Journal of Engineering Sciences
Vol 11, Issue 6,June/2020
ISSN NO:0377-9254

COMPARATIVE STUDY ON LIMITING DRAWING RATIO OF Al 1100 AND PURE COPPER

Dr.R.Uday Kumar

Associate Professor, Department of Mechanical Engineering, Mahatma Gandhi Institute of Technology, Gandipet, Hyderabad-500075

Email: udaykumar403@gmail.com

Abstract—Present trend, the sheet metal applications and utilisation is high in manufacturing lines. The aluminium 1100 and pure copper materials are taken and cut into circular shape with different diameters with constant thickness. The cutting material in circular shape is called as a blank. The lubricant (grease) is added to the blanks before going to testing. Then the blanks are prepared for determination of limiting drawing ratio through swift cup drawing testing on hydraulic deep drawing press. After that the cup formation is generated due to the punch force. In deep drawing process, at some diameter of blank it gets fractured at the bottom of the cup due to punch force. The diameter of blank just before the fracture occurs in the drawn cup is the maximum diameter of the blank. A lubricant (grease) has been added to investigate the effect of friction between the blank and punch in deep drawing process. Drawability of sheet metals expressed in terms of Limiting Drawing Ratio (LDR). Limiting drawing ratio is the deformation of cup without any failure with the help of hydraulic press. LDR is defined as the ratio of maximum diameter of blank to the diameter of punch. The experimental work carried out on aluminium 1100 and pure copper of these sheet metals through hydraulic press deep drawing setup. The load - displacement curves are obtained from the deep drawing setup. LDR values of copper and aluminium are compared with each other. The Limiting drawing ratio is higher in copper is obtained.

Keywords— Deep drawing, limiting drawing ratio, maximum diameter.

1. INTRODUCTION

Sheet metal forming involves conversion of flat-thin sheet metal blanks into parts of desired shape. Sheet metal forming processes like deep drawing, stretching, bending, etc. are widely used to produce large number of simple to complex components in automobile and aircraft industries. In deep drawing which is also called cup drawing or radial drawing, a flat thin sheet is formed into cup shaped component by pressing the centre portion of the sheet in to die opening using a punch to draw the metal in to the desired shape. The blank may be circular or rectangular or some complex shape(1-3). Blank holder is loaded by a blank holder force, which is necessary to prevent wrinkle and to control the material flow into the die cavity. The punch is pushed into the die cavity simultaneously transferring the specific shape of the punch and dies in blank holder-die region and is subjected to compressive and tensile stresses on that portion. When very high blank holding force is applied, the deep drawing process becomes stretching process. Bending is the plastic deformation of metal about linear axis with little or no change in surface area. Bending process is used not only to form such as angle section, flanges, seams and corrugation, but also to impart stiffness to the parts by increasing its moment of inertia. It is the most common type of deformation that occurs in almost all sheet metal operations.

In deep drawing operation bending of sheets take place over die curvature. The bend zone experiences localized strains which are tensile on the outer side of the neutral axis and compressive on the other side(4-6). In deep drawing the majority of the deformation occurs in flange of the cup. The metal is subjected to three types of stresses. This stress has influence over thickness variation in drawn cup. The primary deformation zone is bending around the die radius, while third deformation zone is uni-axial stretching in the cup wall (plane strain) which causes thinning of metal. In the cup bottom which is subjected to bi-axial tension, the thickness is more or less equal to the initial sheet thickness. In conventional deep drawing, the forces on the punch required to produce a cup is the summation of the force required for deformation, force required to overcome plastic deformation and the ironing force. When the punch force in deep drawing of ductile metals generally takes place at the transition between n the punch profile region and punch cylinder region(7-8).The force needed to cause deformation is applied through a punch at the centre portion of the blank. The force is transmitted through the cup of the flange. As the blank size increases there is an increase in total force and if total force exceeds beyond certain value, fracture increase beyond certain value, failure occurs in the cup wall due to tensile stretching and it occurs in the cup wall this puts a limit to blank size that can be successfully drawing into cup without failure. Thickness in the drawn cup at the punch corner will be lower because maximum load is bearing of the material in this region. Since compressive hoop stresses appear in the flange region, so thickness of the cup drawn on the wall region increases. As the diameter of the blank increases thickness of the drawn cup in the punch corner region will decrease.

