Effects Of Different Parameters On Deep Drawing Process: Review

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Abstract :-

Optimization of process parameters in sheet metal forming is an important task to reduce manufacturing cost. To determine the optimum values of the process parameters, it is essential to find their influence on the deformation behavior of the sheet metal. The significance of three important process parameters namely, punch radius, blank holder force and friction coefficient on the deep drawing characteristics of a mild steel cup will be determined. In this paper basic review is presented based on optimization of process parameter in deep drawing process with the use of different techniques. Various literatures of research focus on parameters that affect most in deep drawing process. By analyzing these parameters, the defects like wrinkling, tearing, earing is reduced and also we can get the good quality product.

Keywords: - Deep Drawing Process, Process parameter Optimization

1. Introduction

Sheet metal forming is one of the most important production methods used in different industries such as producing industrial parts, office and home appliances, automobile body, airplane parts, etc. Deep drawing is one of the frequently applied methods in sheet metal forming. Deep drawing operation is based on producing engineering parts with specific shapes through major plastic deformation of flat metal sheets. An external force on a metal sheet does this plastic deformation. This external force has to be large enough to place the material in the plastic zone and to ensure that after displacing the external force, the metal part doesn't spring back or elastic deform again. The final quality of the parts produced through this operation is based on the final wall thickness and being wrinkle-free and fracture-free [1].

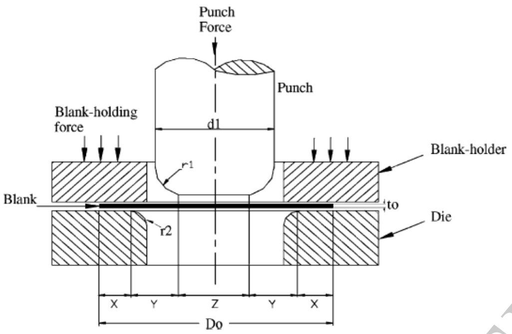

Fig 1.1 The deep-drawing operation [2]

The deformation Process [2]

The flat blank for use in the analysis of deep-drawing may be divided into three zones, X, Y, and Z [13], as shown in Fig. 1.1 As the punch is lowered into the die opening, several distinct phenomena occur. X, the outer annular zone consists of material in contact with the die. Y, the inner annular zone is not initially in contact with either the punch or the die, and Z, the circular zone is only in contact with the flat bottom of the punch. As the deep-drawing operation proceeds, the outer flange portion of the blank, zone X will be subjected to a radial drawing tensile stress as it is drawn progressively inwards towards the die profile and the effect of continuously decreasing the radius in this zone is to induce a compressive hoop stress, resulting in an increase in material thickness [3]. Then when the magnitude of these stresses exceeds a certain critical value, wrinkling and buckling of the flange may occur if the blank-holder pressure is not high enough.

The material in the inner parts of zone X is thinned by plastic bending under tensile stress as it passes over the die profile. The inner parts of zone X are thinned further by tension between the punch and die, resulting in an increase in thickness for the outer parts of zone X. Zone Y is subject to bending and sliding over the die profile, stretching in tension between the punch and die and finally to bending and sliding over the punch profile. Zone Z is subject to stretching and sliding over the punch head [4].

In summary from Johnson and Mellor [5], five processes take place during the course of deep-drawing:

1. Pure radial drawing between the die and blank-holder in zone X, causing the blank to thicken due to the resultant hoop stress.
2. Bending and sliding over the die profile, r_2, which will cause some thinning of the metal.
3. Initial stretching in zone Y. This will cause thinning of the material at the intersection of the bottom of the cup and its side-wall. If a cup fails to form it is invariably due to tensile failure in zone Y.
4. Bending and sliding over the punch profile radius, r1, thinning to some degree occurs here.
5. Stretching and sliding over the punch nose in zone Z, where again some thinning occurs.

Defects in Deep Drawing process:

A number of defects may occur in deep-drawn parts. Figure 1.2 shows the type of defects that may be found after drawing cups. The description of such defects is discussed below:

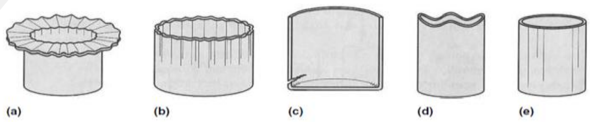

Figure 1.2: Defects in deep-drawn cylindrical cups.
(a) Flange wrinkling.
(b) Wall wrinkling. (c) Tearing. (d) Earing.
(e) Surface scratches [6]

Earing:

It occurs in deep drawn parts made from anisotropic materials. Because of planar anisotropy, the sheet metal may be stronger in one direction than in other directions in the plane of the sheet. This causes the formation of ears in the upper edge of a deep-drawn cup even when a circular blank is used. In practice, enough extra metal is left on the drawn cup so that the ears can be trimmed.

