Design And Analysis of Deep Drawing Die For Copper Cup

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Abstract- *Sheet metal components find application in many fields. Sheet metal working gives a very economical way of manufacturing certain thin walled component such as utensils, automobile body parts, machine covers etc., which otherwise would be very costly if manufactured by the conventional chip forming method. Deep drawing process is one such process in sheet metal working which is prominently applied to the production of thin walled and one end closed components. Deep drawing process is a sheet metal framing process in which a sheet metal clear is radially drawn into a forming die by the mechanical activity of a punch. It is consequently a shape change process. The procedure is viewed as "Deep" drawing when the depth of the drawn part increases its diameter. The final shape of the components can be reached through more drawing steps called as re-drawings. During the process of drawing certain defects are observed namely wrinkling (flanges or walls), Tearing, Earing, surface scratches etc. These defects occur mainly due to defective die design, thus design and analysis of the deep drawing die is of utmost importance for production of a defect less component.*

The project work involves the design and development and analysis of copper cup deep drawing die. The theoretical determination of blank size considering the corner radius, determination of deep drawing force, and stress produced during the deep drawing is determined using empirical relations. Ansys work bench is used to determine the stress values and experimental results are validated using ANOVA Technique.

Keywords- Taguchi method, Optimization, Deep Drawing

I. INTRODUCTION

Profound drawing procedure is sheet metal shaping procedure in which a sheet metal clear is diffusively drawn into a framing kick the bucket by the mechanical activity of a punch. It is thus a shape transformation process. The process is considered "deep" drawing when the depth of the drawn part increases its diameter. This is gain by redrawing the part through a succession of dies. The die shoulder region experiences a radial drawing stress and an indirect compressive stress due to the material retention property. These compressive stresses (hoop stresses) result in flange, wrinkles. Wrinkles can be banned by using a blank holder; the function is controlled material flow into the die radius.

This process allows obtaining a difficult shape part through a simple process, based on the plastic deformation of the metallic sheet. The die defines the shape of the product to be drawn. The punch is used to deform or move the sheet into the die's cavity and deform the sheet to its final shape.

There are certain objectives as Design of deep drawing die for copper cup, Simulation and analysis of behavior of copper in deep, drawing dies in ansys, Fabrication and testing of die.

The forming load is moved from the punch radius through the drawn part wall into the sheet metal flange (deformation region).

In the drawn part wall, which is in contact with the punch, the hoop strain is zero where by the plane strain condition is high. In reality, mostly the strain condition is only approximately planed. Due to tensile forces acting on part wall, wall thinning is prominent and results in an irregular part wall thickness, such that the part wall thickness is lowest at the point where the part wall loses contact with the punch, i.e. at the punch radius. The thinnest part thickness determines the maximum stress that can be transferred to the deformation zone. Due to material volume constancy, the flange thickens and results in blank holder contact at the outer boundary rather than on the whole surface. The maximum stress that can be safely conveyed from the punch to the blank sets a limit on the maximum blank size (initial blank diameter in the case of rotationally symmetrical blanks). A marker of material formability is the restricting drawing proportion (LDR), characterized as the proportion of the most extreme clear distance across that can be deliberately drawn into a container without spine to the punch measurement. Assurance of the constraining drawing proportion (LDR) for complex segments is risky and henceforth the part is inspected for basic regions for which an estimate is conceivable. Amid extreme profound drawing the material work solidifies and it might be essential to temper the parts in controlled climate broilers to reestablish the first flexibility of the material.

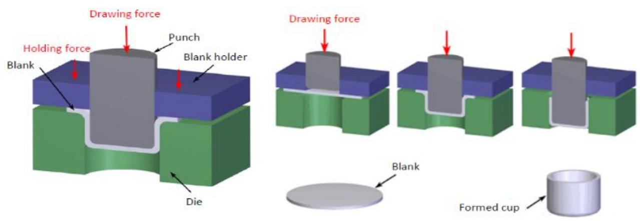

Figure 1: Basic diagram of deep drawing die.

