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The Significant Variables that Affect Metal During Deep Drawing Process in Sheet Metal Work

N Ramesha
Department of Tool Engineering Organization,
Govt, Tool Room and Training Centre,
Mysuru, India,

Ajay Hiremath
M .Tech Student
Govt, Tool Room and Training Centre,
Mysuru, India

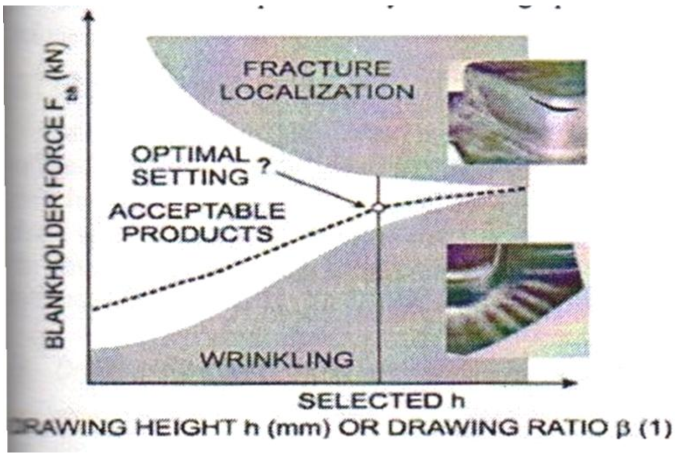
***Abstract*— Deep drawing is one of the most important processes for forming sheet metal parts. It is widely used for mass production of cup shapes in automobile, aerospace and packaging industries. Cup drawing, besides its importance as forming process, also serves as a basic test for the sheet metal formability. The effect of equipment and tooling parameters results in complex deformation mechanism. Existence of thickness variation in the formed part may cause stress concentration and may lead to acceleration of damage. Deep-drawing are well-known manufacturing processes. However all developers are of the same opinion that deep drawing is a very complicated process. There are several factors, such as nonlinearity, large deformation, friction and material characteristics that have a direct influence on the process and sensitive to each other.**

***Key words :* Press working, deep drawing, variables, metal flow.**

I. INTRODUCTION

Press working is a mechanical working of metals in which the latter are subjected to plastic deformation in a cold state. Press working is divided into sheet stamping and cold die forging depending on the material used and the work piece to be manufactured.[1]

Stamping is used for making sheet material items such as automobile components of aircraft, railway cars, chemical apparatuses, electrical appliances and a variety of consumer goods. [1]. Most products of sheet metal press work are not flat blanks that can be produced by die cutting operation alone.



They generally have a third dimension obtained by a shaping operation which deforms the metal to various degrees. The shaping operation may be done separately. [2]. In machine design parts made of sheet metal are widely used for manufacturing of parts with conventional sheet metal forming techniques, for example deep drawing. They are highly specialized. [3]. Deep drawing is sheet metal forming process in which a sheet metal blank is radially drawn into a forming die by the mechanical action of a punch.[4]. It is thus a shape transformation process with material retention. The process is considered “deep” drawing when the depth of the drawn part exceeds its diameter. This is achieved by redrawing the part through a series of dies

The flange region (sheet metal in the die shoulder area) experiences a radial drawing stress and a tangential compressive stress due to the material retention property.

II. VARIABLES THAT AFFECT METAL DURING DEEP DRAWING

A. Radius on punch

A shaper radius requires higher force when sheet metal is folded around punch nose and may result in excessive thinning or tearing at the bottom of the cup. A general rule to prevent excessive thinning is to design punch with nose radius of 4-10 times of the sheet thickness. It may be necessary to form over a large radius and then “Re-strike” to develop the required radius.

B. Draw radius on the die

Theoretically this radius should be large as for as possible to permit full freedom of sheet metal flow. The draw ring or die causes the metal flow' plastically, inside compression and thickening of the outer portion. [2]. the draw radius 4times the material thickness. The draw radius may be increased to 6to 8 times the metal thickness, when drawing shallow cups of heavy gauge metal without a blank holder.

C. Draw speed

Basically draw operation is a slow and gradual, where a material suffers severe strain. Material has to be allowed to enter into the die with a uniform speed. [3]. Hence draw speed is considered as one of the most important point while designing the tool, usually the draw speed for low carbon steel CRCA-Draw quality)ranges between 30 to 50fpm and for non ferrous material like brass, copper, aluminum it ranges between 150 to 200fpm.[4].

