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Effects of Various Parameters in Deep Drawing Process Over Sheet Metal to Get Optimum Result

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***Abstract* - The Deep drawing is a manufacturing process in which sheet metal is progressively formed into a three-dimensional shape through the mechanical action of a die forming the metal around a punch. To reduce various defects in deep drawing process it is necessary to control some parameters of deep drawing process. Sheet-metal drawing is a more complex operation than cutting or bending. Number of defects can occur in a drawn product. To reduce production cost it is necessary to reduce defects accrued during deep drawing process. A punch force, material property of sheet metal, blank holding force, thickness of sheet, velocity of punch are affecting parameters in deep drawing process to regulate defects like wrinkling, tearing, earing and fracture defect. By conducting experiment in universal testing machine we know stress, strain, displacement and load. These results compare with the software for validation**.

***Index Terms* - Deep Drawing, Parameters, defects, Finite Element Analysis**

I. INTRODUCTION

Drawing is a sheet-metal-forming operation used to make cup-shaped, box-shaped, or other complex-curved and concave parts. It is performed by placing a piece of sheet metal over a die cavity and then pushing the metal into the opening with a punch. The blank must usually be held down flat against the die by a blank holder. Common parts made by drawing include beverage cans, ammunition shells, sinks, cooking pots, and automobile body panels. [1]

It is a sheet forming operation, in which the sheet is placed over the die opening and is pushed by punch into the opening. The sheet is held flat on the die surface by using a blank holder.

c –clearance
Db – blank diameter
Dp – punch diameter Rd – die corner radius
Rp – punch corner radius F – drawing force
Fh – holding force

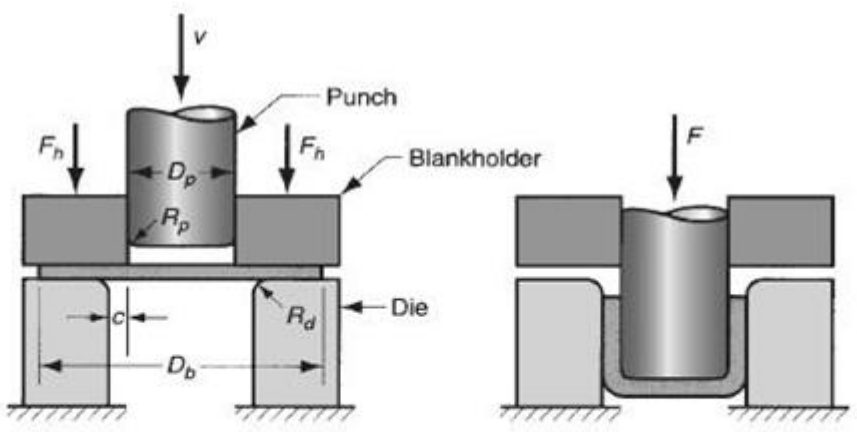

Fig. 1 Deep Drawing [2]

The clearance ‘c’ is defined to equal to 10% more than the sheet thickness ‘t’. If the clearance between the die and the punch is less than the sheet thickness, then ironing occurs.

Defects in deep drawing

A number of defects can occur in a drawn product, some of which we have already alluded to. Following is a list of common defects, with sketches in [2] Figure.

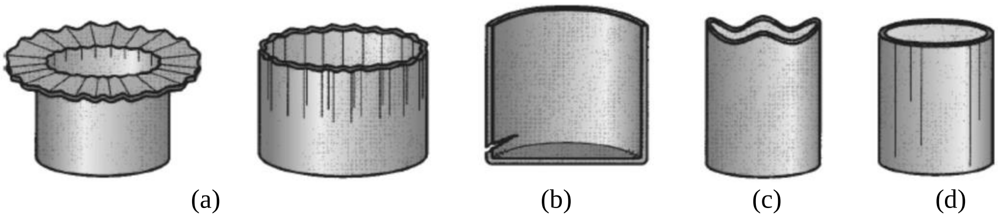

Fig. 2 Various Defects in Deep Drawing Process [2]

a. **Wrinkling in flange and cup wall**: This is like ups and downs or waviness that is developed on the flange. If the flange is drawn into the die hole, it will be retained in cup wall region.
b. **Tearing:** It is a crack in the cup, near the base, happening due to high tensile stresses causing thinning and failure of the metal at this place. This can also occur due to sharp die corner.
c. **Earing**: This is the formation of irregularities (called ears) in the upper edge of a deep drawn cup, caused by anisotropy in the sheet metal. If the material is perfectly isotropic, ears do not form.
d. **Surface scratches:** Usage of rough punch, dies and poor lubrication cause scratches in a drawn cup.[2]

To reduce various defects in deep drawing process it is necessary to control some parameters in deep drawing process.

