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ROLE OF CFD IN SHEET METAL FORMING

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Abstract

CFD is maintained major role in sheet metal forming processes through hydraulic fluids. Computational fluid dynamics (CFD) is the science of predicting fluid flow, heat transfer, mass transfer, chemical reactions and related phenomena by solving the mathematical equations which govern these processes using a numerical process. It is a numerical tool for analyzing two dimensional and three dimensional fluid flow fields in various fields of mechanical engineering streams such as manufacturing area. In the manufacturing area the deep drawing process performance can be improved by using the liquids in the process. The improvement of process performance such as higher in ratio of volume to surface area of product and volume to thickness of product, high quality surface, high accuracy in dimensional , no scratches developed on outer side of cup, higher in limiting drawing ratio and formability index. Deep drawing process is the compression-tension forming process involving wide spectrum of operations and flow conditions. The features of deep drawing process can be developed by fluid pressure for producing the metallic cups. In this 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. In this process the uniform thickness of sheet is obtained even after deformation in plastic region. The fluid pressure is also effects on radial, hoop and drawing stresses of blanks in during the process. 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 by varying the punch radius at constant punch speed.

Key words : CFD analysis, sheet metal forming, viscosity and fluid pressure

1.Introduction

Hydraulic pressure can enhance the capabilities of the basic deep drawing process for making cups. Amongst the advantages of fluid pressure assisted deep drawing techniques, increased depth to diameter ratio's and reduces thickness variations of the cups formed are notable.Sheet metal forming process is known as deep drawing process. It is simple non-steady state metal forming process, it is widely used in industry for making seamless shells, cups and boxes of various shapes. In deep drawing a sheet metal blank is drawn over a die by a radiused punch. As the blank is drawn radially inwards the flange undergoes radial tension and circumferential compression [1]. The latter may cause wrinkling of the flange if the draw ratio is large, or if the cup diameter-to-thickness ratio is high. A blank-holder usually applies sufficient pressure on the blank to prevent wrinkling [2]. In the field of deep drawing process the special drawing processes such as hydro-forming [3], hydro-mechanical forming [4], counter-pressure deep drawing [5], hydraulic-pressure- augmented deep drawing [6] .

In the hydro forming deep drawing process is an automatic co-ordination of the punch force and blank holding force, low friction between the blank and tooling as the high pressure liquid lubricates these interfaces and elimination of the need for a complicated control system [7-10]. 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.

2. Methodology

The sheet metal forming process of deep drawing setup through hydraulic fluid medium as shown in fig.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.

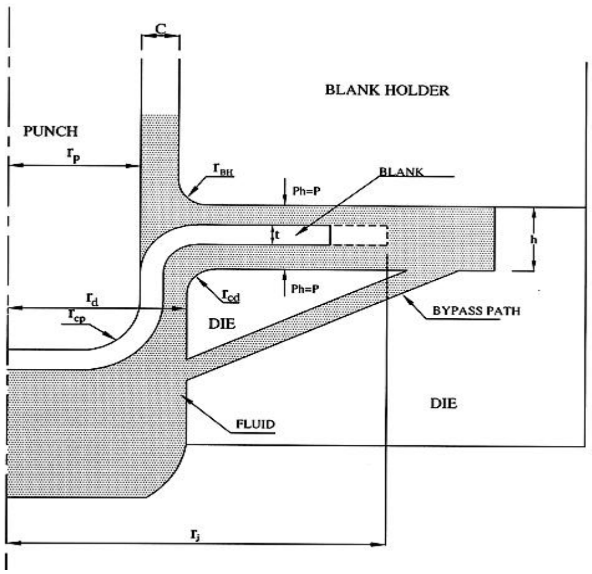

Fig.1 Sheet metal forming- deep drawing process

The wrinkling is reduced in the blank due to the support of high pressurized viscous fluid.The radial pressure of fluid which is produced due to punch movement within the fluid chamber is equal to blank holder pressure.This fluid pressure depends on the punch radius and various process parameters of process. Evaluation of fluids pressure by using ANSYS Flotran CFD analysis software.