Wrinkling in the flange

Wrinkling in deep drawn parts consists of a series of ridges that form radially in the flange due to compressive forces. Wrinkling in the wall occurs when ridges in the flange are drawn into the vertical wall of the cup.

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Tearing

It occurs near the base of the drawn cup and results from high stresses in the vertical wall that cause thinning and failure of the metal at that location.

Surface scratches

It occur in a drawn part if the punch and die surfaces are not smooth or if lubrication is not enough.

2. LITERATURE SURVEY

2.1 Introduction:-

There are many processing and material parameters which are affecting deep drawing process. Some of the functions are there which cover most of the material and processing parameters affecting the thickness distribution and also the quality of the product. During the last decade many researchers have provided those functions which increase the efficiency of the process and reduce the undesirable features like earing and wrinkles. Some of the functions which are covering most of the material and processing parameters and also the effect of different material and processing parameters are shown. So effect of different parameters on the deep drawing and introduction to those functions are given in this review paper.

2.2 Formability of Sheet Metals:

At the end of the nineteenth century, due to the development of the sheet forming technology, sheet metal formability became a research topic. Some of the first researchers interested in this field were Bessemer and Parkers, Adamson, Considere and Erichsen [7].

The formability of sheet metals is affected by many parameters, like material parameters, process parameters and strain bounding criteria. Figure 2.1 summarizes the parameters that have an effect on the formability of sheet metals. There are methods developed for evaluating the formability of sheet metals. Sheet metal formability is measured by simulating tests, mechanical tests, finding limiting dome height and drawing forming limit diagrams.

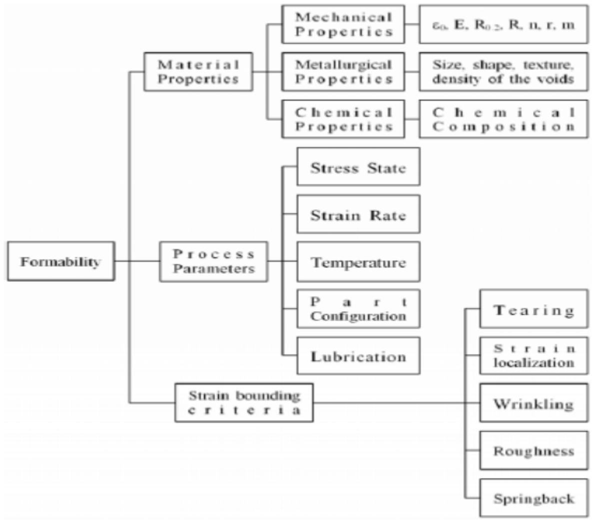


Figure 2.1: Formability of sheet metals [7]

2.3 Effects of Process Parameters:

The process parameters that affect the success or failure of a deep-drawing operation include punch and die radii, punch to die clearance, press speed, lubrication, and type of restraint of metal flow.

2.3.1 Effect of Die Radius:-

As the blank is struck by the punch at the start of the drawing, it is wrapped around the punch and die radii; the stress and the strain developed in the work piece are similar to those developed in bending. The force required to draw the shell at intermediate position has a minimum of three components [8]

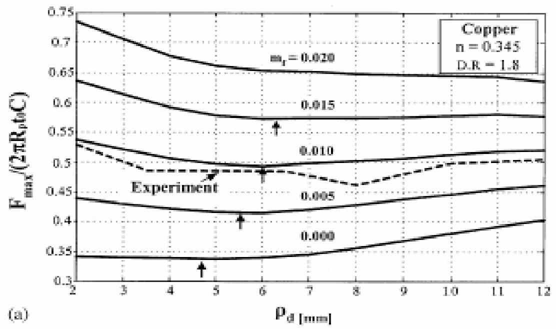
- The forces required for bending and unbending of the metal flowing from the flange into the side wall.
- The forces required for overcoming the frictional resistance of the metal passing under the blank holder and over the die radius.
- The forces required for circumferential compression and radial stretching of the metal in flange.

So increase in the die radius reduces the work required for the deforming as punch radius has not significant affect on the process but it should be appropriate.

On the profile of the die radii flow of the material takes palace. Most of the bending and unbending takes place in that region. Die radii should be optimized for the minimization of the drawing load.

Some details on the several parameters which affect the optimal die curvature are shown below. [9]

Fig: 2.2 Effect of coefficient of friction on Die radius



- The effect of friction coefficient is shown in fig 2.2. It is seen that optimal die radii can be found only for very low coefficients of friction.
- The effect of strain hardening exponent is shown in fig2.3. It is apparently more useful to increase the die curvature when drawing material with relatively high strain hardening exponent.

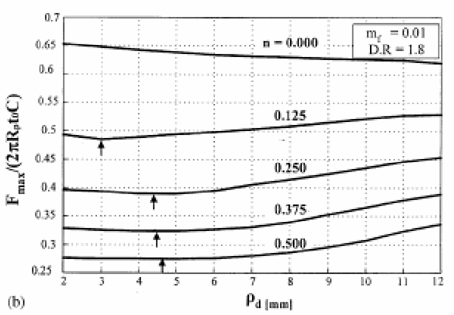


Fig: 2.3 Effect strain hardening exponents on die radii

- The effect of drawing ratio is shown in fig 2.4. Higher drawing ratio increases the optimal die radius.

