Combined Blank Holding Deep Drawing Die Adaptable on Single Action Presses

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Abstract
Deep drawing is one of the extensively used sheet metal processes in the industries for mass production of cup components. One direction of research in this area is to obtain higher drawing ratio in order to reduce the number of drawing operations necessary to obtain a product. One way to increase the drawing ratio is the use combined blank holding deep drawing dies. However, these dies have a complex construction and require double-action presses. The paper presents the design of combined blank holding deep drawing die, adaptable on single action presses, which eliminates the above disadvantages.

Keywords
deep drawing, combined blank holding, simple action press

1. Introduction

Sheet metal forming is one of the most used manufacturing processes for the fabrication of a wide range of products in many industries such as: machine construction, automotive and aeronautics, electrotechnics, production of household items etc. Deep drawing is one of the extensively used sheet metal forming processes for the fabrication of sheet metal cups.

Cup is drawing the operation that transforms a plane blank into a cup of any form or by which are modified the size and dimensions or only dimensions of hollow parts. When the depth of the parts is greater than their diameter, the deformation process is called deep drawing.

The main lines of research in this area relate to optimization of process parameters of deformation in order to obtain products free of defects and increasing the drawing ratio in order to reduce the number of drawing operations necessary to manufacture the product.

The deformation process during deep drawing is very complex and influenced by many factors, such as: properties of sheet metal, blank thickness, drawing ratio, clearance between the punch and die, the punch corner radius and die corner radius, the blank holder force, friction and lubrication.

Many phenomena accompany the deformation process of the blank such as: wrinkling, changing the wall thickness of the piece and uneven edges of the piece due to material anisotropy. Wrinkling is one of the most important effects.

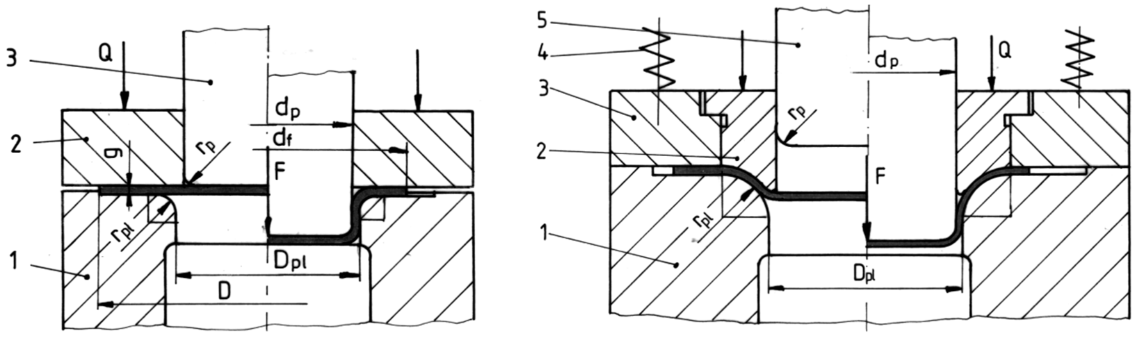
Optimizing blank holder force and the adoption of appropriate geometry for the die's tools represent high importance issues for a smooth running of the deformation process.

2. Blank Holding Methods for Deep Drawing

Wrinkling is one of most severe defect in deep drawing product together with tearing, spring back and other geometrical and surface defects. Wrinkling may be defined as the formation of waves on the surface due to circumferential compressive stress [1]. Wrinkling occurs both on the plane flange as on the toroidal flange of the piece. Winkling on the plane flange can be eliminated with the blank holder (2) actioned with the force Q (Fig. 1a). Wrinkling of the toroidal flange occurs after the blank is released from the holder and moves across the round edge of the die. In order to prevent wrinkling in this area, small values of the radius of the die must be adopted.

A lot of research has been dedicated to wrinkling to predict the apparition, the location and shape of wrinkles [2]. Other research concerns the optimization of blank holder force. A higher value of the blank holder force insures the elimination of wrinkling, but can result in material tearing. That's why the minimal value of blank holder force has to be determined to prevent wrinkling but also material tearing.

