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Research Paper

DETERMINATION OF BLANK HOLDER PRESSURE IN HYDROFORMING DEEP DRAWING PROCESS

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The hydro forming deep drawing process is a sheet metal forming process. In this process the pressurized fluid is used as a medium. This pressurized fluid is used to form different component shapes. The process allows manufacturing lighter complex shapes more with increased strength at lower cost compared to more traditional techniques such as stamping, forging, casting or welding. The hydro formed components are used in the aerospace, automotive and other industries. In hydro forming deep drawing process, applying the hydraulic pressure in radial direction on the periphery of the blank is obtained through the punch movement with in the fluid chamber. The fluid is taking place in the die cavity and punch chamber and these are connected with the bypass path provided in the die. The gap is provided between die surface and blank holder bottom surface for movement of pressurized fluid and blank in the process. The pressure is generated in fluid due to punch movement with in the fluid chamber and directed through the bypass path to the blank periphery and is to reduce tensile stresses acting on the wall of the semi drawn blank. The fluid pressures obtained from ANSYS Flotran CFD analysis software for using the fluids such as olive oil, heavy machine oil and castor oils. The Evaluation of fluids pressure with changing the punch speed at constant punch radius. The pressure of fluid is acting radially on surface of blank during the process. The radial pressure of fluid is controlled by the blank holder pressure. As these two pressures are equal, the deformation of blank is uniform to get a required shape and also it prevents the blank failure during deformation. The pressure of fluid depends on punch speed. The fluid pressure increases with increase in the punch speed. The fluid pressure is the dominant parameter for failure and success of forming of cups from the cylindrical blanks. This pressure of fluid is used to evaluate the blank holding pressure. In this hydro forming deep drawing process the fluid pressure is equal to blank holder pressure is obtained. In this paper the studies are carried on the determination of fluid pressure, blank holder pressure through punch speed in hydro forming deep drawing process. In this

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process, the pressurized fluid is utilized for many purposes as the sheet metal blank is supported in entire forming process, elimination of fracture in deformation of cup and formation of wrinkles on the wall and edges of the cup are minimized.

Keywords: Hydro forming process, Deep drawing, Fluid pressure, Fluid model, CFD analysis, Geometric modeling

INTRODUCTION

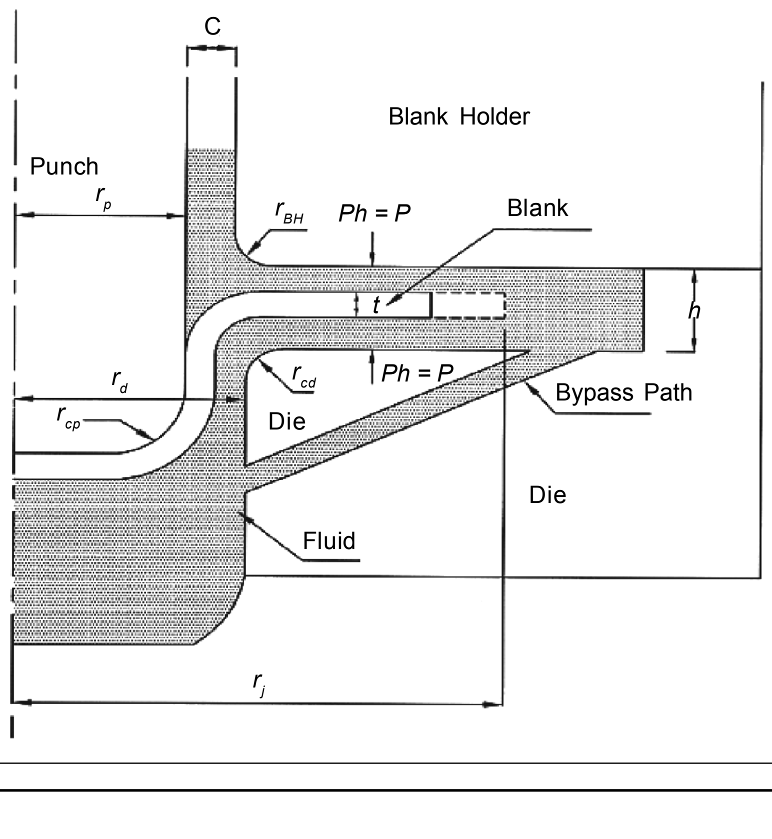
The performance of deep drawing process can be enhanced for producing components through using the liquids in the process. The process performance like draw ratio, thickness ratio, ratio of volume to surface area of product, volume to thickness of product, good surface finish, high quality surface, high accuracy in dimensional, no scratches developed on outer side of cup, limiting drawing ratio, deep drawability and formability index are improved and these are obtained in higher levels. The fluid pressure effects on radial, hoop and drawing stresses of blanks in during the process. The various types of fluid forming are Hydroforming process (Panknin and Mulhauser, 1957; Tirosh *et al.*, 1977; Yossifon and Tirosh, 1984; Yossifon and Tirosh, 1988; and Thiruvarudchelvan and Lewis, 1999), hydromechanical deep drawing process (Larsen, 1977; Yang *et al.*, 1995; and Zhang and Danckert, 1998), Aquadraw process (Chabert, 1976), hydraulic counter pressure process (Nakamura and Kanagawa, 1984; Nakamura and Nakagawa, 1986; and Amino *et al.*, 1990).These processes have some differences and some features are common. These principles are utilized for improvement in production of drawing cups with help of hydraulic pressure through conventional methods.

