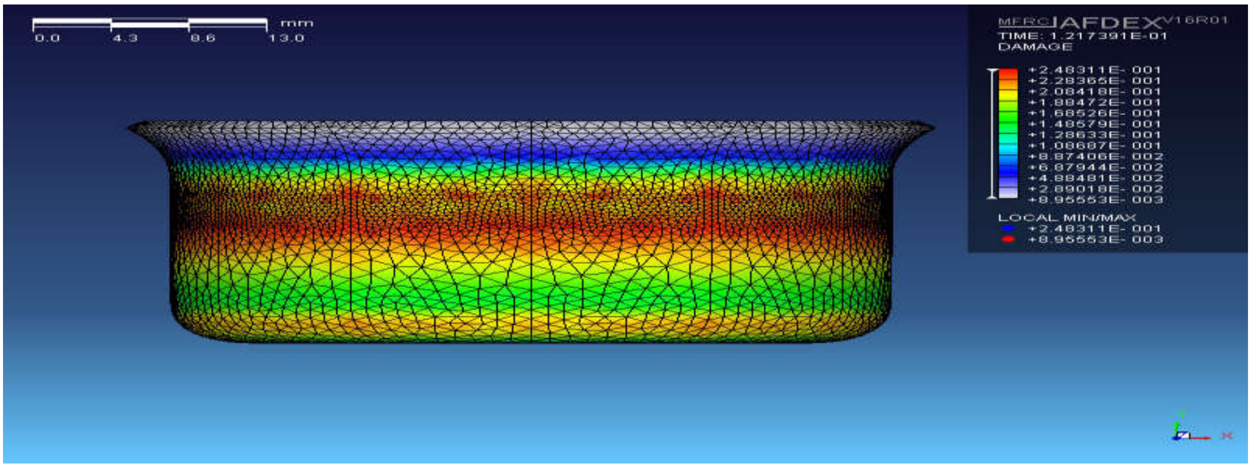


Fig. 10: Damage value of cup drawn through Co-efficient of friction 0.15 and die corner radius 8mm.

VI. CONCLUSIONS

A total of twenty-one iterations were performed in the AFDEX program, with the results acquired by varying the values of factors such as die corner radius & friction coefficient. Both the BHF and the punch velocity were maintained constant.

From above iterations, we can detect damage value found is minimum in 14th iteration (Co-efficient of friction = 0.1 and die corner radius = 8mm). For the value of die corner radius = 8mm and Co-efficient of friction = 0.1, corresponding damage value was 2.35929E-001.

Following parameters were used in the analysis of this iteration,

- BHF = 1265N
- Ram Velocity = 230 mm/sec
- Friction co-efficient = 0.10
- Temperature = 25^{o} C

Following conclusions can be drawn fromresults,

- ❖ Co-efficient of friction is one of the most important parameter in deep drawing process. The damage value is minimum for value 0.10. As the value of coefficient of friction increases there is corresponding increase in damage value.
- ❖ As value of die corner radius increases corresponding damage value inclines to decrease. Hence wrinkling also tearing effect minimizes. The damage value is minimum for the die corner radius 8mm.
- ❖ Final deep drawn cup will be free of all surface defects since there is no folding on the surface and within the component. Hence a defect free component can be drawn using the above combination of parameters.

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