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FINITE ELEMENT ANLYSIS OF EVALUATION OF RADIAL STRESSES IN HYDRO - ASSISTED DEEP DRAWING PROCESS

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Abstract

In this paper presents Evaluation of radial stresses in hydro-assisted deep drawing through Finite element analysis. Hydro assisted deep drawing process, applying the hydraulic pressure in radial direction on the periphery of the blank is obtained through the punch movement within 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 pressure is generated in fluid due to punch movement within the fluid chamber and directed through the bypass path to blank periphery and is to reduce tensile stresses acting on the wall of the semi drawn blank. This fluid creates the fluid film on the upper and lower surfaces of the blank and subsequently reduces frictional resistance. During the process, the blank is taking at centre place in between blank holder and die surface with supporting of pressurized viscous fluid.

In this process the radial stresses are produced in the blank due to punch force applied on it, the shear stresses acted by viscous fluid on the both sides of blank, so apply viscosity phenomenon to this analysis.

In this analysis the radial stresses are evaluated through castor oil medium for magnesium alloys using FEA and also the radial stress distribution of magnesium alloys and fluid pressure were studied. The radial stresses have been increased with increase in the radius of blank and decreased with increase in the radial distance of the blank from the job axis.

INTRODUCTION

Deep drawing is one of the sheet metal forming process; it is widely used in industry for making seamless shells, cups and boxes of various shapes. The Fluids are introduced in this area of deep drawing process is get higher in forming limits. In this the viscosity is maintained the major role in the hydro forming-deep drawing process. The Hydraulic pressure can enhance the capabilities of the basic deep drawing process for making metal cups and this hydraulic pressure contributes positively in several ways to the deep drawing process [1-5].The 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. Hydraulic pressure can enhance the capabilities of the basic deep drawing process for making cups. 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 [6-8].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, the parts can drawn without any scratches on the outside of the part and also obtained in good surface finish, surface quality, high dimensional accuracy and complicated parts [9-10].In the fluid assisted deep drawing process the pressurized fluid serves several purposes are supports the sheet metal from the start to the end of the forming process, thus yielding a better formed part, delays the onset of material failure and reduces the wrinkles formation. In fluid assisted deep drawing process the radial stresses and hoop stresses are generated in the blank due to punch force is applied on it. The radial stresses are evaluated through finite element analysis.

METHODOLOGY

The deep drawing process with fluid medium 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. 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.

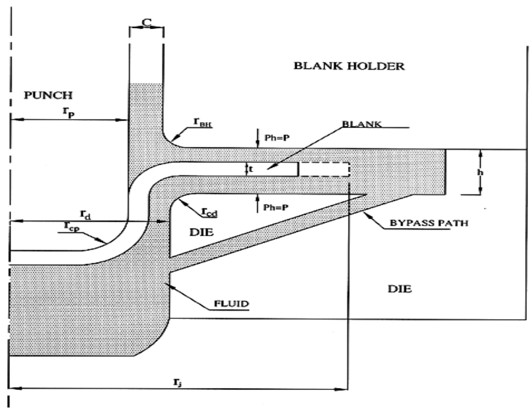

Figure 1 hydro assisted deep drawing process

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.

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Determination of fluid pressure

Ansys - Flotran CFD analysis is used to determination of fluid pressure with given punch speeds at radius using castor oil. This pressure of fluid is to evaluate the blank holding pressure and analization of stresses in this process. The element type is fluid 141 elements from flotran CFD library is selected for meshing. 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 30mm, clearance between punch and die is 5mm and radius of die opening is 35mm.Using adaptive mesh, a converged mesh is obtained. 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 = 12mm/sec. Then the castor oil pressure in this process is obtained. This pressure is applied radially on blank surface during the process. The fine mesh, loading and boundary conditions fig.2