D. Cracking load

The largest allowable drawing load is limited by the load that an be transmitted by the sheet in the region of the punch radius or at the transition form cup wall to bottom radius, which is called as cracking load. It must always be larger than the maximum drawing load. The cracking load can be determined approximately by the equation (Kurt Lang [5])

$$Fcr — \pi\ dmSoSu$$

D. Die Clearance

In practice the dimensions of the die clearance are often determined from the empirical equations suggested by and Kaiser (Kurt Lang [6]). These equations are valid only for deep drawing of circular components without ironing.

$$u_D = So + 0.07\sqrt{\ }\ 10\ So \quad \text{for steel}$$

If the die clearance u is too large, the component does not form a true cylinder, u_D but the upper edge of the cup remains expanded. If the die clearance is too small, ironing can take place, which increases the drawing load and increases the danger of cracking. Furthermore cold welding between the die and the work piece is possible

E. Friction

The force of static friction between the work pieces blank and draw die surfaces must be overcome in a drawing operation. The force of the blank holder adds significantly to the force of static friction. [7]. Once static friction is over come by the start of the blank movement, continuous movement of the punch is quite important because the force needed to overcome dynamic friction is less than that needed for static friction.

F. Lubricants

Lubricants are generally used to reduce the friction shallow draw in light metals can be done with little or no lubrication but when the forces are larger causing wrinkling and tearing a thin film of lubrication between the punch and the sheet materials should be strong enough to permit I deformation without being squeezed from the surface.

G. Material to be drawn

Certain characters are essential in the material for successful draw operation Ductility and yield strength are I most important ductility is the ability to undergo a change in shape without fracturing. Yield strength is the point at which the change in shape occurs. Good yield strength is desirable so that metal flow will begin easily near the punch radius.

H. Drawing load for circular components for first draw

The required drawing load for deep drawing and its variations along the punch stroke can be determined in two ways, either from theoretical equations based on plasticity theory, or by using empirical equations.
holder is

$F_{BH} = A_{BH}\ P_{BH}$.

The pressure necessary to avoid wrinkling depends on the sheet material, the relative sheet thickness, and the drawing ratio. An investigation by Siebel and Beisswanger shows that the required blank holder pressure can be estimated from following equation. Where the factor c ranges from 2 to3

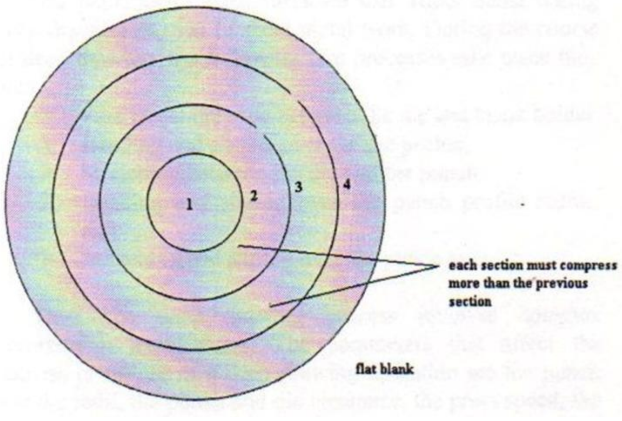
$$P_{BH} = 10^{-3}\, c\left[(\beta - 1)3 + 0.005 do/So\right]$$

I. Blank holder pressure

In the flange there are tangential compressive stresses. They can cause wrinkles due to buckling. Wrinkles can be avoided through the use of a blank holder, which is pressured with a pressure P_{BH} against the flange of the drawn component.[8].

III. METAL FLOW DURING DRAWING

To understand what happens to the metal during a drawing operation, the process should be broken into progressive stages of formation, as shown in the figure here a flat circular blank is drawn into a flat bottomed cup by forcing a punch against the blank, which rests on a die. Note that the blank is divided into sections for easy reference. During the first stage the punch contacts the blanks as shown in figure. The area of punch contact is denoted as section 1. This section forms the flat bottom of the cup and is not distorted by the punch. Upon further penetration of the punch the metal in section 2 is bent or wrapped around the punch nose and die radius as shown in figure.



(a)
Fig. 1. Metal flow during drawing

As the punch penetrates still further the metal that was previously bent over the die radius be comes straightened. Additional metal is pulled over the die radius, which in time is straightened as the punch progresses down ward. In the other words the outside edge of the blank is being drawn toward the punch. In order to accomplish this successfully, the sections of the blank must reduce in circumference and the only way to do this is for the metal to compress and the only way to do this is I for the metal to compress and become thicker.