II. LITERATURE SURVEY

Adnan I.O. Zaid (2016) et.al investigated on, the mechanism of deformation, effect of the geometrical factors involved and the defects encountered in the process are presented and discussed. These include:- the radial clearance percentage, punch and die profile radii. Recent experimental investigation on the effect of radial clearance percentage, punch and die profile radii on punch load- punch displacement curves and on quality of the produced blanks is carried out and the results are presented and discussed. It was found that the maximum drawing force decreases with increase of the die profile radius and increases by increase of the punch profile radius. [1]

Pradeep M Patil (2013) et.al this paper reports on the initial stages of a joint experimental and finite element analysis (FEA) of a deep drawing process. A profound drawing apparatus was outlined and worked for this reason. Punches and bites the dust of different geometries were produced. It has also been observed from the work to date that the speed of drawing plays an remarkable role, in so far as, the higher is the speed the further is the draw, which is not totally as expected.. If the blank-holder force is not kept within the upper and lower limit of sensible range it does have a significant effect on depth of draw, with the punch tearing through the bottom of the cup if the force is high and if low wrinkling of the flange area occurs. [2]

S V. Modanloo (2016) et.al in this investigation, the effect of deep drawing process parameters of brass/steel laminated sheet composites on required forming force has been investigated. The process simulated using finite element method (FEM) and then validated by using experimental results. Afterward, the effect of process parameters including friction coefficient between punch and sheet, friction coefficient between die and sheet, blank holder force and the initial blank diameter all in three different levels investigated using design of experiments by Taguchi method. Based on four selected parameters in three levels, experiments done by Taguchi L9 orthogonal array and then the maximum punch force of each experiment was obtained using validated FE model. Signal to noise (S/N) analysis validated that the die friction is the most important parameter in deep drawing of brass/steel laminated sheet that by its reduction, the maximum punch force decreases. Also analysis of variance (ANOVA) results illustrated that the die friction and initial blank diameter are involved 52.1% and 42.4% of contribution on maximum punch force, respectively. [3]

Ali Hassan Saleh (2015) et.al work on Development technique for deep drawing without blank holder to create circular cup of brass alloy. He work on a new mechanism for deep drawing was proposed to create circular cup from thin plate without blank holder. In this system the pass on gathering incorporates punch, pass on and kick the bucket punch. A 2D pivot symmetric limited component model was assembled utilizing DEFORM programming. Impact of pass on geometry (half-cone edge) on extraordinary load, thickness dispersion, strain dissemination and impact of leeway proportion amongst punch and (kick the bucket punch) on the wrinkling of the container were explored. Three half-cone edges of bite the dust (30o, 15o and 45o) were utilized for framing sheet metal of metal (CuZn37) which had introductory thickness of (0.1cm) at four freedom proportion (c/t) for pass on of 30o half-cone point. Limited component demonstrate comes about indicated great concurrence with exploratory outcomes. Kick the bucket of 30o half-cone point with leeway proportion (c/t) of 0.9 gave the best item without wrinkling.

B.Beglarzadehand B. Davoodi (2016) et.al work on numerical simulation and experimental examination of forming defects in multi-point deep drawing process. According to this, as the blank holder force increases up to 2000 Newton, folds were removed gradually and finally a perfect piece may be formed by applying 2000 Newton blank holder force. Comparison of Cockcroft-Latham and Clift criteria of each element indicate that elements pertaining to Clift criterion are ruptured earlier. [5]

Daw-kweiLeu (1997) et.al conducted a study of influence of material properties and variable processes in contradiction of the magnitude of drawing maximum load and the possibility of cracking. In their study, a constant blank holder force (BHF) is applied in each position of the punch stroke, so some product without cracking in exceptional case would be difficult to achieve. [6]

III. OBJECTIVE

1. Design of the Deep drawing blank for given component shape.
2. Statistical analysis of the parameter to find optimal deep drawing force without holding force to determine the Optimal Die Clearance Optimal , Optimal Drawing speed and Optimal Drawing Radii, by use of Taguchi method of Design of Experiment and ANOVA for variance validation.
3. Design and Analysis of the Component produced by theoretical method and using ANSYS workbench 16.0 to validate results.
4. Experimental validation of results by experiment using optimal values determined by the Ansys analysis and Statistical analysis.

IV. EXPERIMENTATION

Selection of Materials for Punch –

En24: EN24 is a high carbon Alloy steel which accomplishes a high level of hardness with compressive quality and scraped area resistance that are appropriate for some car applications, for example, substantial obligation adapt, shaft, pinion, cam shafts. It is neither remotely weak nor malleable because of its lower carbon substance and lower hardness.

Table 1: Properties of En24

Chemical Composition (%)				
Carbon	*Silicon*	*Manganese*	*Phosphorous*	*Sulphur*
0.18	0.35	1	0.05	0.05

Table 2:Properties of En24

Thermal expansion	Melting point	Elastic modulus GPa.	Rockwell hardness	Izod impact	Density
10.4 x10-6 / °C	1421 ºC	190-210	62	77.0 J	7.7 x 1000 kg/m3

As compare both costs En24 is lower than D2 steel therefor En24 steel is suitable for copper due to soft material.