A punch force, material property of sheet metal, blank holding force, thickness of sheet, velocity of punch are affecting parameters in deep drawing process to regulate defects like wrinkling, tearing, earing and fracture defect. By conducting experiment in computer integrated universal testing machine we know stress, strain, displacement, load. These results compare with the software for validation.

II LITERATURE REVIEWED

Optimization of process parameters in sheet metal forming is an important task to reduce manufacturing cost by reducing defects accrued during deep drawing. Hence many researchers have don researches on different parameters to obtain optimum results in deep drawing process.

R. Venkat Reddy[3] has research on the Effect of Various Parameters on the Wrinkling during Deep Drawing process. The appearance of dimensional deviations of shape and position, of the defects in the metal sheets that have been subjected to a cold plastic deformation process (deep drawing), represents a critical problem for the specific industry, especially for the mass production, like the machine manufacturing industry. The aim of this publication is to present the principal aspects that effect of various factors like BHF, punch radius, die edge radius, and coefficient of friction on the wrinkling of cylindrical parts in deep drawing process. The initiation and growth of wrinkles are influenced by many factors such as stress ratios, the mechanical properties of the sheet material, the geometry of the work piece, and contact condition. It is difficult to analyze wrinkling initiation and growth while considering all the factors because the effects of the factors are very complex and studies of wrinkling behavior may show a wide scattering of data even for small deviations in factors. In the present study, the mechanism of wrinkling initiation and growth in the cylindrical cup deep drawing process is investigated in detail.

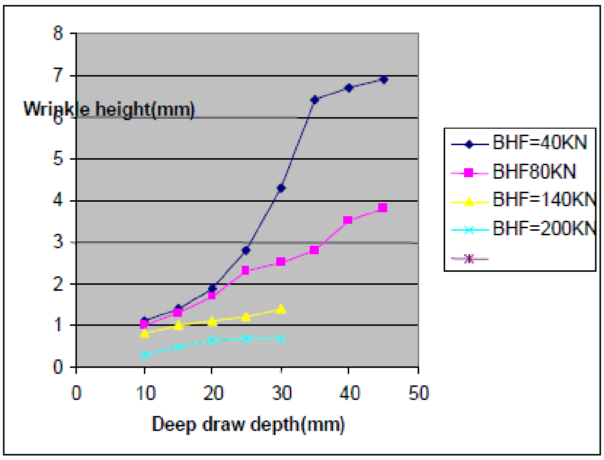

Fig. 3 The Effect of the Blank Holding Force and the Deep Drawing Depth on the Wrinkling

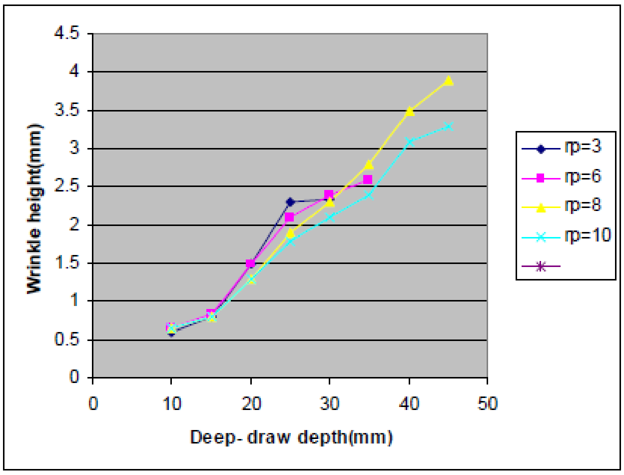

Fig. 4 The Influence of the Die and Punch Edge Radius on the Wrinkling

He conclude that, the height of the wrinkles is reduced by increasing the blank holding force, decreasing friction, increasing the tools edge radius and reducing deep-drawing depth all together in one operation. Concerning friction, the reduction of coefficient of friction has to be made up to a certain limit that won't lead to material breakage. Reducing the coefficient of friction down to the minimal value has a contradictory influence for the desired propose.

R. Padmanabhana[4] has researched 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, die-radius, blank holder force and friction coefficient on the deep-drawing characteristics of a stainless steel axi-symmetric cup was determined. Finite element method combined with Taguchi technique form a refined predictive tool to determine the influence of forming process parameters. The Taguchi method was employed to identify the relative influence of each process parameter considered in this study Based on the predicted thickness distribution of the deep drawn circular cup and analysis of variance test, it is evident that die radius has the greatest influence on the deep drawing of stainless steel blank sheet followed by the blank holder force and the friction coefficient. Further, it is shown that a blank holder force application and local lubrication scheme improved the quality of the formed part. FEM and Taguchi technique forms an effective tools combination to predict the influence of process parameters. FEM and Taguchi technique forms an effective tools combination to predict the influence of process parameters.