Most research in the area is based on finite element method. The paper [2] a finite element explicit solver LS Dyna was used for de simulation of effect of various parameters on the optimum blank holder force: friction coefficient, die radius, clearance and sheet thickness. The conclusion was that for a given set of punch die and working conditions there exists an optimum blank holding force that prevents wrinkles and at same from the stresses induced in the cup is minimum. This force decreases with increase of coefficient of friction for a small range of coefficient of friction and with increase of die radius up to a certain value, optimum blank holder force drastically reduces beyond that it remains constant.



a) b)

Fig. 1. Deep drawing dies with: a) - plane blank holding; b) – combined blank holding

A pulsating blank holder force with a frequency range from ultra-high to ultra –low values can reduce friction and deformation resistance and improve the drawability as compared with a static constant blank holder force [3].

During deep drawing sheet metal components having complex geometries, varying thicknesses of materials occur in the flange area. In paper [4] the authors propose the use of a blank holder composed of one cover plate which is supported by numerous appropriate elastic elements made of cast iron. Stiffness of the blank holder as well as pressure distribution during deep drawing was optimized by varying elasticity and order of the supporting elements in real trials.

Recently, variable blank holder force is an attractive approach for improving the product quality. In paper [5] a method is proposed to simultaneously determine both optimal blank shape minimizing earing and the optimal variable blank holder force trajectory for a cylindrical cup deep drawing.

A new technique on friction aided deep drawing is proposed in the paper [6], by using a blank holder built on two layers: stationary layer or base with for planes of 5° taper and moving layer divided into four tapered segments which can move radially to the die opening with a constant speed by using a specially designed compression tool (Fig. 2). Using this method, a considerable improvement of the drawing ratio was obtained, up to the value of 3.67.

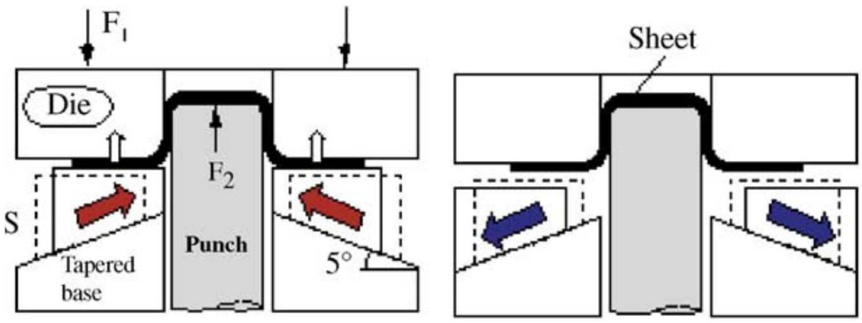


Fig. 2. Deep drawing using tapered blank holder divided into for segments [6]

The die radius influences greatly the limit value of the drawing ratio. For higher values of the radius correspond higher values of the drawing ratio. However, when the radius has high values, wrinkling is possible upon the release of the blank from the holder. In order to be able to increase the die radius, blank holding is necessary, both in the plane zone of the flange as in the toroidal area of the flange, method known as the "combined blank holding" (Fig. 1b). By using this method, one can increase the radius of active plate to a maximum admissible value, which allows a considerable increase of drawing ratio up to the value of 2.27 [7]. Thus, a part that requires two drawing operations with plane blank holding dies can be obtained in one operation on a die with combined blank holding.

Combined blank holding deep drawing dies used in practice are driven by double-action presses (Fig. 1b). The die is provided with two blank holders, a plane one, 3, which presses the blank in the plane area of the flange and a profiled one, 2, which prevents wrinkling of the blank during the movement over the rounded edge of the die 1. The subassembly consisting of the two blank holders is driven by the exterior slider of the press. The work cycle of these dies is conducted in the following way: during the downward stroke of the exterior slider of the press, first the blank is retained in the plane area of the flange by the blank holder 3, driven by the springs 4. Next during the movement of the exterior slider, the shaped blank holder 2 makes the partial deformation of the blank over the rounded edge of the die 1, until it rests on the plane blank holder 3. From this moment, the two blank holders are solidary and operate as a single profiled blank holder, driven by the force Q by the outside slider of the press. This ensures the complete blank holding throughout the drawing process. Afterwards, during the downward stroke of the interior of the press slider, the punch 5 continues the deformation process of the blank until the complete drawing of the part. During the upward stroke of the interior press slider, the part is removed from the punch.

3. The Combined Blank Holding Deep Drawing Die Driven by a Single Action Press

As it was shown above, when the drawing uses dies with combined blank holding, the deformation degree of the material is much higher than using simple dies. However, the applicability of the method is limited by the need to use double-action presses for the operation of the die. This disadvantage is eliminated by the design of die that is the subject of this paper, which requires simple action presses equipped with hydraulic cushion.