Design of blank size –

The size of blank is given by:

$$D = \sqrt{d^2 + 4dh} - r/2$$

Where d = 166 mm

H= 98mm r = 6.3 mm

D = 301.198 mm ---- rounding off,

D = 302 mm

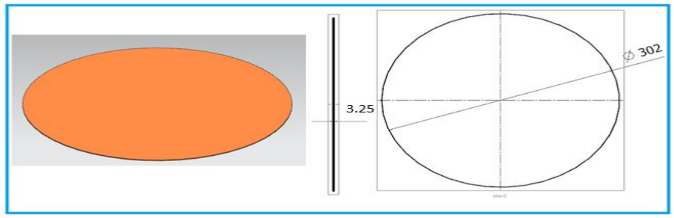

Figure 2: Blank drawing**.**

Determine Press force –

$F = n * \pi * d * t * Sut$ =728415 N

Thus the maximum tonnage of press required is less than 90 tons hence a 100 tons press will be suitable for the operation.

Figure No. 3: Double acting hydraulic press 200 tones.

Main Effects Plot for Means –

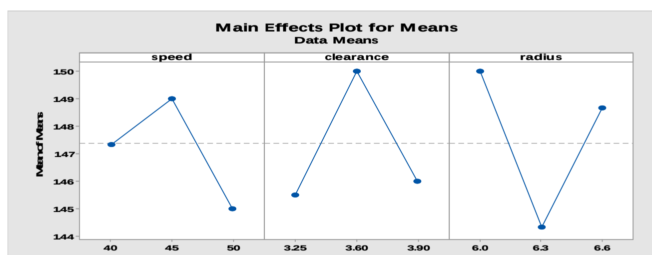

Figure No. 4: Main Effects Plot For Means

The least variation and the optimal design are obtained by means. Lower means, more stable the achievable quality (Tosun et al., 2004). It is clear from Figure lowest means FIRST level of speed (50), THIRD level of clearance (3.9) mm, SECOND level of radius (6.3) mm therefore, the optimal setting of process parameters which yield maximum surface finish is **A1B3C2.**

The table below gives the results of the various test that were conducted during experimentation.

Table 3: Various Test Conducted During Experiment

Drawing Speed	Drawing Clearance	Drawing Radii	Thickness (t)
50	3.25	6.0	1.48
50	3.6	6.3	1.42
50	3.9	6.6	1.41
45	3.25	6.3	1.54
45	3.6	6.6	1.52
45	3.9	6.0	1.50
40	3.25	6.6	1.48
40	3.6	6.0	1.44
40	3.9	6.3	1.43

V. RESULTS AND DISSCUSSION

Final Result after the test were conducted on optimal values:

Table 4: Optimal Value Result

Drawing Speed	Drawing Clearance	Drawing Radii	Thickness (t)
50	3.9	6.3	1.51

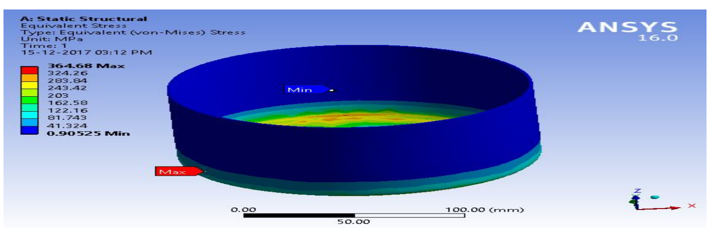

Figure 5: Von-Mises Stress of Cup

During the result, Von mises stress induced = 364.68 MPa maximum and 0.90525 MPa min as shown in figure.

Theoretical Determination of Stress developed in Wall Thickness due to drawing force

Stress = Force / Area

$= 728415 / (\pi * (166^2 - 163^2) /4)*2.6$

$= 728415 / (775.2)*2.6$

Stress = 364 .2 Mpa

VI. CONCLUSION

1. Theoretically blank size was derived and the blank size was 302 mm diameter and 3.25 mm in thickness.
2. The optimal value of drawing speed is 50 m/min
3. The optimal value of drawing clearance is 3.9 mm
4. The optimal value of the drawing radius is 6.3 mm
5. The maximum tonnage derived for the given operation was 88 Tons a machine used for the operation was 200 Ton hydraulic press.
6. The maximum stress developed in the component is 364 .4 MPa which is less than the ultimate strength of material but higher than the yield strength of material hence the perfect condition of deep drawing is attained and the experiment is validated by theoretical, experimental and Analytical ways.
7. After using the optimal values for final test the component thickness is 1.51 mm which conforms to the design value of 1.5 mm, hence the experiment is validated.

