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Simulation Study of Effect of Binder Holding Distance In Single Stage Deep Drawing Process Using AFDEX Software

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Abstract— The objective of this project is to study the effect of binder holding distance & die corner radius with different binder holding forces in deep drawing process and to determine the factors influencing on deep drawing process & analyse the process by varying die corner radius & Binder holding distance by keeping the following parameters like punch radius, drawing speed, coefficient friction, blank thickness etc, are constants with different BHFs for this CAD Technique the simulation process modelling using unigraphics and process of simulation by CAD AFDEX Software. The material used for this simulations process is Aluminium Alloy 6061 within initial diameters as 185mm the analysis was carried out to find out the optimum minimum damage value using different calculated BHFs, binder holding distances and die corner radius.

Key words: Uni-Graphics, AFDEX, BHF and Co-efficient of friction, Binder Holding Distance etc.

I. INTRODUCTION

Deep drawing is the metal working process used for shaping flat sheets into Cup-shaped articles such as bath tubs, shell cases, Rim, automobile panels etc. This is done by placing a blank of appropriate size over a shaped die and pressing the metal into the die with a punch. When the blank is forced through a die the sheet flows through the die surface and a change in shape is obtained. The total surface area remains unchanged. Generally a clamping or Hold-down pressure is required to press the blank against the die to prevent wrinkling

When the ratio $\frac{\text{blank diameter}}{\text{cup diameter}} > 1$ then the drawing is said to be deep drawing process.

When H/D ratio of the drawn component is > 1.5D then drawing had to be done in stages

The main variables involved in this process are

- Blank holder force
- Co-efficient of friction
- Punch velocity
- Blank thickness
- Die corner radius
- Drawing speed
- Punch radius
- Binder Holding distance

A. Direct Extrusion

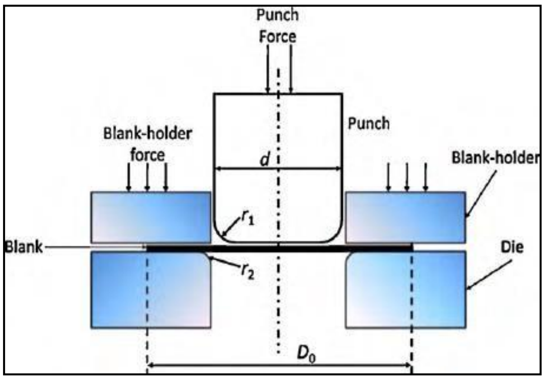

Fig. 1: Principal of Deep Drawing process

A flat work piece (blank) is formed into a cylindrical cup by forcing a punch against the center portion of the blank which is resting on the die shown in fig-1.

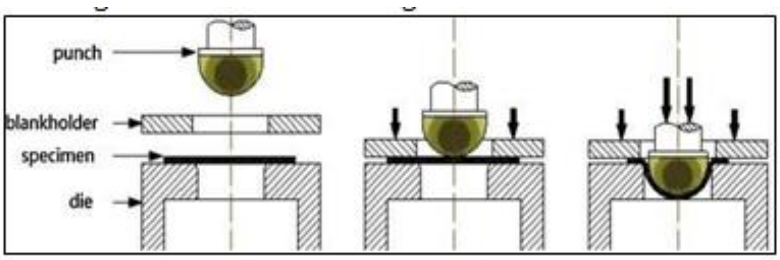

Fig 2 : A sequence of operation is shown

During the deep drawing process, the blank is clamped between die and blank holder. The blank holder is to avoid the occurrence of wrinkling while the punch is forming the blank into die cavity, blank material flows into die cavity. This effect is called material flow. It is important to control Blank holder force to get defect- free components, to have a defect free component Calculated value of BHF 2904N Keeping this as reference point an incremental value (± 300) have been studied in this project.

B. Literature survey

Kondapalli sivaprasad, &Chalamasetti srinivasa rao [1] **Optimising Die Corner Radius of Deep Drawing Die**

The objective of this paper is to study and determine the factors influencing on die corner radius in deep drawing process and analysing the process by varying the die corner radius. As the die corner radius plays a vital role in manufacturing the product in deep drawing process. The present works deals with different die corner radii for stainless steel blank. Static and transient analysis carried out in ANSYS for (4,5,6,7and 8mm)corner radii of the die grade 310s stainless steel is considered to study the effect of die radius. The observations shows the study as the die corner radii reduced the amount of force required to drawn the process is increased and it creates tearing and earing type quality problems. increased die corner radius creates wrinkling marks.