2. METHODOLOGY

The experiments were carried out on experimental test rig which is specially designed for deep drawing operations. Aluminium and copper blanks of 0.5mm thickness were cut into circular shape using wire cut EDM and deep drawing was carried out on blank diameters ranging from 110mm to 150mm of aluminium and 140mm to 170mm of copper blanks. Hydraulic press of 40 Tons capacity was used for deep drawing on aluminium and copper blanks. Since there is tendency in the material to change dimensions at higher temperatures, inconel-600 is used in designing and manufacturing the die, blank holder and punch. The lubricant is applied to reduce the friction between the punch and die. Blank is fixed rigidly between the upper and lower dies. Punch is then rammed down to deep draw the blank into a cup. The forming load is transferred from the punch radius through the drawn part wall into the deformation region (sheet metal flange). Due to tensile forces acting in the part wall, wall thinning is prominent and results in an uneven part wall thickness. The maximum stress that can be safely transferred from the punch to the blank sets a limit on the maximum blank size (initial blank diameter in the case of rotationally symmetric blanks). Determination of the LDR for complex components if difficult and hence the part is inspected for critical areas for which an approximation is possible.

2.1DETERMINATION OF LIMITING DRAWING RATIO (LDR)

The limiting drawing ratio is evaluated experimentally for Aluminium 1100 and Copper through deep drawing process.The main importance of limiting drawing ratio is selection of material for successful formation of cups in Deep drawing operation. Limiting Drawing Ratio (LDR) is defined as the ratio of maximum diameter of blank (D_{max}) for which gives successful formation of cup to the diameter of the punch (d).

LDR is represented by

$$LDR = \frac{Dmax}{d}$$

Where

D_{max} = Maximum diameter of blank

d = Diameter of punch

As per Experiment, Greater in LDR gives higher formability and lesser in LDR gives lower formability of metals. This LDR parameter can be evaluated for Aluminium1100 and Copper metals. After that comparisons were too made. The draw ration (DR) of a deep drawing process is calculated as the ratio of blank diameter to the cup diameter. For achieving a very high draw ratio, redrawing and ironing or annealing between successive drawings is performed. The maximum draw ratio can that can be obtained under perfect deep drawing condition is called limiting drawing ratio the LDR and is considered as a good measure of drawability of materials.

3. RESULTS AND DISCUSSION

3.1 LIMITING DRAWING RATIO OF ALUMINIUM 1100

The formation of cup from the Aluminium 1100 cylindrical blanks from Diameters range D is 110mm - 150mm with incremental 5mm. Thickness of each blank is 0.5mm.The failure of Aluminium1100 cup occurred at 150mm diameter. Just before this diameter of blank is gives successful formation of cup, this diameter is called maximum diameter of blank. Therefore the maximum diameter of blank which is given successfully formation of cup is denoted by D_{max}.

D_{max}=145mm;

diameter of punch d = 80mm

$$LDR = \frac{D_{max}}{d}$$

$$LDR = \frac{145}{80}$$

$= 1.81$

3.2 LIMITING DRAWING RATIO OF PURE COPPER

The formation of cup from the pure copper cylindrical blanks from Diameters range D is 140mm - 170mm with incremental 5mm. Thickness of each blank is 0.5mm.The failure of copper cup occurred at 165mm diameter. Just before this diameter of blank is gives successful formation of cup, this diameter is called maximum diameter of blank. Therefore the maximum diameter of blank which is given successfully formation of cup is denoted by D_{max}.

$D_{max} = 165mm$

diameter of punch d = 80mm

$$LDR = \frac{D_{max}}{d}$$

$$LDR = \frac{165}{80}$$

$= 2.06$

The failure of Pure Copper cup occurred at 170mm diameter with thickness of 0.5mm and the maximum load of 43kN is taken from Graph at punch displacement of 38mm.The failure of Aluminium cup occurred at 150mm diameter with thickness of 0.5mm and the maximum load of 39kN at punch displacement of 32mm.From above Results the limiting drawing ratio (LDR) of aluminium1100 is 1.81 and LDR of Pure Copper is 2.06. So that Pure Copper have higher formability compare to Aluminium1100, because of higher LDR value. The experiments have been performed with utmost care and the results are presented in load displacement curves for both Aluminum 1100 and copper as shown in fig.1 and fig.2 respectively.

