International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 3.45 (SJIF-2015), e-ISSN: 2455-2585
Volume 4, Issue 5, May-2018

EFFECT OF FRICTION AND LUBRICATION IN DEEP DRAWING

Dr.R.Uday Kumar

Associate Professor
Department of Mechanical Engineering
Mahatma Gandhi Institute of Technology
Gandipet, Hyderabad-500075.
E-mail: u_kumar2003@yahoo.co.in

Abstract

Forming process is a very economical process as the desired shape, size and finish can be obtained without any significant loss of material. So the wastage of material in metal working processes is either negligible or very small, and the production is in general is very high. These two factors give rise to the economy in production. Moreover, a part of input energy is utilized in improving the strength of the product. Deep drawing is a simple non-steady state sheet metal forming process for making seamless shells, cups and boxes of various shapes. Though the process is simple it has several parameters determining the outcome and the analysis of the process can be complex. The parameters include the draw ratio, die and punch radii, blank holder force, blank holder and die friction and lubrication, material properties, such as the stress–strain curve, anisotropy, grain size, etc. To produce cups of satisfactory quality the right combination of the parameters must prevail in the drawing process. The maximum draw ratio possible is governed by the material properties, the stress needed to radially draw the metal into the die cavity, frictional resistances at the flange of the cup being drawn and at the die radius and the bending and unbending at the die radius. The drawing force and the energy needed are provided by the punch. Variations to the simple or conventional deep drawing processes make use of flexible tool materials such as urethane, hydraulic pressure or other aids. In deep drawing process, the various defects are occurred in the forming of cups such as wrinkling in flange, wrinkling in wall, tearing, earing, localized necking and fracture. The blank is drawn radially inwards the flange undergoes radial tension and circumferential compression. The latter may cause wrinkling of the flange if the draw ratio is large, or if the cup diameter-to-thickness ratio is high. A blank-holder usually applies sufficient pressure on the blank to prevent wrinkling. Radial tensile stress on the flange being drawn is produced by the tension on the cup wall induced by the punch force. Hence, when drawing cups at larger draw ratios, larger radial tension are created on the flange and higher tensile stress is needed on the cup wall. Bending and unbending over the die radius is also provided by this tensile stress on the cup wall. In addition, the tension on the cup wall has to help to overcome frictional resistance, at the flange and at the die radius. As the tensile stress that the wall of the cup can withstand is limited to the ultimate tensile strength of the material. In this paper presents the parametric study on deep drawing with presentations with influence of friction and lubrication to be studied.

Key words : Deep drawing , Sheet metal forming, Lubrication, Friction

1. Introduction

In sheet metal forming, on the other hand, a piece of sheet metal is plastically deformed by tensile load into three dimensional shape, after without significant changes in sheet thickness or surface characteristics. The metal forming process two deformations are occurred, one is elastic deformation and other is plastic deformation[1-3]. In elastic deformation ability of material to regain its original shape after deformation when external load is removed. In plastic deformation material retains the deformation permanently even after removing the load. The forming processes are can be grouped under two broad categories namely cold forming and hot forming. The division of these two processes obtained on the basis of amount of heating applied to the metal before applying the mechanical force[4-7].

If the working temperature is higher than the recrystallization temperature are forming as hot forming or working, below the recrystallization temperature is termed as cold forming or working. Generally the cold working is carried at room temperature. The flow stress behavior of a material is entirely different above and its recraytallization temperature. During hot working, a large amount of plastic deformation can be imparted without significant of strain hardening. This is important because a large amount of strain hardening renders the material brittle. The frictional characteristics of the two forming processes are entirely different. For cold working the coefficient of friction is order of 0.1 whereas that is hot working can be high as 0.6. Further hot working lowers down material strength so that machine with a reasonable capacity can be used even for product having large dimensions [8-12].

