International Journal of Advanced Information Science and Technology (IJAIST) ISSN: 2319:2682
Vol.6, No.11, November 2017 DOI:10.15693/ijaist/2017.v6i11.60-63

A Study On Effect Of Process Parameters And Defects In Deep Drawing Of Sheet Metals

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Abstract— Deep drawing technology is a significant metal forming process used in the sheet metal forming operations. In this process, complex shapes can be manufactured with fewer defects. Deep drawing process has different effectible process parameters from which an optimum level of parameters can be identified so that an efficient final product with required mechanical properties will be obtained. The sheet metal or blank will deformed into desired shape like cylindrical, conic, or boxed shaped part and also complex parts which normally require redrawing processes by using progressive dies. One of the most common outcomes in deep drawing process is the defects that occur in the cup shell. These defects are caused by many parameters like blank holder force, Die Radius, Punch Radius, Blank diameter, friction between punch and blank and Die, anisotropy of material, and blank geometry.

Keywords: — Deep drawing, wrinkling, tearing, friction, blank holder force and earing **.**

I. INTRODUCTION

The sheet metal forming operating is 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[1-2]. 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. In sheet metal forming, on the other hand, a piece of sheet metal is plastically deformed by tensile load into three dimensional shapes, after without significant changes in sheet thickness or surface characteristics. The stresses induced during the process are greater than the yield strength, but less than the fracture strength of the material. The type of loading may be tensile, compressive, bending or shearing or a combination of these. The metal forming processes are used to achieve optimum mechanical properties in the metal. Sheet metal forming is one of the most widely used manufacturing processes for the fabrication of a wide range of products in many industries. The reason behind sheet metal industry 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 mass and volume of metal are conserved and metal is displaced from one location to another. The sheet metal operations done on a press may be grouped into two categories cutting or shearing operations and forming operations.

The cutting operation includes:

- Punching
- Blanking
- Cutting off and parting
- Notching
- Lancing
- shaving
- Trimming
- Perforating

The forming operation includes:

- Bending
- Drawing
- Roll forming

- Deep drawing

Deep drawing is process to produce cups, shells, boxes and similar parts from metal blank[3-5]. 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. A round blank is first cut from flat stock. The blank is then placed in the draw die, where the punch pushes the blank through the die. On the return stock the cup is stick with punch, to avoid this blank holder is used. 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. A typical Deep drawing operation is shown in fig 1.

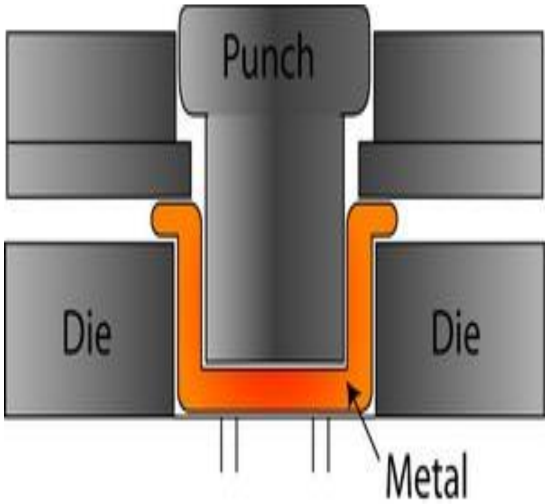

Fig 1. A typical Deep drawing operation

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II. METHODOLOGY

Deep drawing of sheet metal is performed with a punch and die. The punch is the desired shape of the base of the part, once drawn. The die cavity matches the punch and is a little wider to allow for its passage, as well as clearance. This setup is similar to sheet metal cutting operations. As in cutting, clearance is the lateral distance between the die edge and the punch edge. The sheet metal work piece, called a blank, is placed over the die opening. A blank holder, that surrounds the punch, applies pressure to the entire surface of the blank, holding the sheet metal work flat against the die. The punch travels towards the blank. After contacting the work, the punch forces the sheet metal into the die cavity, forming its shape. Equipment for sheet metal deep drawing processes would involve a double action, one for the blank holder and one for the punch. Both mechanical and hydraulic presses are used in manufacturing industry.