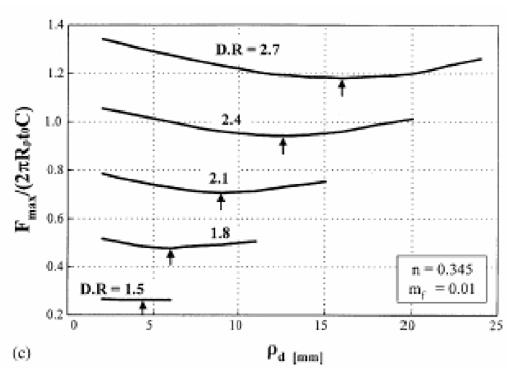


Fig: 2.4 Effect of drawing ratio on die radii.

- The effect of initial blank thickness is shown in fig 2.5. The upper bound solution indicates that initial thickness has negligible effect on optimal die radii.

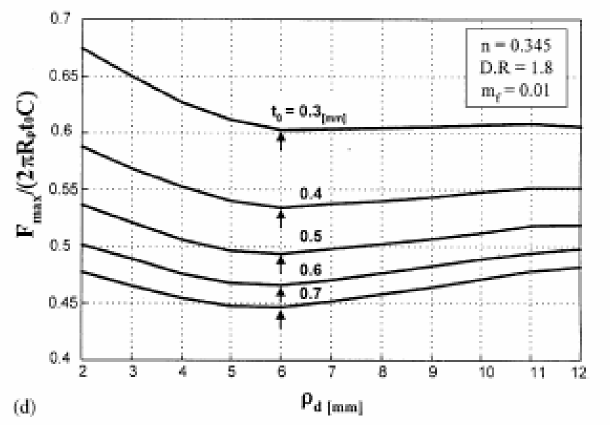


Fig: 2.5 Effect of initial blank thickness on die radii.

2.3.2 Effect of punch-to-die clearance

The selection of the punch-to-die clearance depends on the requirements of the drawn part and on the work metal. Because there is a decrease and then a gradual increase in the thickness of metal as it is drawn over the die radius, clearance per side of 7 to 15% greater than stock thickness helps prevents burnishing of the side wall and punching out of the cup bottom. Clearance between the punch and die for a rectangular shell, at the side walls and at the ends is same as in the circular cup. Radius at the corner may be as much as 50% greater than stock thickness to avoid ironing in those areas. [10]

2.3.3 Effect of blank holding force.

Even simplest drawing operation, the thickness of the work metal and die radius offers some restraint to the flow of the metal into the die. For drawing all but simplest of the shape some restraint is required for the controlling the flow of the material. [10]
Compressive forces on the metal in the area beyond the edges of the die cause the work metal to buckle. If this buckled or wrinkled metal is pulled into the die during the drawing operation, it increases the strain in the area of the punch nose to the point at which the work metal would fracture soon after the beginning of the draw. The blank holder force is used to prevent this buckling and subsequent failure. The amount of blank holding force required is one third of the drawing. [11]

Fig: 2.6 Effect of blank holding force on wrinkling

As we can say that blank holding force prevent blank from the buckling and for the proper distribution of the strain, blank holding force is required otherwise problem like wrinkles can also occurs which is shown in the fig: 2.6 with and without friction.

2.3.4 Effect of the press speed.

Speed is of greater significance in drawing stainless steels and heat resistant alloys than in drawing softer, more ductile metals. Excessive press speeds have caused cracking and wall thinning in drawing these stronger, less ductile materials. [12]

2.3.5 Effect of lubrication.

When two metals are in sliding contact under pressure, as with the dies and the work metal in drawing, galling (pressure welding) the tools and work metal is likely [12]. When extreme galling will occurs, drawing force will increases and becomes unevenly distributed causing fracture of the work piece. Selection of the lubricant is depends on the ability to prevent galling wrinkling, or tearing during the deep drawing. It is also influenced by ease of application and removal, corrosivity, and other factors.

3. CONCLUSION

The detailed study is carried out about wrinkles elimination specially wall wrinkling. Following conclusion have been drawn based on analysis. The main reason for the wrinkles occurrence in that industrial vessel is abruptly sectional changes and the ratio of the upper and base diameter is not constant in both stages of forming. So, it is important that this ratio within certain limit. Punch and die radius should be large enough to reduce tearing in deep drawing process.

Blank holder force increases friction and hence the required punch load. Therefore, blank holder force should be just enough to prevent wrinkling of the flange. The edges of the punch and die are rounded for the easy and smooth flow of metal. Clearance between die and punch is also provided so that sheet metal could be easily accommodated. Insufficient or large clearance may result into shearing and tearing of sheet.

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