The metal forming operating are carried out manually by using equipments, machines and using computer aided approach. Metal forming is an economical method of manufacturing components because loss of material is too less. It is a process in which the desired size and shape of the components are obtained through the plastic deformation of metal. In metal forming process the mass, volume are conserved to form it as a desired shape and size. The forming of metals into desired shape is almost the oldest fabricating technique. Many new methods have been introduced which can be produced components more economical than conventional forming methods or slow velocity forming methods. The conventional forming methods are press work, rolling, forging, extrusion spinning and drawing. Whereas new forming methods are high velocity forming, high energy rate of forming process, explosive forming, Electro hydraulic forming and electromagnetic forming.

2. Deep drawing process

Sheet metal forming is one of the most common manufacturing processes to plastically deform a material into a desired shape. Products include hundreds of automotive components, beverage cans, consumer appliances, aerospace parts, submarine hulls and air craft frames. The reason behind sheet metal forming gaining a lot of attention in modern technology is due to the ease with which metal may be formed into useful shapes by plastic deformation processes in which the volume and mass of the metal are conserved and metal is displaced from one location to another. Deep drawing is the process to produce cups, shells, boxes and similar parts from metal blank. The deep drawing process setup with geometry as shown in fig.1.In the drawing of a cylindrical cup, a round sheet metal blank, is placed over a circular die opening and is held in place with a blank holder. The punch travels downward and forces the blank into the die cavity, forming a cup. It is a sheet metal forming process in which a sheet metal blank is radially drawn into forming die by the mechanical movement of the punch. It is thus a shape transformation process with material retention.

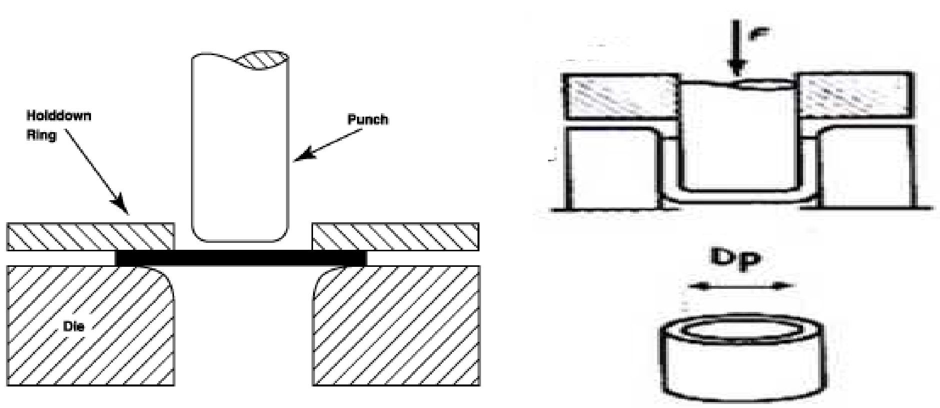

Fig.1 Deep drawing process

Generally, a drawing operation is referred to as shallow drawing when the depth of cup is less than the diameter of cup and drawing of cup is deeper than half its diameter then it is called deep drawing. Deep drawing of metal sheet is used to form containers by a process in which a flat blank is constrained while the central portion of the sheet is pressed into a die opening to draw the metal into the desired shape without folding of the corners. This generally requires the use of presses having a double action for hold down force and punch force. The term deep drawing implies that some drawing in of the flange metal occurs and that the formed parts are deeper than could be obtained by simply stretching the metal over a die. Clearance between the male punch and the female die is closely controlled to minimize the free spam so that there is no wrinkling of the side wall. This clearance is sufficient to prevent ironing of the metal being drawn into the sidewalls is to be part of the process; it is done in operations subsequent to deep drawing. Suitable radii in the punch bottom to side edge, as well as the approach to the die opening, are necessary to allow the metal sheet to be formed without tearing. In most deep drawing operations, the part has a solid bottom to form a container and a retained flange that is trimmed later in the processing. In some cases, the cup shape is fully drawn into the female die cavity, and a straight-wall cup shape is ejected through the die opening. To control the flange area and to prevent wrinkling, a hold-down force is applied to the blank to keep it contact with the upper surface of the die. A suitable sub press or a double-action press is required. Presses can be either hydraulic or mechanical devices, but hydraulic presses are preferred because of better control of the rate of punch travel.