Kopinathi Gowtham, K.V.N.S Srikanth, &K.L.N Murthy[2**] Simulation of the Effect of Die Radius on Deep drawing Process.** The objective of this paper is to study the deep drawing process by varying the die corner radius and keeping the friction , punch, blank thickness as constant. The punch, blank thickness geometry made by CATIA software and analytical, numerical and exponential methods have been developed in order to analyse it and the simulation process carried out by finite element analysis by varying die corner radius. The material used for this process of simulation AL6061 an aluminium alloy initial diameter taken as 56mm and drawing speed is 0.9m/sec friction constant is taken as 0.3.observation shows the minimum damage value found in die radius 7mm gave an optimum levels with minimum damage.

Arshad Ayyub, & Bharat S Kodli [3**] Simulation Study on Effect of Die Corner Radius in Single Stage Deep Drawing Process.** The objective of this paper is to study the effect of die corner radius in deep drawing process simulation, and to determine the factors influencing the deep drawing process and analysing the process by varying the die corner radius by keeping the fallowing parameters Blank thickness, Punch radius, Drawing speed, and Coefficient of friction constant. For this CAD Technique is combined with the process simulation to enable modelling using Uni-graphics, then simulation is performed using AFEDEX software., Aluminium alloy 6061 is used for deep drawing with initial diameter as 74mm.

R. Venkat Reddy, Dr T.A Janardhan Reddy, &Dr.G.C.M [4] **Effect of Various Parameters on the Wrinkling in Deep Drawing Cylindrical Cups**. The appearance of dimensional deviations of shape and position, of the defects in the metal sheets that have been subjected to a cold plastic deformation process (deep drawing), represent a critical problem for the specific industry, especially for the mass production , like the machine manufacturing industry. The aim of this publication is to present the principal aspects that effect of various factors like BHF, punch radius, die edge radius, and coefficient of friction on the wrinkling of cylindrical parts in deep drawing process. The initiation and growth of wrinkles are influenced by many factors such as stress ratios, the mechanical properties of the sheet material, the geometry of the work piece, and contact condition. It is difficult to analyse wrinkling initiation and growth while considering all the factors because the effects of the factors are very complex and studies of wrinkling behaviour may show a wide scattering of data even for small deviations in factors. In the present study, the mechanism of wrinkling initiation and growth in the cylindrical cup deep drawing process is investigated in detail.

II. SIMULATION

In this project UNIGRAPHICS software is used to design and effort is made to simulate the deep drawing process using AFDEX software. AFDEX (Adviser for metal forming process design Expert) is a general purpose metal forming simulator which can be applied not only for deep-drawing but also for forging, rolling, extrusion etc. This software can predict blank holder force to assist in selecting appropriate BHF in order to find optimized damage values and also to develop and optimize the metal forming process, this prediction pro-long the die life and thus increased productivity and company with a great return on investment.

Metal forming software (AFDEX-2014) will be used in this project to design and simulate the metal forging process. AFDEX is a general purpose metal forming simulator, which can be applied not only to conventional bulk metal forming processes including forging, rolling, extrusion, and drawing, but also to new creative bulk metal forming processes. AFDEX is theoretically based on the rigid-thermo-visco plastic finite element method. AFDEX can solve the metal flow and heat transfer problems present in metal forming and die structural analysis

III. METHODOLOGY

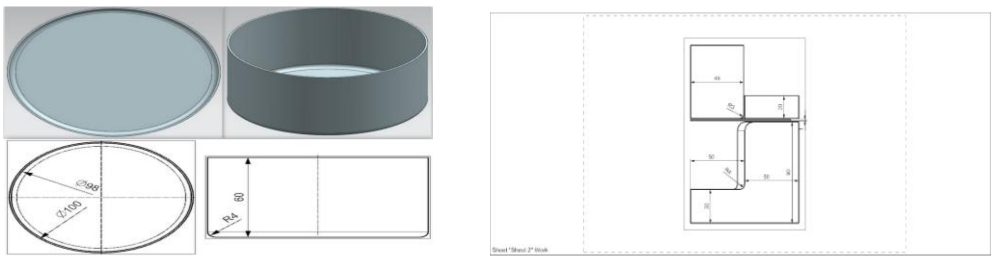

Fig 3 . Drawing Of Cup

The deep drawing process has been analysed for different BHF & Co-efficient of friction for different combinations of process variables. The various assumptions & combinations are used in this study is made to investigate optimize the damage value, for this various iteration is performed. The material used for the analysis is AA6061 an aluminium alloy.