REFERENCES

[1] LiwenTian, Changfeng Men, Qiang Yu, "Optimization of Process Parameters in Deep Drawing Process Based on Orthogonal Experiment Method", 3rd International Conference on Mechanical Engineering and Intelligent Systems (ICMEIS 2015),pp- 684 – 688.

[2] Pradeep M Patil and Prof. Prashant S Bajaj, I. Constantin, '"Tool Design of Cylindrical Cup for Multi-StageDrawing Process", International Journal of Latest Trends in Engineering and Technology (IJLTET), ISSN: 2278-621X, 2013, pp 100-106.

[3] S V. Modanloo, R. Hasanzadeh*, P. Esmaili, "The Study of Deep Drawing of Brass-steel Laminated Sheet Composite Using Taguchi Method", IJE TRANSACTIONS A: Basics.Vol. 29, No. 1, (January 2016), pp - 684 – 688.

[4] Ali Hassan Saleh, AmmerKhalaf Ali, "Development technique for deep drawing without blank holder to produce circular cup of brass alloy",International Journal of Engineering & Technology, 4 (1) (2015) 187-195.

[5] B. Beglarzadeh, B. Davoodi, "Numerical simulation and experimental examination of forming defects in multi-point deep drawing process", ISSN 1392-1207. MECHANIKA. 2016 VOLUME 22(3): PP: 182-189.

[6] Dr R Uday Kumar, P Ravinder Reddy and A V SitaRamaraju "Determination of blank holding pressure in hydroforming deep drawing process", International Journal of mechanical Engineering and robotics research (2012):ISSN 2278 – 01492.

[7] Daw-KweiLeu. "Prediction of the maximum drawing load in the cup drawing process of sheet metals", Journal of Materials Processing Technology, ElsevierScience S.A. 1997; 72; 256-261.

[8] T. Cwiekala, A. Brosius, A.E. Tekkaya. "Accurate deep drawing simulation by combining analytical approaches",

International Journal of Mechanical Sciences, Elsevier Ltd. 2011; 53: 374-386.

[9] Kenichi Hanazaki, Naoto Shigeiri& Nobuhiro Tsuji "Change in microstructures and mechanical properties during deep wire drawing of copper",Materials Science and Engineering a 527 (2010); 5699–5707.

[10] Kenichi Hanazaki "Significant change in mechanical properties of deep drawn ultrafine grained copper wire by additional deformation", Materials Science and Engineering a 534 (2012) 720– 723.

[11] D. K .Karupannasamy **"**A friction model for loading and reloading effects in deep drawing processes" Wear318 (2014)27–39.

[12] DaneshManesh H, KarimiTaheri A. "Theoretical and experimental investigation of cold rolling of tri-layer strip". J Mater Process Technol 2005; 166:163–72.

[13] Islam MD, Olabi AG, Hashmi MSJ. "Feasibility of multi-layered tubular components forming by hydroforming and finite element simulation". J Mater Process Technol 2006; 174:394–8.

[14] Lang L, Danckert J, Nielsen KB. "Multi-layer sheet hydroforming: experimental and numerical investigation into the very thin layer in the middle". J Mater Process Technol 2005; 170:524–35.

[15] Takiguchi M, Yoshida F. "Analysis of plastic bending of adhesive-bonded sheet metals taking account of visco plasticity of adhesive". J Mater Process Technol 2003; 140:441–6.

[16] Wang H, Gao L, Chen M. "Hydrodynamic deep drawing process assisted by radial pressure with inward flowing liquid". Int J MechSci 2011; 53:793–9.

[17] Kapin´ski S. "Analytical and experimental analysis of deep drawing process for bimetal elements". J Mater Process Technol 1996; 60(1–4):197–200.

[18] Fereshteh-Saniee F, Alavinia A, Atrian A. "An experimental investigation on the deep drawing process of steel–brass bimetal sheets". In: Proceedings of metal forming. Krakow, Poland, Conference, Conference; 2008. p. 63–70.

[19] Parsa MH, Yamaguchi K, Takakura N. "Redrawing analysis of aluminum– stainless-steel laminated sheet using FEM simulations and experiments". Int J MechSci 2001; 43(10):2331–47.