In this process the blank is subjected to fluid pressure on its periphery to get high forming limits and also preventing the failure. So there is improvement of deep drawing process for making the cups with utilization of fluid pressure. The contribution of hydraulic pressure to the deep drawing process is positively in several ways. The frictional resistance reduces in the flange due to lubrication of flange and dies radius. In this analysis three different fluids medium are used. Deep drawing process is a simple non-steady state metal forming process, it is widely used in industry for making seamless shells, cups and boxes of various shapes. Deep drawing is an important process used for producing cups from sheet metal in large quantities. In deep drawing a sheet metal blank is drawn over a die by a radiuses punch. Amongst the advantages of hydraulic pressure assisted deep drawing techniques, increased depth to diameter ratio’s and reduces thickness variations of the cups formed are notable. In addition, the hydraulic pressure is applied on the periphery of the flange of the cup, the drawing being performed in a simultaneous push-pull manner making it possible to achieve higher drawing ratio’s then those possible in the conventional deep drawing process. The pressure on the flange is more uniform which makes it easiest to choose the parameters in simulation. The pressure in the die cavity can be controlled very freely and accurately, with the approximate liquid pressure as a function of punch position.In the hydro forming deep drawing process the pressurized fluid also serves to delays the on set of material failure and reduces the wrinkles formation. In the present work an attempt has been made to evaluate fluid pressure by changing the punch speed.

METHODOLOGY

The hydro forming deep drawing process as shown in Figure 1. The hydraulic pressure is to be applied on the periphery of the blank in radial direction for successful formation of cup. The fluid is placed in the die cavity and punch chamber, which are connected through bypass path in the die. The gap is provided between the blank holder and die surface for the fluid and blank movement.The punch movement in the fluid chamber produces pressure in the fluid. This pressurized fluid is directed through the bypass path and acts radially on the blank periphery. The blank is supported by pressurized viscous fluid in between blank holder and die surface within the fluid region in the gap and a fluid film is formed on the upper and lower surfaces of blank which reduces frictional resistance. The wrinkling is reduced in the blank due to the support of high pressurized viscous fluid. The radial pressure of fluid P, which is produced in hydro forming deep drawing process, is due to punch movement within the fluid chamber is equal to blank holder pressure P_h. So mathematically expressed as $P = P_h$. This fluid pressure depends on the punch speed and various process parameters of process. Evaluation of fluids pressure by using ANSYS Flotran CFD analysis software.

Figure 1: Hydro Forming Deep Drawing Process



Determination of Fluid Pressure and Blank Holder Pressure

Ansys – Flotran CFD analysis is used to study the variation of pressure of fluid with different punch speeds at constant punch radius using three fluids such as castor oil, olive oil and heavy machine oil. This pressure of fluid is used to evaluate the blank holding pressure and analization of stresses in this process.The element type is fluid 141 element from flotran CFD library is selected for meshing.The fluid 141 element shown in Figure 2. This figure shows fluid 141 geometry, locations of node and coordinate system for this element. The element is defined by three nodes [triangle] or four nodes [quadrilateral] and by isotropic properties of material.