Typically the hydraulic press can control the blank holder and punch actions separately, but the mechanical press is faster. Punch and die materials, for the deep drawing of sheet metal, are usually tool steels and iron. However, the range of materials for punch and die can span from plastics to carbides. Parts are usually drawn at speeds of 4 to 12 mm per second. The process of deep drawing of sheet metal is shown in fig 2.

Force used to accomplish a sheet metal deep drawing operation must be adequate enough to provide for the sheet's deformation, enact proper metal flow and overcome friction during the process.

Magnitude of force must not be too high or applied incorrectly, or else tearing of the sheet metal may occur. The punch and the blank holder will exert separate forces and force analysis should be done for both. Understanding the material flow during the manufacturing process is essential to understanding the forces acting on the work.

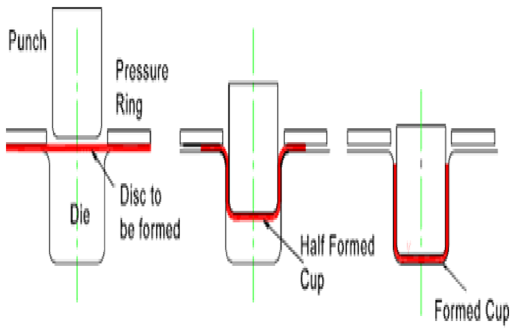


Fig 2. Deep drawing of sheet metal

Imagine placing a piece of paper flat on a round cup. This is similar to a piece of sheet metal on a round die cavity. Now, imitating the action of the punch, the paper is forced into the cup to take the cylindrical form of the cup. What happen is the paper folds or wrinkles in the process. This is not how a sheet metal work piece should act during a deep drawing operation. One reason is that metal material can flow, unlike the paper. So instead of the paper, place a piece of aluminum foil on the cup. Aluminum foil is metal but it still wrinkles when forced into the cup. The reason why aluminum foil wrinkles when forced into the cup is because of the inadequate thickness of the foil. Imagine now, a sheet metal blank being deep drawn into a round cylindrical part. The material under the punch gets forced into the cavity, pulling material with it, to form the walls of the part[6-10]. Sometimes in deep drawing an amount of sheet metal material is not drawn into the die and forms a flange around the completed part. However, during a deep drawing operation all of the material not yet drawn over the die radius and into the die cavity is often referred to as the flange. During the ongoing process material from the flange is constantly being forced into the die. Metal flow in deep drawing is shown in fig 3.The diameter of the die cavity is smaller than that of the sheet metal blank and metal is flowing from the outer peripheral inwards.

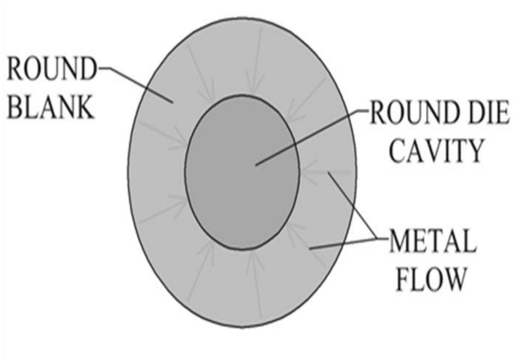


Fig 3. Metal flow in deep drawing

EFFECTS OF PROCESS PARAMETER DURING DRAWING

A. **Tool geometry**: The tools geometry is an important and difficult problem in sheet metal forming. The limit drawing ratio and the residual stress are greatly linked with the tools geometry, particularly the shoulder radius. Their surface condition is also essential to reduce the friction and give a good appearance to the final part. The tools should not mark, damage or weaken the final part. Therefore, the absence of contours in the project parts can make easier the conception of the tools and the parts. Thus, a geometry study should be developed in function of the material.

