Design and Fabrication of Inverted Cup Single Action Press Draw Tool

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Abstract: **The seamless drawn cups typically find wide applications in all the fields of life such as food storage cans, appliances, automotive and aerospace industries. The operation of cup drawing using flat sheet metal blank requires two forces, one for drawing operation and the other is for strip holding force to control the flow of stock during drawing operation. Generally drawing operation is carried out using straight type draw tool (punch at the top and die at the bottom) utilizing Double Action Press which gives the two required forces.**

The present paper deals with the idea of designing and fabrication of an Inverted Draw Tool which can perform in Single Action Press. This Press gives only one force which is utilized for drawing and the other force required for strip holding is created in the tool by means of a compression spring. The strip holding force is calculated using empirical formula which is related to drawing force. The spring of suitable design is selected for use. The provision is made in the tool to vary the spring force so that the optimum spring holding force can be obtained by trial and error method to enable getting drawn components without draw defects. The design and fabrication of the inverted draw tool was successful and drawing operation from the stock was carried out.

Keywords*: *Cup drawing operation, Inverted draw tool, Single Action Press, Draw force, Spring holding force,

I. INTRODUCTION

Cup drawing is a deep drawing process for transforming flat sheet blanks (stock) into cup or box shaped parts without defects like spring back, flange side wall wrinkles, excessive localized thinning and fracture of part walls. In drawing, the stock flows plastically throughout a constant contour. When a stock is drawn into a die by means of forcing a punch, a change in its shape is brought by forcing the stock to flow in a plane parallel to the die cavity. With the result the thickness and surface area of drawn dup remains same as that of stock. Therefore the stock diameter can be calculated by equating its area with the drawn component.

Drawing is a complicated metal flow. The drawing operation develops severe cold working in the stock resulting in different types of stresses like radial, compression, tension and bending.

The forces required for drawing operation are force to draw the stock (drawing force) and the force to control the flow of stock during drawing operation (strip holding force).

The existing literatures are reviewed. A.R.Sahani and I. Salehinia [1] informs the effect of important parameters in deep drawing such as punch speed, the clearance between the die and punch, the blank holding force and the radius of the die shoulder to reduce the wear of tool. M.R. Jensen et.al. [2] have highlighted the optimization approach relevant at the tool design state to reduce the tool wear with small expenditure. Wenfeng Zhang and Rajiv Shivpuri [3] have indicated that the designing and controlling the process parameters of cup drawing are blank dimensions, blank holding force, press stroke and interface friction to provide the greatest drawability of aluminum. Kopanathi Gowtham et.al. [4] have spoken about the effect of die radius on the formability and quality characteristic of deep drawing process. M. Eriksen [5] has highlighted the influence of die geometry on tool wear in deep drawing.

II. DESIGN OF TOOL

In the present paper, a draw tool has been designed to perform the dual activity of draw process by single action press. The design is based on some empirical formulae and to suit the process in the press.

In the process the strip holding force should be optimum such that the components are drawn without defects caused due to drawing. If the strip holding force is low, it may result in wrinkles appearing on the flange of the component and finally onto its vertical planes and thereby resulting in poor quality components. Wrinkles are the result of uncontrollable circumferential stresses. Wrinkles also spoil the die face. If the strip holding force is high it may result in thinning and rupture. Thinning and rupture are due to the tension stresses. Therefore, the optimum force can be obtained by trial and error method. The empirical formula for the strip holding force is $1/3^{rd}$ of draw force.

The space between the punch and die is called draw clearance which is equal to the thickness of the stock and the allowance. The allowance is required to prevent excessive wall friction during the draw operation and to minimize the stretching forces, which if exceeds can rupture the component. The allowance depends upon thickness of the stock, physical characteristic of material, diameter and height of the drawn cup.

Draw die radius allows the stock to flow easily without rupture. Too large the radius, the stock will be released by the stripper plate before the draw is completed. This may result in the formation of wrinkles in the upper portion of the drawn cup. Too small radius obstructs the easy flow of material and may result in rupture of component. Hence the optimum radius is to be obtained by trial and error method which is chosen as five times the thickness of stock. The nose radius of the punch determines the bottom radius of the drawn cup. However, too small radius may result in rupture of the component as it develops the rapid tensile straining of stock.

Locating plate locates stock in concentric with respect to punch and die, otherwise cup of unequal heights may result. Knock out pad will eject the drawn component from die during its upper motion on the press. The vent is provided in the punch to eliminate suction during stripping of cup from punch. The force created by the compression spring transmits through stripper bolts to the stripper plate which in turn transmits to the stock during drawing operation.

Spring assembly consisting of compression spring, spring end plates and stripper bolts are located in the cavity of the press table.

The die, punch, stripper plate, knock out pad to be made with oil hardened steel and ground on specific areas where the stock is come in contact. This is to reduce wear, to have less friction and for easy flow of material during drawing operation. The remaining parts are made with mild steel. Suitable fasteners are used for assembling die unit, punch unit and spring unit.