Figure 3 presents the axial section of a drawing die with combined holding, adaptable on a single action press [8].

The blank S is placed into the die and centred on the plane blank holder 8, provided with a clearance made specifically for this purpose. During the downward stroke of the upper subassembly B, actuated by the slider of the simple-action press, the active plate 10 performs the drawing of the part together with the punch 4. During the first stage of the deformation process, the blank holding is made only by the plane holder 8, driven by the coil spring 6. The holder descends until it rests on the flange of the profiled blank holder 5, moment when the two blank holders will combine and function as one body. Thus are created the conditions for the blank holding both on the plane flange and in the rounding radius area of the active plate 10. The force required for holding the blank is transmitted from the hydraulic press cushion through the three rods 14. Once the drawing process ends, the mobile subassembly B is raised and the part is removed from punch 4 by the profiled blank holder 5. During the last part of the upward stroke movement, the part is removed from the active plate 10 by the eliminator 9, driven by the coil spring 13.

The active surfaces of the two blank holders form a continuous surface, which is obtained by processing them in the assembled state, when the plane blank holder 8 is resting on the flange of the profiled blank holder 5.

4. Conclusions

Deep drawing is one of the most used methods of cold plastic deformation. In practice, several methods are used to increase the drawing ratio in order to reduce the drawing operations needed to obtain a product.

A relatively simple method that can increase the degree of deformation - drawing with the combined blank holding - is less used in practice because it involves the use of double-action presses.

The combined blank holding deep drawing die shown in this paper can be adapted to a single action press, which offers the possibility of applying this method in any cold pressing workshop.

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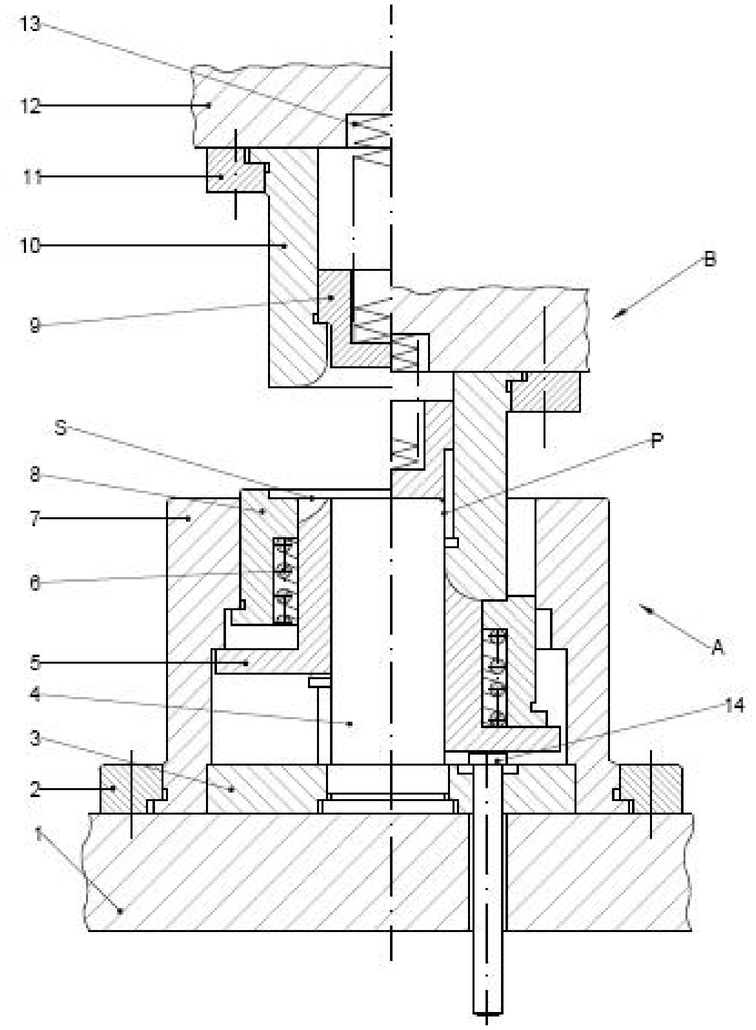

Fig. 3. Combined blank holding deep drawing die

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