INFLUENCE OF VISCOSITY ON FLUID PRESSURE IN HYDROFORMING DEEP DRAWING PROCESS

Dr. R. Uday Kumar\(^1\) , Dr. P. Ravinder Reddy\(^2\)

\(^1\)Assistant professor, Dept. of Mechanical Engineering, Mahatma Gandhi Institute of Technology, Gandipet, Hyderabad. 500075. Andhra Pradesh. India.

\(^1\)Corresponding author. E-mail: u_kumar2003@yahoo.co.in

\(^2\)Professor & Head, Dept. of Mechanical Engineering, Chaitanya Bharathi Institute of Technology, Gandipet, Hyderabad. 500075. Andhra Pradesh. India.

E-mail: reddy_prr@yahoo.com

ABSTRACT

Today, Hydroforming technology provides an attractive alternative to conventional matched die forming, especially for cost-sensitive, lower volume production, and for parts with irregular contours. Some of the advantages of sheet hydroforming are improving the material formability, reduction of friction force, the accuracy of the forming part and the reduction of forming stages because of improvement of limiting drawing ratio. The hydroformed components are used in the aerospace, automotive and other industries. In hydroforming 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 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 and viscosity of fluids. The fluid pressure increases with increase in the punch speed and viscosity of fluid. 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 hydroforming deep drawing process the fluid pressure is equal to blank holder pressure.
is obtained. In this paper presents the determination of fluid pressure and influence of viscosity on fluid pressure through various punch speed in hydro forming deep drawing process.

Key words: fluid pressure, deep drawing, hydro forming process, fluid model, CFD analysis, geometric modeling.

1. INTRODUCTION

Hydroforming deep drawing (HDD) is one of the metal forming processes that is used in industry to produce complex sheets with high limiting drawing ratio (LDR). A pressurized fluid is employed in front of the work piece. As the punch travels, the work piece begins to deform into a cylindrical cup in the hydroforming deep drawing process.

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[1-2]. The frictional resistance reduces in the flange due to lubrication of flange and dies radius.

The types of fluid forming are Hydroforming process [3-5], hydromechanical deep drawing process[6-8], Aquadraw process [9], hydraulic counter pressure process [10-12].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. 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 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 with different viscosities by changing the punch speed.

2. METHODOLOGY

The fig.1 shows hydro forming deep drawing process. In this process 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. This fluid pressure depends on the punch speed.
2.1 Determination of fluid pressure

Ansly - 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 analysis 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 fig.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 40mm, clearance between punch and die is 5mm and radius of die opening is 45mm. The resulted geometry with 2D geometric options are shown in fig.3.

Using adaptive mesh, a converged mesh is shown in fig.4. The total number of elements and nodes in the model are 7972 and 8364.
Boundary and loading conditions: $V_x = V_y = 0$ on the boundary and punch velocity, $V_y = 15,20,25,30 \text{mm/sec}$.

The fig.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.

3. RESULTS AND DISCUSSION

The variation of fluid pressure is evaluated with various punch speed at constant punch radius for three different oils viscosities such as olive oil, heavy machine oil and castor oil as medium in hydroforming deep drawing process. The parameters considered as punch speed $u = 15,20,25$ and $30 \text{mm/sec}$ , radius of punch $r_p = 40 \text{mm}$ and radius of die opening $r_d = 45 \text{mm}$. viscosity of olive oil $\mu = 0.081 \text{N–sec/m}^2$, viscosity of heavy machine oil $\mu = 0.453 \text{N–sec/m}^2$ and viscosity of castor oil $\mu = 0.985 \text{N–sec/m}^2$. The ANSYS Flotran CFD analysis results are presented in fig.6.
From fig. 6 the fluid 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. Fluid pressure increases with increase in the viscosity of fluids. The range of fluid pressure for castor oil, heavy machine oil and olive oils are 164.5 N/m$^2$ – 318.8 N/m$^2$, 70.4 N/m$^2$ – 124.8 N/m$^2$ and 16.32 N/m$^2$ – 30.24 N/m$^2$ respectively. The fluids pressure is maximum at $u = 30$ mm/sec for castor oil viscosity is 318.8 N/m$^2$, heavy machine oil viscosity is 124.8 N/m$^2$ and in olive oil viscosity which is 30.24 N/m$^2$. At $u = 15$ mm/sec, the least variation is observed for castor oil viscosity is 164.5 N/m$^2$, heavy machine oil viscosity is 70.4 N/m$^2$ and olive oil viscosity is 16.32 N/m$^2$. High fluid pressures are found for castor oil viscosity medium and least in olive oil viscosity medium and within these heavy machine oil viscosity is observed.

In hydroforming deep drawing process with viscous fluid medium, the fluid 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 and premature tearing produced in flange due to excess fluid pressure. So appropriate pressure of fluid is used for success in forming of cups in this process. This pressure of fluid is used to evaluate the blank holding pressure. The induced pressure in the oil is highest with high viscosity oil and the generated pressure in the oil is lowest with low viscosity oil.

4. CONCLUSIONS

The following conclusions are drawn from the present work.

- Fluid pressure has been increased with increase in the viscosity of fluid.
- Fluid pressure has been increased with increase in the punch speed.
- Fluid pressure in the process depends on the geometry of process and process parameters.
- Base on the order of viscosity of oils as $\mu_{\text{castor oil}} > \mu_{\text{heavy machine oil}} > \mu_{\text{olive oil}}$ then order of fluids pressure as $P_{\text{castor oil}} > P_{\text{heavy machine oil}} > P_{\text{olive oil}}$
- For a given punch radius and punch speed, the order of fluid pressure is obtained as $P_{\text{olive oil}} < P_{\text{heavy machine oil}} < P_{\text{castor oil}}$.
- The fluid pressure is controlled and the blank holder pressure is evaluated.
- 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 wrinkling is reduced in the blank due to the support of high pressurized viscous fluid.
- High fluid pressures are found for castor oil viscosity medium and least in olive oil viscosity medium and within these heavy machine oil viscosity is obtained.

ACKNOWLEDGEMENT

One of the authors (Dr. R. Uday Kumar) thanks the management and principal of Mahatma Gandhi Institute of Technology for encouraging and granting permission to carry out this work.
REFERENCES