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DEEP DRAWING BEHAVIOUR OF CRCA SHEET AND WRINKLING CONGESATION OF ROUND FLANGE CUP

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ABSTRACT

In this publication, an investigative study of deep drawing behavior and wrinkling congestion during metal forming operation for manufacturing of round flange cup of 1.6 mm thick material of CRCA (cold rolled cold alloy) sheet have been carried out. A drawbility characteristic of deforming of sheet metal has been found out. It has been trace out that the strain hardened material has a great impact on controlling of wrinkling behavior. It gives the resistance to wrinkling through its mechanical properties and chemical composition of material and stop tearing. The exponential strain distributions also influence the drawing during sheet metal operation. Higher circumferential compressive stress has produced in the cup walls from the high strain hardened exponent material thus resists the wall to wrinkling and also reduces the effect of high radial tension in the sheet of a high radial stress bearable material. The possibilities of wrinkling can also be reduced by increasing the blank holder load, decreasing the die profile radius or using a high grade lubricant on both sides of blank in the press tool. A high strain hardened material to wall wrinkling always begins first in the lowest r-value direction. Therefore both high r (anisotropic plasticity) and n (strain hardening exponent) are required for high strength low alloy steel due to its high flow stress. The required parameter have been tried to establish to reduce the wrinkle as minimum as possible to eliminate the fracture during deep drawing operation.

Keywords: *Strain hardening exponent, Sheet Metal forming, Deep-drawing process, Wrinkling and Fracture or tearing etc.*

1. Introduction

Deep-drawing is the sheet shaping operation used to produce deep round cup by a process in which a flat sheet blank is firmly held by hold down forces, while the central portion of the sheet is impacted by a flat- bottom punch into a desired shape, without formation of wrinkles of the side wall. In this manufacturing process of forming sheet metal into shapes that are more than half of their diameter in depth as shown in figure-1. Sheet metal properties may be termed by means of plastics properties of material such as : strain hardening exponent n, initial true strain ε., strain rate sensitivity β, anisotropic plasticity r, sheet metal uniformity f, and the strength parameters such as yield stress, ultimate tensile stress, elongation, hardness as well as chemical composition of material.

It is a plastic deformation of flat sheet by a tensile load into a part of desired shape, without fracture or excessive thinning. There is a limit of stretch forming of sheet metal which restricts the material to pull into die cavity and sheet deforms by elongation and uniform thinning to get the good product as shown in figure-2. It is widely used in the manufacture of automobiles & its fuel tanks, kitchen sink and electrical devices, white goods, agricultural machinery, instrument manufacture and in many other industries.

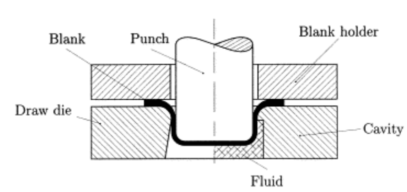

Fig. 1 Deep Drawing Operation

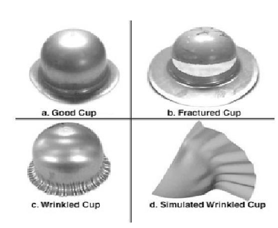

Fig. 2 Samples of Deep-Drawing Cup

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The use of high yield strength sheet metal for automobile or tractor structure enables increasing the safety without increase in weight. The weight is one of the major parameter which has an influence on fuel consumption of an automobile. Therefore the reduction in weight, especially for economical purpose is mandatory. In view of reducing the weight of an automobile it is imperative to reduce the weight of structure of automobile at the time of manufacture. In fact, the ability of sheet metal to absorb energy without rupture during plastic deformation under high load, permits manufacturing light structure elements ability to absorb high proportion of shock energy.

In deep drawing operation draw of sheet metal should takes place into the die as much as possible. This helps in minimizing the thinning of the cup wall.

The outer perimeter of the blank reduces, causing a compressive hoop stress which, when exceeds a limit, may result in a plastic wrinkling of the round flange cup.

These wrinkles cannot be ironed out afterwards but can be avoided by using a blank holder. However, an excessive pressure from the blank holder resists an easy drawing of the material into the die. In this process, various types of forces operate simultaneously. The above mentioned properties, i.e high yield strength, high capacity for plastic deformation, good resistance under shock loads resulting deep drawing operation without tearing. The given below equation give the relationship between blank holder pressure and draw ratio.

$$P_b = 10^{-3} c \left[(DR\cdot 1)^3 + \frac{0.005 d_0}{t_0} \right] S_u$$

where: pb = blank holder pressure

c = an empirical factor ranging from 2 to 3

DR = draw ratio (blank diameter/punch diameter)

d_0= blank diameter

t_0= initial blank thickness

S_u= ultimate tensile strength

Because the draw ratio constantly changes through the deep drawing process, this equation can be used to predict an optimal BHF trajectory, as shown in Figure-3. The BHF decreases as expected during the process until the very end, when BHF is increased to ensure proper strain hardening of the final part.