The initial diameter is taken as 185 mm, the deep drawing speed used here is 0.9m/sec, the Co-efficient of friction between blank and die is 0.1, 0.2, and 0.3

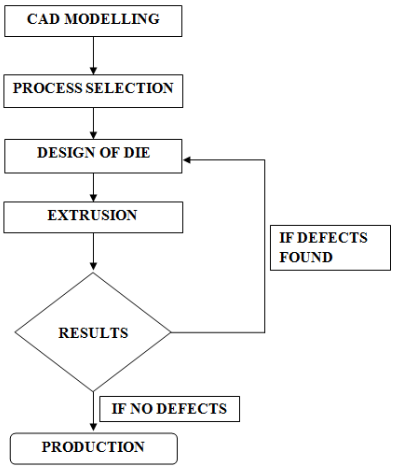

Fig 4 : Steps Involved In Simulation

TABLE I

Dimension specifications of the process

Component	Dimensions(mm)
Punch diameter	98
Blank diameter	185
Blank thickness	3
Punch fillet radius	4
Co-efficient of friction	0.1 , 0.2 , 0.3
cup height	60
Clearance die and punch	1

Table II

Material AA-6061 composition

Component	Weight %
Aluminum (Al)	97.36
Magnesium (mg)	0.8
Silicon (Si)	0.4
Iron (Fe)	0.7
Copper (Cu)	0.15
Zinc (Zn)	0.25
Titanium (Ti)	0.15
Manganese (Mn)	0.15
Chromium (Cr)	0.04

Table III

Physical Properties of AA-6061

Density	2.7g/cc
Tensile Yield Strength	276MPa
Ultimate Tensile Strength	310Mpa
Modulus Of Elasticity	68.9Gpa
Hardness – Vickers	107
Poisson’s Ratio	0.33

IV. RESULT AND DISCUSSIONS

Table IV

Input parameter

Sl No	Friction Co-efficient	Punch Velocity (m/s)	Die Corner Radius (mm)	Calculated BHF (N)
01	0.1	0.9	2	2914
02			3	2904
03			4	2887
04			5	2869
05			6	2852
06			7	2834
07			8	2817
08	0.2	0.9	2	2914
09			3	2904
10			4	2887
11			5	2869
12			6	2852
13			7	2834
14			8	2817
15	0.3	0.9	2	2914
16			3	2904
17			4	2887
18			5	2869
19			6	2852
20			7	2834
21			8	2817

Table V

Calculated Binder Holding Distances

Sl No	Binder Holding Distance (%)	Calculated BHD
01	70	60×0.7=60-42=18
02	75	60×0.75=60-45=15
03	80	60×0.80=60-48=12
04	85	60×0.85=60-51=9
05	90	60×0.90=60-54=6

V. FINAL RESULTS

The values and the output after simulation are analysed and tabulated as follows: Case 1: Friction Co-efficient (μ) = 0.1, Punch velocity = 0.9 m/sec or 900mm/s

Table VI

Results of case 1

Sl No	BHF	DIE CORNER RADIUS	DAMAGE VALUE
01	2904	3	+4.62483E-001
02	2887	4	+3.54483E-001
03	2869	5	+2.77437E-001
04	2852	6	+2.61832E-001
05	2834	7	+2.32058E-001
06	2817	8	+2.20363E-001

Case 2: Friction Co-efficient (µ) = 0.2, Punch velocity = 0.9 m/sec or 900mm/s

Table VII

Results of case 2

SL NO	BHF	DIE CORNER RADIUS	DAMAGE VALUE
01	2904	3	+5.57431E-001
02	2887	4	+3.80575E-001
03	2869	5	+3.38723E-001
04	2852	6	+2.96740E-001
05	2834	7	+2.69649E-001
06	2817	8	+2.44040E-001