The fluid model is developed in Ansys preprocessing using geometric modeling approach. The radius of punch is 45 mm, clearance between punch and die is 5 mm and radius of die opening is 50 mm.The resulted geometry with 2D geometric options are shown in Figure 3. Using adaptive mesh, a converged

Figure 2: Fluid 141 Element Geometry

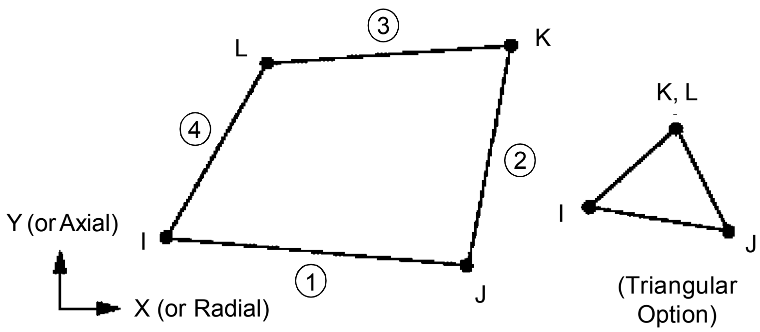
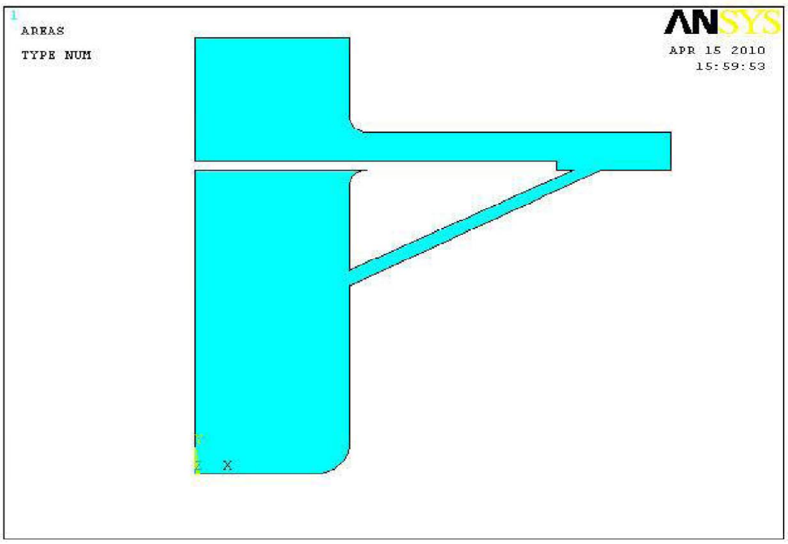


Figure 3: Geometric Fluid Model (Axisymmetric) of the Hydro Forming Deep Drawing Process



mesh is shown in Figure 4. The total number of elements and nodes in the model are 8204 and 8692. The Boundary and loading conditions are $V_x = V_y = 0$ on the boundary and punch velocity, V_y = 10-25 mm/sec. The Figure 5 shows the boundary and loading conditions of process. In this hydro forming deep drawing process the pressure of the fluid is equal to the blank holder pressure is obtained.