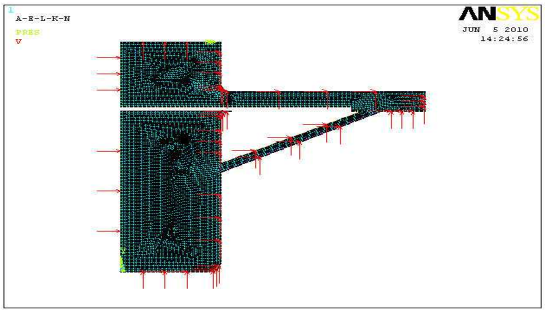

Figure 2 Boundary Conditions of Hydro Assisted Deep Drawing Model

FINITE ELEMENT ANALYSIS OF DEEP DRAWING PROCES

PLANE 42 Element Description as shown in fig.3.The PLANE42 is used for 2-D modeling of solid structures. The element can be used either as a plane element (plane stress or plane strain) or as an ax symmetric element. The element is defined by four nodes having two degrees of freedom at each node: translations in the nodal x and y directions. The element has plasticity, creep, swelling, stress stiffening, large deflection, and large strain capabilities.

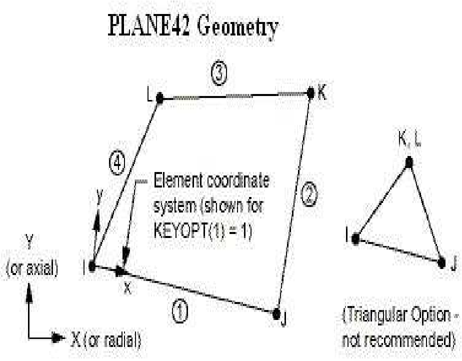

Figure 3 PLANE42 Element Descriptions

Process Parameters used in this Analysis

The following process parameters and yield stress values of magnesium alloy are considered for evaluation of radial stresses of magnesium alloy with given fluid for successful formation of cup in hydro assisted deep drawing process.

Radial pressure of fluid = P

Punch speed (velocity of blank) u =12mm/sec

Height between Blank holder and Die, h =12 mm

Thickness of blank t = 3 mm

Radius of blank r_j = 95mm and 100mm

Radius of punch r_p = 30mm

Type of fluid used: castor oil Density = 960 Kg/m ^{3}

Viscosity = 0.985 N-sec/m ^{2}

Type of materials used: Magnesium alloy - AZ31B-O

Composition [%] of AZ31B-O: Al – 2.5-3.5, Zn – 0.7-1.3, Mn – 0.2-1.0 and Mg is balance

Mechanical Properties AZ31B-O:

Elastic Modulus (Gpa) = 45, Yield Strength (Mpa) =140, Ultimate Tensile strength (Mpa) = 240 Poisons Ratio = 0.35

Geometric Modeling of the Blank:

After arriving the pressure from Flotran-CFD Analysis, that pressure is taken as input load in structural analysis. It is also Axi-symmetric, so only half of the blank is modeled. Here, the model is Rectangular blank for the structural Analysis, it is modeled using the options rectangle (by dimensions, in create areas option. Fig. 4 shows the Axi-symmetric Blank Model.

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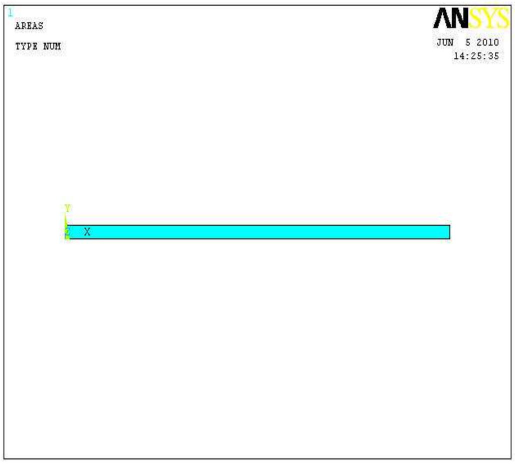

Figure 4 Geometric Model of Blank

Meshing of the Blank:

The mesh has been generated for the blank is, using mesh ¾ sided area in Mapped mesh option. The element type which we have used here is 'Solid Quad 4node 42'. Fig.5 shows the meshed blank. The number of elements generated is 80 and number of nodes are 28.