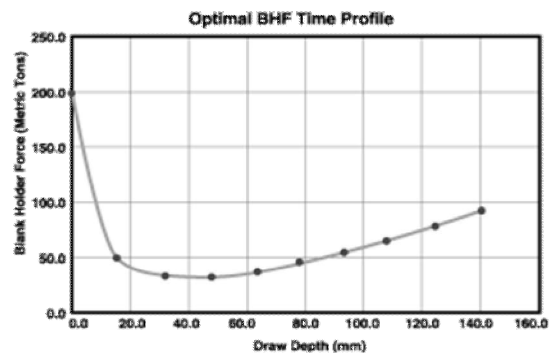

Fig. 3 Optimal BHF Trajectory

By optimizing BHF variation as a function of punch stroke, it has documented dramatic increases in LDRs, including, for example, an increase from 2.1 to 2.6.

2. Methodology

A Hydraulic press of 100T was selected. Its maximum stroke was 6 fit with a daylight opening of 8fit 6 inch. The ram diameter being 10 inch and the maximum operating pressure 3,000 lb/in square. The power was provided by two motor driven mono radial pumps and the speed of drawing was versed over a large range of shutting down some of the 24 cylinders of each pump on using only one motor and pump in a similar manner. The maximum drawing speed was 16 ft/min. If the drawing ratio is not more than 1.2, the operation can be conducted even without a blank holder. Higher values of the drawing ratio can be achieved depending on the thickness of the blank and die profile. When the ratio of the blank diameter and the final cup diameter is too large, the operation is performed in more than one stage

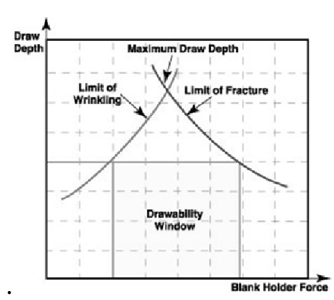

Fig. 4 Plot for Maximum Possible Draw Depth

In the figure-4 the intersection of the lines plotting the BHF and the draw depth of a cup reveal the maximum possible draw depth for a given blank.

Table 1: Mechanical Properties of CRCA Sheet for Different Deep-Drawing Operations

Sl.No	Drawing	Yield Strength (MPa)	Tensile Strength (Mpa)	Elongation in 50 MM	Hardness HRB	Strain Hardening Exponent (n)	Plastic Strain Ratio (rm)
1.	Drawing	207	310	45	40	0.24	1.2
2.	Deep Drawing	172	296	40	40	0.22	1.6
3.	Deep Drawing (Commercial)	234	317	35	45	0.20	1.0
4.	Extra Deep Drawing	152	317	45	45	0.24	2.0

The successive drawing operations after the first one are known as redrawing. In conventional redrawing the material bends in the opposite directions around the blank holder and the die corners. In the extreme case, the die can be provided with a round edge resulting in a less severe working of the material. Since some amount of strain hardening takes place during the initial operation annealing is normally advised to restore the ductility before commencing the redrawing operation. In general, the flow of metal is not uniform throughout the workpiece and in most cases the drawn parts have to be trimmed to remove the undesired metal. Such a trimming can be done either by hand-guided operation or by using a separate trimming die. During the return stroke, the punch pressure is removed from the cup as a result the drawn cup tends to spring back.

Due to this action the recess prevents to drawn cup from moving along with the punch during its upward stroke. The evaluation of the usefulness of sheet metal for different drawing operations is of the primary importance for the industrial plants employing that type of process, as well as the sheet metal manufacturers. To that evaluation quite a number of drawability tests are used, which results from the fact that the sheet metal drawability depends not only on its properties, but also on the deformability condition occurring in a specific deep drawing operations.

A typical mechanical property of cold rolled cold alloy steel sheet and composition of material as per international standard CRCA sheet as shown in table-1 and table-2 has to be taken into consideration while selecting the metal sheet for deep drawing purpose.

Table 2: Composition of CRCA Sheet Material

Steels	C max	Mn max	P max	S max
Ordinary	0.15	0.60	0.055	0.055
Drawing	0.12	0.50	0.040	0.040
Deep Drawing	0.10	0.45	0.035	0.035
Extra Deep Drawing	0.08	0.40	0.030	0.030

3. Result & Discussion

For good quality of deep draw components limiting drawing ratio to be maintained. Limiting drawing is the ratio between maximum blank diameter to punch diameter. It can be influenced by sheet thickness, sheet quality, thickness of coating, punch diameter, clearance between punch and die, punch profile radius, die profile radius, lubrication quality, speed of the punch, surface finish of the tooling.

There is a limit of deformability in a deep drawing operation. The load, which is necessary to deform the sheet lying between the drawing block and press pad, originates from the punch itself pushing against the base of the pressed part and has to be transmitted to the wall via the curved edge of the pressing. The drawing stress may not exceed the strength of the sheet metal in this region or the material will fail. Because of the different magnitudes of shape changes involved, the mean tensile strength increases with the pressed cup height. We have examined the stressed deformation state of the central part of a blank when drawing the elements by a spherical edge punch taking into account hardening, thinking and blank friction against the punch edge during shaping. The edge to obtain the required stretching over the punch.

4. Conclusion

Fracture is the most important type of failure in press formed parts. In deep drawing the depth of the part being made is more than half its diameter. The formation of wrinkles is the main causes to necking and fracture. As the buckling stress becomes higher with increasing strength there is a pronounced tendency to wrinkling during press forming.

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