Figure 4: Flotran CFD Model of the Hydro Forming Deep Drawing Process

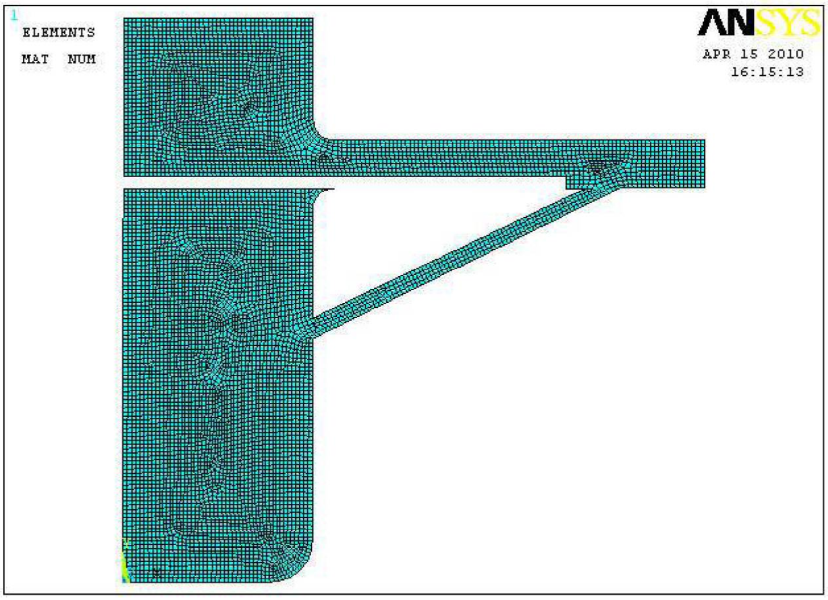
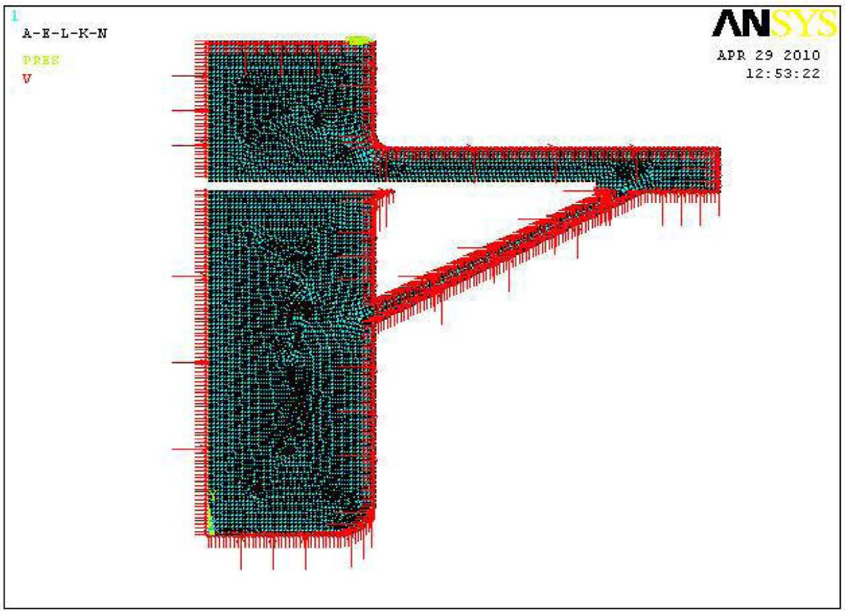


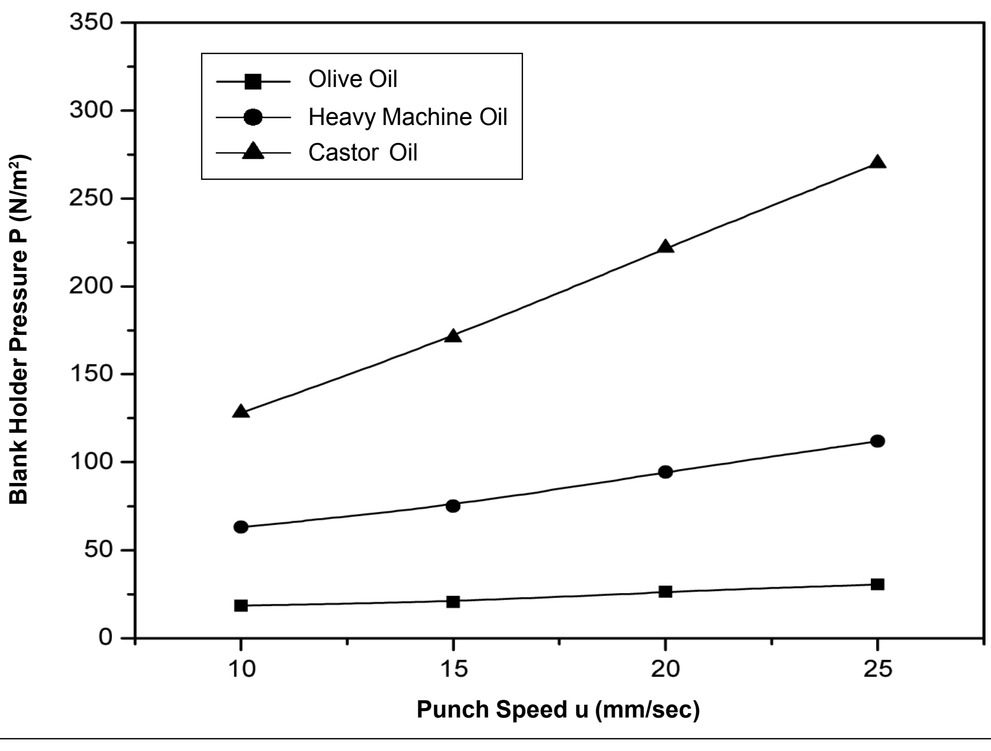
Figure 5: Boundary and Loading Conditions of the Hydro Forming Deep Drawing Process