Any metal that can be processed into sheet form by a cold rolling process should be sufficiently ductile to be capable of deep drawing. Both hot and cold rolled sheet products are used in deep drawing processes. The cold work effects introduced during the processing of the sheet products for deep drawing applications must be removed (by annealing)**,** and the as delivered coils should be free of any aging. This would imply that aluminum killed drawing quality steel, for example, would be preferred over rimmed steel. After the deep drawing operation, ductility can be returned to that of the original sheet by in-process annealing, if necessary. In many cases, however, metal that has been deep drawn a first operation can be further reduced in cup diameter by additional drawing operations, without the need for intermediate annealing. The properties considered to be important in sheet products designed for deep drawing include: Composition with a minimum amount of inclusions and residual elements contributing to better drawability. Mechanical properties of which the elongation as measured in a tension tests, the plastic strain ratio and the strain hardening exponent are of primary importance. The strength of the final part as measured by yield strength must also be considered, but this is more a function of the application than forming by deep drawing. Physical properties including dimensions, modulus of elasticity and any special requirements for maintaining shape after forming. Once a metal has been deep drawn into a suitable form, it can be further processed to develop additional shape. The first shape is usually a round cylinder or a modification of this a square box with rounded corners. This latter shape is related to the cylinder in that the four corners are essentially quarter segments with straight walls between each segment. The clearance between the punch and die is such that the metal in the cup side is free to move without excessive rubbing on the die walls. It has been found that slight roughening of the punch radius and minimizing the lubrication of this area contribute to deeper drawability; however, the die opening should be smooth and well lubricated with a suitable drawing compound.

3.Lubrication

The lubrication in necessary in all sheet metal working process to get the required mechanical changes and to ensure on acceptable product. The lubricants used many vary from gasses to inert solids with liquid lubricants being more popular. The use of lubricants is essential in most sheet metal forming operation. The functions of lubricants as follows :

- Reduction or elimination of direct sheet metal to die contact and the associated wear
- The surface friction should be minimized which restricts rise in temperature
- The heat generated should be dissipated or reduce the heat generation
- The wear rate at the metal - tool interface should be reduced
- The adhesion of metal to the die to be reduced

No single lubricant is optimal for all types and rates of forming and all combinations of work and die materials. Rankings of lubricants change considerably for different types of operations and material combinations; this necessitates evaluation on an individual basis. Differences in the performance of lubricants are to be anticipated in view of the differences in surface composition, roughness, and texture of work and die materials and the different strain paths and rates of different forming operations. For example, some stretching operation involves local increases in area in excess of 100%, but in many drawing operations, a negligible or negative change in area occurs. In addition, the range at which the work material slides over the dies varies widely. The various regimes of lubrication that is, thick film, thin film, mixed, and boundary lubrication. A simple test for evaluating lubricants measures the frictional force exerted on a lubricated strip of sheet metal when it is pulled between tow rectangular blocks of die material. The force used between the blocks and the test rate can be varied. The number of strips that can be tested before the onset of galling provides an additional measure of the effectiveness of the lubricant. However, this test does not include some of the important aspects of actual forming operations, such as plastic deformation of the work material, the ranges of sliding speeds and rates of straining involved, die geometry (which influences the amount of residual in various locations as the operation progresses) and the heating that occurs in high-volume production operation. Sheet metal lubricants are soap solution soluble oils, mineral oils, straight fatty oils, phosphate coating, graphite, molybdenum disulfide, glass etc are used as lubricants in sheet metal forming processes.

4. Friction

This subject of friction plays a great role in all engineering applications whenever solid surfaces are in sliding contact with each other. This is particularly true in metal working processes where the sliding pair of surfaces is metals and where plastic deformation of the softer of the two metals usually takes place. Friction conditions between deforming tool and work-piece in metalworking are of greatest importance to a number of factors such as force and mode of deformation, properties of the finished specimen, resulting surface roughness etc. Therefore one of the most significant stumbling blocks in establishing correlation between theory and application in deformation process has been the certainty attached to the magnitude of interface friction. Even the simplest theory must account for the effects of friction on forces, power requirements and material flow and the magnitude of this friction must be known together with the correct value of the flow stress – if the validity of a theory is to be checked.