Case 3: Friction Co-efficient (µ) = 0.3, Punch velocity = 0.9 m/sec or 900mm/s

Table VIII

Results of case 3

SL NO	BHF	DIE CORNER RADIUS	DAMAGE VALUE
01	2904	3	+5.43744E-001
02	2887	4	+3.84683E-001
03	2869	5	+3.18996E-001
04	2852	6	+3.02914E-001
05	2834	7	+2.75927E-001
06	2817	8	+2.51939E-001

Wrinkling and tearing are the common defect found in metal forming process a large increase or decrease creates wrinkling, thinning and tearing type quality problems in order to minimize this problem. The simulations are carried out to find list damage value by varying die corner radius 2,3,4,5,6,7,8mm with BHF of 2904,2886,2869,2852,2834,2817N.

Before doing simulation process keep constant of some parameters ie. punch velocity, drawing speed, coefficient of friction, blank thickness etc,.

It is observed that tearing, wrinkling and thinning in BHF 2914 and 2904 at Die Corner Radius 2mm the blank holding forces is decreases with increases of die corner radius the minimum damage value will found. The minimum damage value is find in BHF 2817N and binder holding distance 90% in coefficient of friction 0.1.

For BHF 2817N

Friction Co-efficient (µ) = 0.1, Punch velocity = 0.9 m/sec or 900mm/s

The damage value for BHF(2817N) and Binder Holding Distance of 90% with 8mm Die Corner Radius initial and final values are shown below

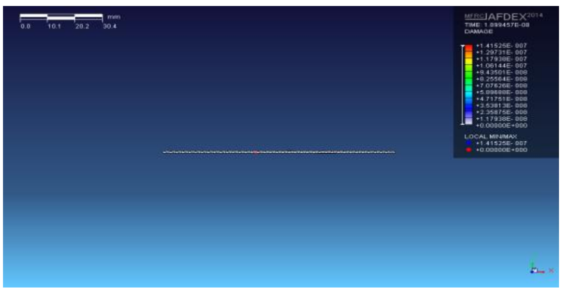

Fig4 Initial damage value = 1.41525E-007

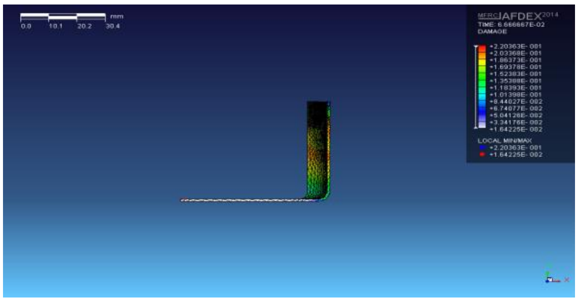

Fig5. Final damage value = 2.20363E-001

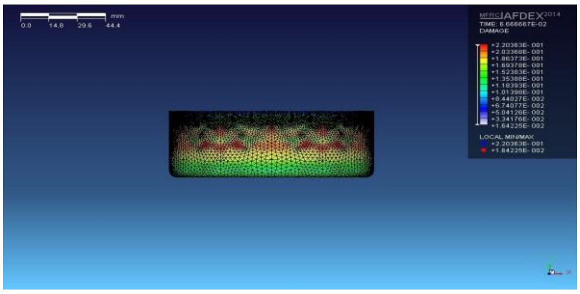

Fig6 Front view of damage

Fig7 Load vs. Time Graph

Friction Co-efficient (μ) = 0.2, Punch velocity = 0.9 m/sec or 900mm/s

The damage value for BHF(2817N) and Binder Holding Distance of 90% with 8mm Die Corner Radius initial and final values are shown below