RESULTS AND DISCUSSION

The variation of fluid pressure and blank holder pressure is evaluated with different punch speed at constant punch radius for three different oils such as olive oil, heavy machine oil and castor oil as medium in hydro forming deep drawing process. The parameters considered as punch speed u = 10, 15, 20 and 25 mm/sec, radius of punch r_p = 45 mm and radius of die opening r_d = 50 mm. viscosity of olive oil μ = 0.081 N-sec/m^2, viscosity of heavy machine oil μ = 0.453 N-sec/m^2 and viscosity of castor oil μ = 0.985 N-sec/m^2. The ANSYS Flotran CFD analysis results are presented in Figure 6. In this process the pressure of the fluid is equal to the blank holder pressure. From Figure 6 the blank holder pressure increases with increase in the punch speed for all three fluids. The high pressures are obtained in castor oil medium and low pressures are obtained in olive oil medium. Also the pressure of oil depends on its viscosity. The range of blank holder pressure for castor oil, heavy machine oil and olive oils are 128.5 N/m^2 – 270.3 N/m^2, 63.2 N/m^2 – 112.55 N/m^2 and 18.37 N/m^2 – 30.6 N/m^2 respectively. The blank holder pressure is maximum at u = 25 mm/sec for castor oil is 270.3 N/m^2, heavy machine oil is 112.55 N/m^2 and in olive oil which is 30.6 N/m^2. At u = 10 mm/sec, the blank holder pressure is least variation is observed for castor oil is 128.5 N/m^2, heavy machine oil is 63.2 N/m^2 and olive oil is 18.37 N/m^2. High fluid pressures as well as blank holder pressure are found for castor oil medium and least in olive oil medium and within these heavy machine oil is observed.

Figure 6: Variation of Blank Holder Pressure for Different Fluids by Varying Punch Speed at Constant Punch Radius



In hydro forming deep drawing process, the fluid pressure as well as blank holder pressure is the dominant parameter for failure and success of forming of cups from the cylindrical blanks. The undesirable wrinkles are formed in the flange due to an insufficient pressure of fluid as well as blank holder pressure and premature tearing produced in flange due to excess fluid pressure as well as blank holder pressure. So appropriate pressure of fluid as well as blank holder pressure is used for success in forming of cups in this process. The induced pressure in the oil is higher with high viscosity oil and the generated pressure in the oil is lower with low viscosity oil. So blank holder pressure is required high for high viscosity oil and low for low viscosity oil.

CONCLUSION

In this present work the conclusions are drawn as follows:

- In this process the uniform deformation of blank is obtained to get a required shape and also blank failure is prevented during deformation due to fluid pressure and blank holding pressure being equal.
- The blank holder pressure is evaluated and the fluid pressure is controlled.
- The wrinkling is reduced in the blank due to the support of high pressurized viscous fluid with supporting of equal blank holding pressure
- Based on the viscosity of oils the variation of blank holder pressure studied based on the order of fluids pressure as Pcastor oil > Pheavy machine oil > Polive oil
- Fluid pressure in the process depends on the geometry of process and process parameters.
- Fluid pressure as well as blank holder pressure has been increased with increase in the punch speed.
- The variation of blank holder pressure studied based on the order of fluid pressure at given punch radius and its velocity as Polive oil < Pheavy machine oil < Pcastor oil.
- Blank holder pressure as well as Fluid pressure has been increased with increase in the viscosity of fluid.

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