B**. Blank-holder forces:** The main goal of using a blank-holder is to control the blank sheet flow and avoid wrinkling. A too high value for the blank-holder force leads to materials rupture, but a too low blank-holder force allows the sheet wrinkling. Therefore, it is of paramount importance to find the appropriate value for the blank-holder force. Higher values of blank holder force also contribute for a higher punch force and reduce the thickness on the cup’s wall. On the other hand, for higher blank-holder force values the spring back phenomenon seems to decrease, due to the high values of plastic strain attained and to the thickness reduction. When using a constant blank-holder force during deep drawing the pressure in the flange region increases due to the decreasing contact area. In fact, the flange is strongly compressed in the circumferential direction while it is also being compressed in the thickness direction, which can lead to a gradient in the stress state along the cup’s wall.

C. **Temperature:** Traditionally the deep drawing process takes place at room temperature. However, some researchers have focused their attention in exploring the influence of temperature in the mechanical properties of metallic sheets. In warm forming, the sheet metal is processed bellow the recrystallization temperature. The temperature effects tend to decrease the stress gradient in the cup wall, which is directly linked to the decrease of the spring back and stamping forces. This also permits to increase of the limit drawing ratio. The temperature increase activates the dislocation motion and dislocation-dislocation interactions that result in a viscosity decreases.

D. ***Deep drawing speed:*** Deep drawing speed has a greater influence in the deformation process. The use of a high drawing speed can lead to rupture, but a slow speed is also not possible in industrial processes, because in industry time is money. This parameter is directly linked to the material’s mechanical behavior and, consequently, to the deep drawing forces. The strain rate sensitivity indicates if a material is sensitive to the strain rate or not.

A material that shows the same stress-strain curve for increasing strain rates is say to present a null strain rate sensitivity. If the stress-strain levels increase with the strain rate the material presents positive strain rate sensitivity, otherwise is negative. Therefore, a material that presents positive strain rate sensitivity will present higher punch forces for higher punch speed. However, this characteristic can change with temperature.

E. Friction*:* Friction is primarily connected with the contacting pair of materials and the lubricant conditions. Basically, higher punch force values are linked with higher global friction coefficient values. In fact, high friction coefficient values are dangerous to the drawing process, but the friction can be easily reduced through the use of a lubricant. Unfortunately, this parameter cannot be experimentally measured with the desired accuracy, because it changes with many conditions including the contact pressure and Analysis of the influence of process parameters in the deep drawing of a cylindrical cup. The difficulties related with its accurate modeling result also from the fact that it is influenced by many parameters, including temperature, sliding velocity and the characteristics and amount of lubricant used.

III. DEFECTS IN DEEP DRAWING MANUFACTURING

Defects that occur during deep drawing of sheet metal can be controlled by careful regulation of process factors. The common defects in deep drawing processes

A. **Wrinkling in the flange***:* This defect occurs due to compressive buckling in the circumferential direction. Due to less blank holding force this defect may occur. Because of the material flow is not restricted and more material is trying to flow inside the die cavity.

B. **Wrinkling in the wall**: This defect takes place when wrinkled flange is drawn into cup or if the clearance is very large, which results in large unsupported region. Wrinkling is avoided by applying a blank holder force through a blank holder. This increases friction and hence the required punch load increases. The edges of punch and die are rounded for the easy and smooth flow of metal.

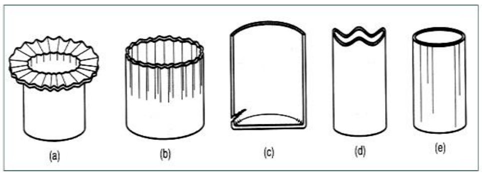
C. **Tearing***:* This defect occurs because of high tensile stresses that cause thinning and failure of the metal in the cup wall. Tearing can also occur in a drawing process if the die has a sharp corner radius. If die radius is too small because of that, more restriction to flow of material. If punch radius too small because of that more thinning of material is occur at that corner of formed part.