The detailed sectional assembly drawing is shown in Figure 1. The main parts of draw tool are die, die holder, knock out rod, punch, punch holder, locating plate, stripper plate, stripper bolts and spring assembly.

The sectional assembly and the 3D assembly of the tool are shown in figure 1 and figure 2 respectively. The real tool and sample drawn products are shown in figure 3 and figure 4 respectively.

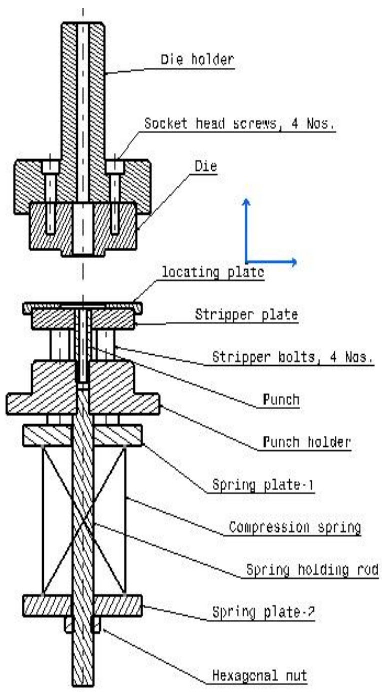

Fig. 1: Sectional assembly

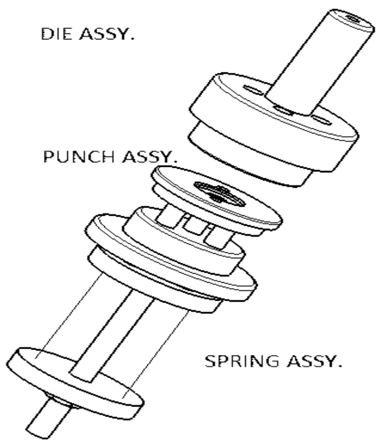

Fig. 2: 3D assembly

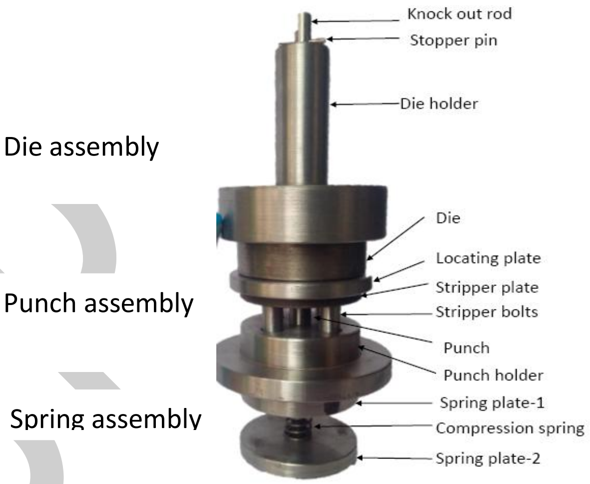

Fig. 3: Real tool

Fig. 4: Sample products

III. METHODOLOGY

The sample cup taken for designing the tool is made up with 0.2 mm thickness aluminum having outer diameter 11.4 mm and height 10 mm. The diameter of stock required works out to be 24 mm. The punch diameter is decided based on the inner diameter of the cup which is 11 mm. The die cavity diameter works out to be 11.5 mm by considering the punch diameter and clearance is taken same as the stock thickness. The die corner radius and punch nose radius are taken as five times the stock thickness. The remaining dimensions of the die, punch and other parts of the draw tool are proportionately designed looking into the easiness and accurate assembly of the whole draw tool so as to accommodate in the press. Die assembly is fixed to the ram and is in line with the punch assembly mounted on the press table. The spring assembly attached to the punch assembly is housed in the cavity of the Press table.

The job is tried out by placing the stock in the locating plate and the Press ram is brought down to enable the die to force the stock to form a cup around the punch. After formation of the cup, the job is stripped off from the punch by the spring pressure operating through the shoulder bolts and then to stripper plate. The blank holding pressure is suitably varied by adjusting the spring pressure by means of a nut so that the defect free component comes out of the draw tool. In the design of the tool, a suitable mechanism in the form of knock out rod is incorporated to eject the cup from the die cavity if the drawn cup is stuck in the cavity.

IV. CONCLUSION

It is possible to design and fabricate a deep draw tool which can be done in Single Action Press. The draw tool is of inverted type wherein the die is at the top and it is fixed to the ram of the Press and the punch is at the bottom and it is mounted on the press table. The Single Action Press provides one force which is utilized for drawing operation and the second force required for stock holding is obtained by means of a compression spring. The pressure from the compression spring can be varied to get optimum strip holding pressure for obtaining defect free deep drawn component. The design and fabrication is validated by successful completion of the specimen components which are defect free.

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