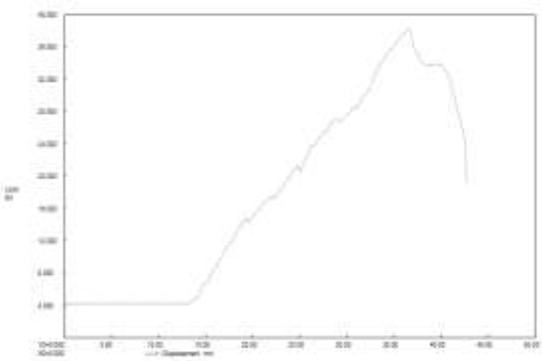

Fig.1 Load varies with displacement for 145mm diameter of aluminium

From this graphs, the successful formation of cup from Aluminium 1100 are occurred at 145 mm diameter with the maximum load of 38kN at punch displacement of 43mm.The successful formation of cup from pure copper are occurred at 165 mm diameter with the maximum load of 46kN at punch displacement of 50mm.

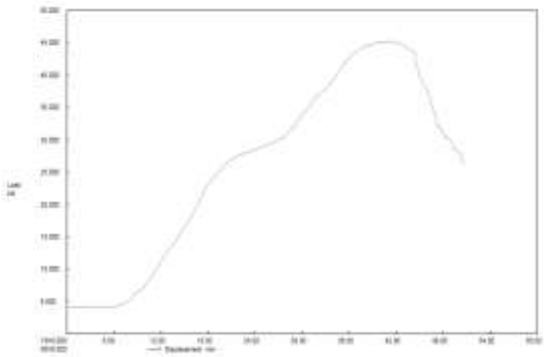

Fig.2 Load varies with displacement for 165mm diameter of copper

4. CONCLUSIONS

The Limiting Drawing Ratio (LDR) has been found out to be 1.81 for Aluminium 1100 and 2.06 for Copper. The safest blank size which can be conveniently deep drawn is up to 145mm of Aluminium 1100 and 165mm of copper with given specifications. After that, 150mm diameter of Aluminium is observed as fractured cup and 170mm diameter of Copper is observed as fractured cup with the thickness of 0.5 mm. From test results the LDR is high in copper compare to Aluminium 1100. So that copper having higher LDR which makes higher drawability of material. So Copper is a highly formable material to be used in industries and future applications.

REFERENCES

[1] Jain, M., J. Allin, and M. J. Bull. "Deep drawing characteristics of automotive aluminium alloys." Materials Science and Engineering: A Vol.256, No.1, pp.69-82, 1998.

[2] G. Behrens, F. O. Trier, H. Tetzel and F. Vollertsen, "Influence of tool geometry variations on the limiting drawing ratio in micro deep drawing ", International Journal of Material Forming Vol.9, No.2, pp.253-258, 2016.

[3] Xiao-bo Fan, Zhu-bin He , Wen-xuan Zhou and Shi-jian Yuan. "Formability and strengthening mechanism of solution treated

Vol 11, Issue 6,June/2020
ISSN NO:0377-9254

Al–Mg–Si alloy sheet under hot stamping conditions" Journal of Materials Processing Technology Vol.228, pp.179-185, 2016.

[4] Pourboghrat, Farhang, Senthilkumar Venkatesan, and John E. Carsley. "LDR and hydroforming limit for deep drawing of AA5754 aluminum sheet." Journal of Manufacturing Processes Vol.15 No.4, pp.600-615, 2013.

[5] Wen-yu Ma, Bao-yu Wang, lei Fu, Jing Zhou and Ming-dong Huang. "Influence of process parameters on deep drawing of AA6111 aluminium alloy at elevated temperatures" Journal of Central South University vol.22,No.4, pp.1167-1174, 2015.

[6] Lucian Lazarescu, IoanNicodim, and Dorel Banabic, "Evaluation of drawing force and thickness distribution in the deep-drawing process with variable blank-holding. In Key Engineering Materials", Trans Tech Publ. Vol.639, pp.33-40, 2015.

[7] Demirci, Halil Ibrahim, CemalEsner, and Mustafa Yasar. "Effect of the blank holder force on drawing of aluminum alloy square cup: Theoretical and experimental investigation." Journal of materials processing technology Vol. 206, No.1 pp.152-160, 2008.

[8] Muhammad Safwan Bin Ismail. "experimental study of formability of sheet metals in deep drawing process" University of Malaysia Pahang 2010 through internet.