D. **Earing** *:* Ears are often wavy projections or unevenness formed along the edge of the flange or end of the wall of the cup. These are formed due to uneven metal flow in different directions, which is primarily due to presence of the planar anisotropy in the sheet.

E. **Localized necking***:* The appearance of any local neck that leads to tearing and failure will obviously terminate the forming process. This can be considered as local instability that that can be analyzed by considering a local element.

F. ***Fracture:*** it is possible for a plastically deforming element to fracture in almost a brittle manner. This is not common for sheet used for forming and is often preceded by some local instability. Basically the quality of deep drawn parts is depended on the better control over metal flow during process. A blank holder is used to prevent the formation of wrinkle. There should enough forces on the blank holder to prevent the wrinkles because after winkle is started, the blank holder is raised from surface of the metal and allow other wrinkles. The force created by the blank holder also increase frictional forces. Too much blank holder pressure may tear the side wall of the drawn cup, and also increases tonnage capacity of press tool. Both the condition is not advisable. So, one another method is used and it is a use of draw bead on die or on blank holder surface. The common defects generated in sheet metal in deep drawing process as shown in fig.4

Fig.4 . Common Defects in Deep drawing Process



(a) Wrinkling in the flange or (b) in the wall (c) tearing,
(d) Earing, (e) surface scratches

IV. CONCLUSIONS

- The clearance between the die and the punch is equal to the job thickness when without considered into thickening and thinning of sheet metal. The same clearance is maintained between blank holder and punch.
- 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 case of plastic deformation the forces applied to material is above the elastic limit. Basically this process is done at room temperature (in cold state) and in this state the material is more rigid than in hot state. Thus to deform the metal greater pressure is needed in cold state then in hot state. The amount of deformation is depended on the ductility of material.
- The effective stress increases with the increase of friction due to increase of normal pressure between die and blank. Blank holder force controls metal flow, it also affects thickness variation, strain path, stress path and wrinkling behavior.
- It is observed that the optimum blank shape reduces forming load, increases forming limits and reduces possibilities of wrinkling and tearing. Friction affects relative thickness distribution and surface quality in forming process

Acknowledgement

The authors thanks the Management and Principal of Mahatma Gandhi Institute of Technology , Hyderabad for encouraging and carry out this work

References

1) J. Duncan, S.J.Hu, Z.Marciniak "Mechanics of sheet metal forming" Butterworth Heinemann Publications, 2002.
2) K.Lange , "Hand book of metal forming",Mc Graw-Hill, New Delhi.
3) D.M. Woo, "Analysis of cup drawing process", J.Mech.Engg., sci., Vol.6, pp.116-131,1964.
4) 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 ,pp.1062 – 1067,.2007.
5) S.Raju, G.Ganesan, "Influence of variables in deep drawing of AA 6061 sheet" Trans.Non-ferrous society of china 20, 1856-1862, 2010.
6) 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", KSME International Journal; VoL 15 No.4,pp. 459- 464, 2001.
7) 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,pp.479-482,2007.
8) Fallahi Arezodar and A. Eghbali, "Evaluating the Parameters Affecting the Distribution of Thickness in Cup Deep drawing of ST14 Sheet" , Journal of Advanced Science and Engineering Research Vol 2, No 3,pp. 223-231, 2012.
9) Kopanathi gowtham, K.V.N.S. Srikanth & K.L.N. Murty, "Simulation of the effect of die radius on deep drawing process, International Journal of Applied Research in Mechanical Engineering Volume-2, Issue-1, 2012.
10) Zein, M. El-Sherbiny, M. Abd-Rabou, M. El Shazly, "Effect of Die Design Parameters on Thinning of Sheet Metal in the Deep Drawing Process", American Journal of Mechanical Engineering, Vol. 1, No. 2,pp.20-29, 2013.