3.CFD- Determination of fluid pressure

Ansys - Flotran CFD analysis is used to study the variation of pressure of fluid with different punch radius at constant punch speed using three fluids such as castor oil, olive oil and heavy machine oil. This fluid pressure is to evaluate the blank holding pressure and also 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 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.

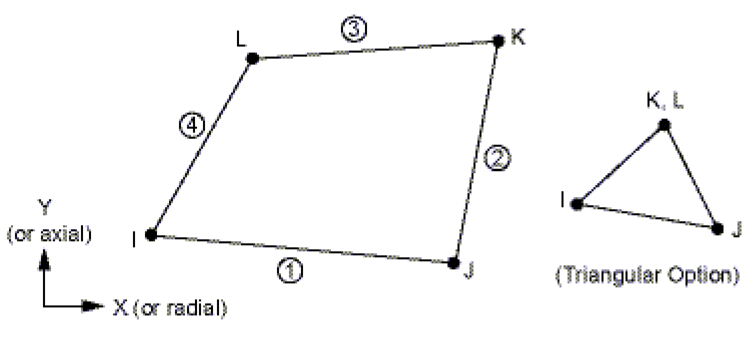

Fig.2 FLUID 141 Element geometry

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

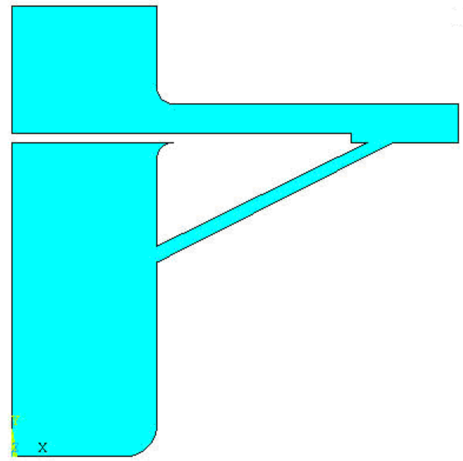

Fig.3 Geometric fluid model of the sheet metal forming -deep drawing process

Using adaptive mesh, a converged mesh and boundary and loading conditions is shown in fig.4 . The total number of elements and nodes in the model are 8246 and 9634.

Boundary and loading conditions:

$V_x = V_y = 0$ on the boundary and punch velocity, $V_y = 9$mm/sec.

The fig.4 Flotran CFD model and boundary and loading conditions of process.

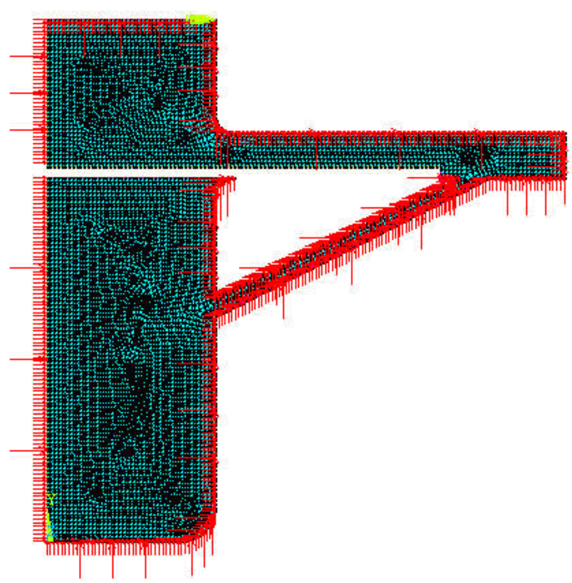

Fig.4. CFD model and boundary and loading conditions of process.