The initial population is selected at random, which could be the toss of a coin, computer generated or by some other means, and the algorithm will continue until a certain time or a certain condition is met. In order to use GA to solve the problem, variables x i's are first coded in some string structures. It is important to mention here that the coding of the variables is not absolutely necessary. There exist some studies where GA is directly used on the variables themselves. Binary-coded strings having 1's and 0's are mostly used. In general, a fitness function $F(x)$ is first derived from the objective function and used in successive genetic operations.

Reproduction is usually the first operator applied on a population. Reproduction selects good strings in a population and forms a mating pool. That is why the reproduction operator b sometimes known as the selection operator. In the crossover phase new strings are created by exchanging information among strings of the mating pool. Many crossover operators exist in the GA literature. In most crossover operators, two strings are picked from the mating pool at random and some portions of the strings are exchanged between the strings.

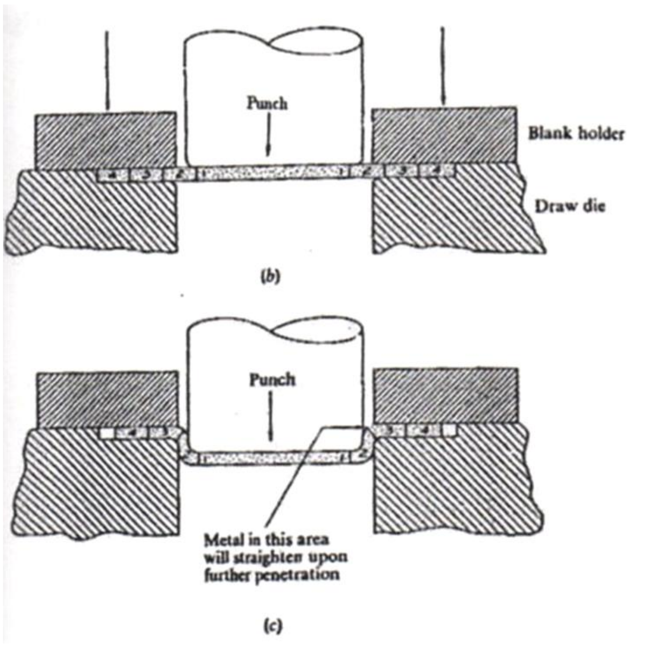


Fig.2. Metal flow during drawing

The amount of compression and thickness increase as the blank edge nears the punch. The metal may tend to wrinkle rather than compress, especially in thin sheets or with deeper draws. A blank holder is used to prevent the formation of wrinkles in this case. There must be enough force on the blank holder is raised from the surface of the metal and allows other wrinkles to start.

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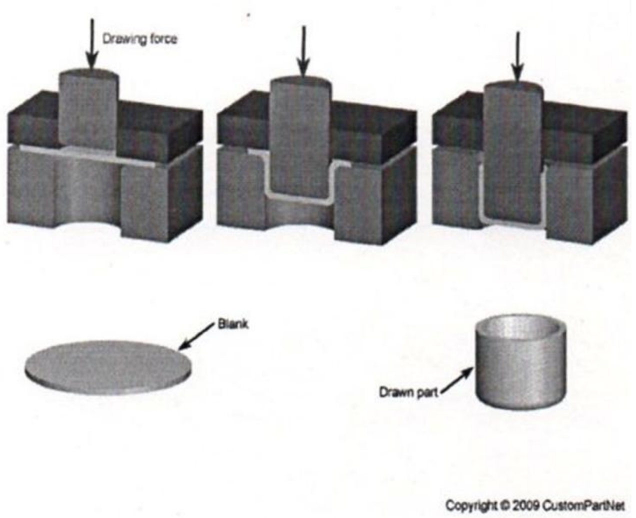

Figure 2: Automotive cup original

IV. Conclusions

This paper deals with variables that affect metal during deep drawing process in sheet metal work. During the course of deep drawing, the following five processes take place they are:

- Pure radial drawing between the die and blank holder
- Bending and sliding over the die profile,
- Stretching between the die and the punch,
- Bending and sliding over the punch profile radius, and
- Stretching and sliding over the punch face.

Thus, the deep drawing process involves complex deformation mechanisms. The parameters that affect the success or failure of a deep drawing operation are the punch and die radii, the punch and die clearance, the press speed, the lubrication and the type and the extent of restraint to metal flow material in deep drawn shapes. Among these the die shoulder radius and the blank holder force are considered to be the significant parameters in deep drawing processes.

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