The friction stress, is measured in force units per unit surface area of contact. The surface area of contact is a boundary of the deformed metal. The frictional stress or resistance is thus also the shear stress in the material at its boundary. The mechanics of friction is a complex phenomenon and depends upon a number of variables such as nature of materials, size and shape of the specimen, velocity of deformation, temperature and the atmospheric conditions etc. The friction place an important role in all sheet metal working processes.

5.Conclusions

The following were concluded

The Lubricants must meet many requirements to be used in a production operation for producing components

- Suitable viscosity over the ranges of temperatures and pressures encountered
- Chemical and physical compatibility with work and die materials
- Ease of application removal, and disposal
- Compatibility with welding operations, sealant and paint systems
- It should be ensure proper surface finish
- More uniform distribution of strain and therefore an increase in the overall deformation
- Lowers the operating forces

The major effects of friction in sheet metal forming as following.

- The work load increases with the increasing in friction
- Friction causes the various sheet metal working tools such as die, punch, to wear out
- The presence of friction results in a modification of the deformation pattern of the sheet metal
- The blank holding force has the major influence in the deep drawing process
- The main concern of the deep drawing industry is to optimize the process parameters in order to get a complete deep drawn product with least effects and high limiting drawing ratio.
- In order to achieve this optimization objective a large number of solution runs need to be performed in order to search for the optimum solution. Furthermore the quality of the products can be increased. With reference to an economical success it is very important to put better and cheaper products faster on the market than other competitors.

ACKNOWLEDGEMENT

The author (Dr.R.Uday Kumar,Associate Professor,Dept.of Mechanical Engineering, Mahatma Gandhi Institute of Technology, Hyderabad) thanks the Management and Principal of Mahatma Gandhi Institute of Technology , Hyderabad for encouraging and granting permission to carry out this work.

REFERENCES

[1] D.F. Eary, E.A. Reed, “Techniques of Press-working Sheet Metal”, prentice-Hall, New Jersey, 1974, pp. 100–172.

[2] Mark Colgan, John Monaghan, “Deep Drawing process: analysis and experiment”, Journal of Materials Processing Technology, 132, 2003, 35-41.

[3] J.Duncan, S.J.Hu, Z.Marciniak “Mechanics of sheet metal forming” Butterworth – Heinemann Publications, 2002.

[4] J.M. Alexander, “An appraisal of the theory of deep drawing”, Met. Rev. 5 (19) (1960) 349– 409.

[5] Ghosh and Malik “Manufacturing science” East-West Press (P) Ltd., New Delhi 1985.

[6] J. Duncan, S.J.Hu, Z.Marciniak “Mechanics of sheet metal forming” Butterworth –

Heinemann Publications, 2002.

[7] Phillip Ross “Taguchi techniques for Quality Engineering”

[8] D.M. Woo, “Analysis of cup drawing process”, J.Mech.Engg., sci., Vol.6 (1964), pp.116-131. [9] R. Padmanabhan, M.C. Oliveira, J.L. Alves, L.F. Menezes, “Influence of process parameters on the deep drawing of stainless steel”, Finite Elements in Analysis and Design 43 (2007) 1062 – 1067.

[10] S.Raju, G.Ganesan, , “Influence of variables in deep drawing of AA 6061 sheet” ,Trans.Non-ferrous society of china 20(2010) 1856-1862.

[11] Young Hoon Moon, Yong Kee Kang, Jin Wook Park, Sung Rak Gong, “Deep Drawing With Internal Air-Pressing to Increase The Limit Drawing Ratio of Aluminum Sheet”, KSMEInternational Journal; VoL 15 No.4,pp. 459-464, 2001.

[12] Y. Marumo, H. Saiki, L Ruan, “Effect of sheet thickness on Deep Drawing of Metal Foils”, Journal of Achievements in Materials and Manufacturing Engineering Vol 20 issue 1,January-February 2007,pp.479-482.