4. Results and Discussion

The variation of fluid pressure is evaluated with different punch radius at constant punch speed for three different oils such as olive oil, heavy machine oil and castor oil as medium in fluid assisted deep drawing process. The parameters considered as radius of punch r_p = 10 - 50mm with 5mm increment, punch speed u = 9mm/sec , clearance between punch and die is 3mm. Viscosity of olive oil μ = 0.081N–sec/m^2 , viscosity of heavy machine oil μ = 0.453 N–sec/ m^2 and viscosity of castor oil μ = 0.985N–sec/ m^2 .The ANSYS Flotran CFD analysis results are presented in fig.5. From fig.5 the fluid pressure increases with increase in the punch radius 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 fluid pressure for castor oil, heavy machine oil and olive oils are 31.5N/m^2 – 138.7N/m^2 , 11.25 N/m^2 – 71.5N/m^2 and 2.23N/m^2 – 25.43 N/m^2 respectively. The fluids pressure is maximum at r_p = 50mm for castor oil is 138.7N/m^2 , heavy machine oil is 71.5N/m^2 and in olive oil which is 25.43 N/m^2. At r_p = 10mm, the least variation is observed for castor oil is 31.5N/m^2 , heavy machine oil is 11.25N/m^2 and olive oil is 2.23N/m^2 .

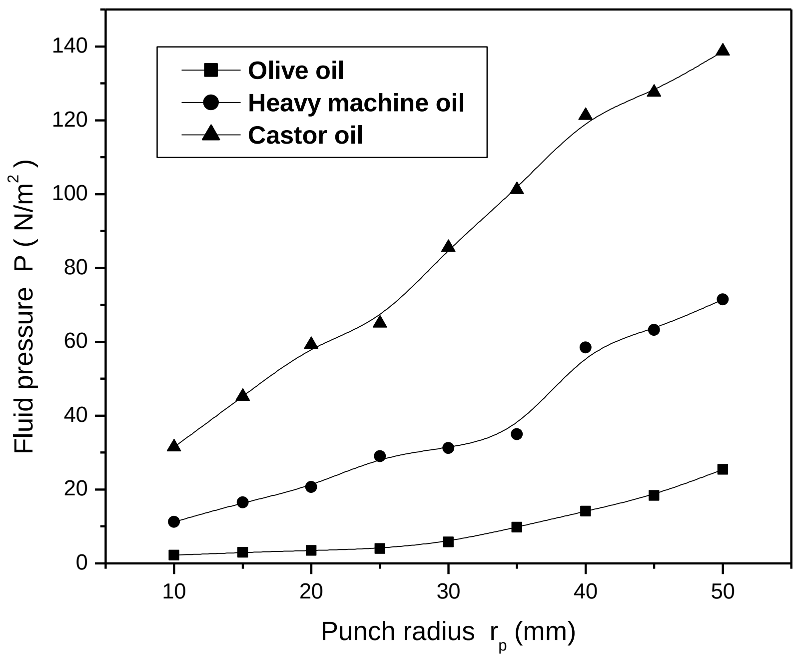

Fig.5 hydraulic fluid pressure variation with radius of punch

High fluid pressures are found for castor oil medium and least in olive oil medium and within these heavy machine oil is observed.In sheet metal forming - deep drawing process, the fluid pressure is the dominant parameter for failure and success of forming of cups from the cylindrical blanks.

5. Conclusions

The conclusions are obtained from the present work of this paper.

- The fluid pressure has been increased with increase in the punch radius.
- Fluid pressure has been increased with increase in the viscosity of fluid.
- The fluid pressure is controlled and the blank holder pressure is evaluated.
- For a given punch speed and punch radius, the order of fluid pressure found as $P_{castor\ oil} > P_{heavy\ machine\ oil} > P_{olive\ oil.}$
- Based on the viscosity of oils , the order of fluids pressure as $P_{castor\ oil} > P_{heavy\ machine\ oil} > P_{olive\ oil}$.
- The wrinkling is reduced in the blank due to the support of high pressurized viscous fluid. 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.

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