To produce wrinkle free product the Determination of optimum process parameters is required, Anupam Agrawal[5] has worked on this. In the research work, an attempt is made to predict the minimum blank holding pressure required to avoid wrinkling in the flange region during axisymmetric deep drawing process. Thickness variation during the drawing is estimated using an upper bound analysis presented in this paper. The minimum blank holding pressure required to avoid wrinkling at each punch increment is obtained by equating the energy responsible for wrinkling to that which suppresses the wrinkles. The predictions of the developed model are validated with the published numerical and experimental results and are found to be in good agreement. Parametric study is then carried out to study the influence of some process variables on the blank holding pressure to avoid wrinkling.

To validate the proposed wrinkling model, its predictions are compared with the published experimental and simulation results. The predictions of the present model are in very good agreement to the experimental results as compared to the simulation results of Senior. Anupam Agrawal[6] has also worked on multi stage deep drawing process. In his research Prediction of Wrinkling and Determination of Minimum Blank holding Pressure in Multistage Deep Drawing had analyzed. Wrinkling in the flange region has been observed during redrawing operation by a few researchers. In the present work an analysis methodology, based on a combination of upper bound and energy approaches, is proposed for the prediction of number of wrinkles and minimum blank holding pressure necessary to avoid wrinkling in redrawing operation. Thickness variation predicted by the upper bound formulation is used as input for the wrinkling analysis by assuming a suitable waveform based on geometrical and process conditions. The flange is constrained at both ends, i.e., by the blank holder profile radius and at the die entry point (where the sheet enters into the die cavity). The waveform for present analysis is assumed such that it has zero displacement at both ends (since it is constrained) and the maximum amplitude of the wave at some point in between those ends. The wrinkling predicted by the present methodology seems to be reasonably accurate considering the geometrical and process constraints of the redraw. An attempt is made for the prediction of number of wrinkles and the minimum blank holding pressure necessary to avoid the wrinkling in the redrawing operation by proposing a methodology based on the upper bound and energy approaches, by assuming a suitable waveform based on the geometrical and process conditions, while considering the thickness variation. The number of wrinkles increases and the minimum blank holding pressure decreases with the normal anisotropy. With an increase in the initial sheet thickness, the number of wrinkles decreases and the minimum blank holding pressure decreases.

In deep drawing process properties of material used is also the important factor to reduce cost by reducing defects. Hence in Amir Atrian's[7] paper the effects of several parameters on the deep drawing process of laminated sheets are comprehensively studied. The main reason to carry out such a process is taking the advantages of different materials, such as high strength, low density and corrosion resistibility, at the same time and in a single component. With this regard, it is possible to take the benefits of the forming processes, such as low waste of material and high directional strength of the components. This research work is concerned with the experimental and finite element studies of the deep drawing process of steel/brass laminated sheets. Several tests were conducted to investigate the influences of some variables, such as the stacking sequence of the layers, lubrication, blank-holder force and the diameter of the composite blank on the load–displacement curve and the final shape of the produced components. Investigation of stress and strain distributions in the deep drawn cup were also done and the FE results showed that the numerical method can predict the same place of tearing for bimetal cup as occurred in experimental tests. The main issues studied in this work are the material flow (occurrence of defects such as wrinkling and fracture) of the layers of the specimen and the required drawing force.

As a result of this research work he got fairly good agreement of the experimental and finite element results showed that the FEM can be used in parameter studies of any industrial procedure. In the present investigation, the required drawing force was overestimated about 10% by the FE simulations. A linear relation was obtained between the initial blank diameter and the maximum necessary force. This was demonstrated by both the experimental and numerical techniques. It was also shown that increasing the initial blank diameter from 7.5 cm to 10 cm, resulted in about 100% increase in the required maximum drawing load. It was found that similar to single-layer deep drawing, the maximum punch force during the deep drawing of the composite blanks takes place when the outer diameter of the drawn component reaches about 0.77 of the initial blank diameter.

II. CONCLUSION

Forming is the process of obtaining the required shape and size on the raw material by subjecting the material to plastic deformation through the application of tensile force, compressive force, bending or shear force or combinations of these forces. Forming is a widely used process which finds applications in automotive, aerospace, defense and other industries. Sheet metal forming is one of the non-cutting operations that can be performed on power press. Deep drawing process is one of them. In this method sheet metal is drawn into cup. Sheet-metal drawing is a more complex operation than cutting or bending, and more things can go wrong. A number of defects can occur in a drawn product like wrinkling in flange and cup wall, tearing, earing and surface scratches.To reduce various defects in deep drawing process it is essential to control or vary some parameters of it. A blank holding force, punch force, material property of sheet metal, thickness of Sheet, velocity of punch, these are all affecting parameters in deep drawing process to regulate wrinkling effect, tearing effect and fracture defect.

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