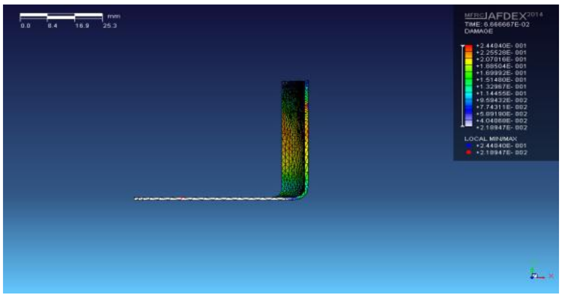

Fig8 Final damage value =2.44040E-001

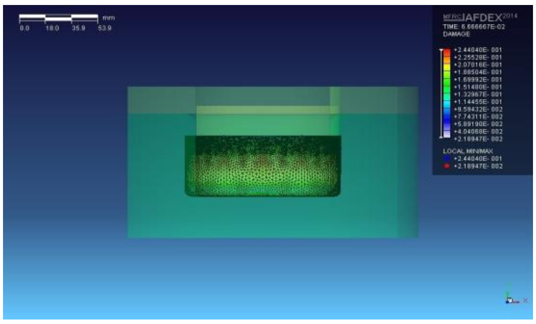

Fig9 Front view of damage value with die

Fig10 The maximum load for this iteration is 3.381E+1

Friction Co-efficient (μ) = 0.3, Punch velocity = 0.9 m/sec or 900mm/s

The damage value for BHF(2817N) and Binder Holding Distance of 75% with 8mm Die Corner Radius initial and v final values are shown below

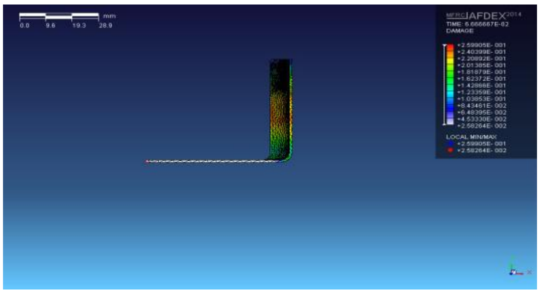

Fig11 Final value of damage = 2.59905E-001

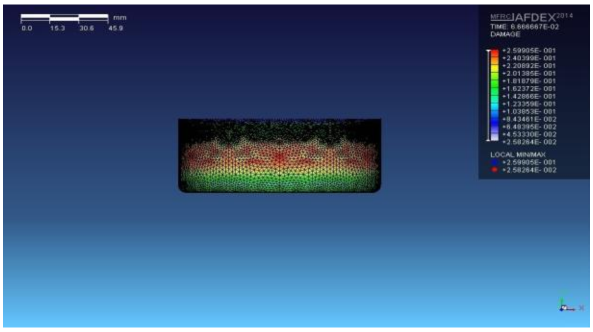

Fig12 Front view of damage

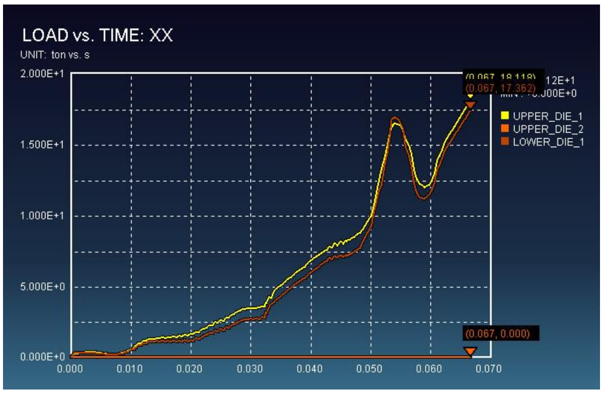

Fig13 The maximum load for this iteration is 0.121E+1

VI. CONCLUSION

So conclusion can be made by considering the results obtained by performing several iterations during which the parameters like Binder holding distance, Die corner radius, BHF, Co-efficient of friction and Punch velocity were varied as shown in the methodology table.

Sl No	Damage Value	Binder Holding Distance (%)	Binder Holding Force(N)	Co-efficient of Friction
01	2.45488E-001	70	2817	0.1
02	2.47530E-001	75	2817	0.1
03	2.25798E-001	80	2817	0.1
04	2.24397E-001	85	2817	0.1
05	2.20363E-001	90	2817	0.1

[1]. As per the result obtain it is evident that binder holding distance is an important parameter as similar to BHF and Die corner radius.

[2]. It is evident that the wrinkling and tearing is minimum and damage value also minimum at the fallowing cases.

[3]. The minimum damage value found in BHF 2817 N ,Binder holding distance 90% and 0.1 coefficient of friction, with die corner radius 8mm gives less wrinkling and tearing.

[4]. One thing we conclude that as the BHF decreases with less coefficient of friction the damage value will be minimum.

[5]. Out of several combinations, Iterations were carried out . It is evident that the BHF=2817, coefficient of friction =0.1, Binder holding distance % =90 are optimized value since the damage value is least and there is no wrinkling, thinning or tearing in drawn cup.

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