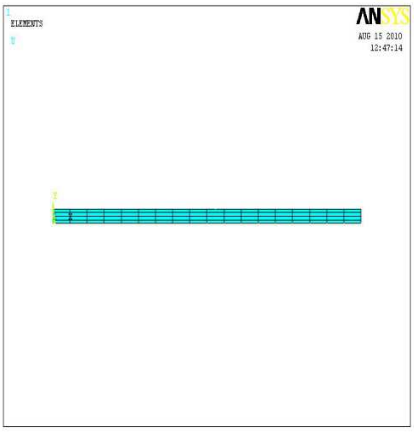

Figure 5 Meshed model of Blank

Loads and Boundary conditions for Blank:

For the Blank model, the pressure which is generated in Flotran CFD is the load. Loading and boundary conditions are shown in fig.6.The red colour arrow indicates the pressure (i.e load). The boundary conditions here are constrained in Y-Direction (Roller supported) beyond the clearance limit.

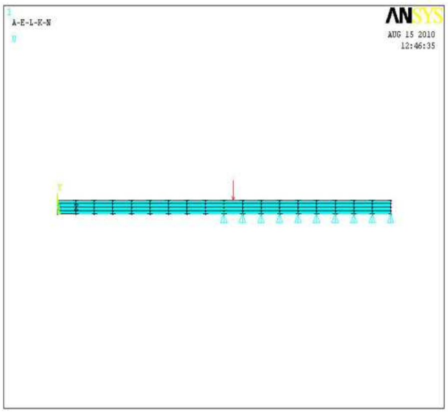

Figure 6 Boundary and loading Conditions of the Blank

Results and discussion

Castor oil Pressure

For the Ansys Flotran-CFD Analysis, castor oil is considered. In this Analysis, oil the pressures is found for different blank sizes as r_j = 95mm and 100mm by the punch velocity u =12mm/sec at given radius of punch. The table 1 shows the pressure values for corresponding blank sizes with respect to punch velocity.

Table 1 Castor oil pressure in hydro assisted deep drawing process

Punch velocity u mm/sec	Castor oil pressure N/m^2	
	Blank radius 95mm	Blank radius 100mm
12	134.5	130

With castor oil medium and punch velocity for different blank sizes such as r_j = 95mm and 100mm the pressure values obtained are in slightly decreasing order. This is due to punch moves with velocity and hits the blank, in doing so it develops shear forces on blank. These forces are same for every blank size. But here the blank areas are varying, so pressure is varying. The variation in area is very small, so the pressure variation here is also very small. From the table fluid pressure is decreases with increase in blank radius.

In this Analysis, castor oil pressure values are taken for the different blank sizes (r_j = 95mm and 100mm] under the punch velocity of u = 12mm/sec to do the structural Analysis to determine the Radial stresses.

Radial stress distribution in AZ31B-0 alloy of Rj = 95mm blank

In Ansys Flotran-CFD Analysis, the Pressure obtained for Castor oil for r_j = 95mm size blank under the punch velocity u=12 mm/sec is taken as the input load (i.e., P=134.5N/m^2) in Ansys Structural Analysis for the same size blank (i.e. r_j =95 mm). Due to this Load, the Radial stresses are developed in blank material. The radial stresses of magnesium alloy (AZ31B-0) blank of thickness, t = 3mm & r_j = 95mm radius, with the radial distance r = 45, 55 , 65 & 75mm from the vertical center axis of blank are shown in table. From the magnesium alloy (AZ31B-0) of blank size r_j = 95mm with castor oil viscosity, the FEA results of radial stresses are shown in table 2. It is observed that the range of radial stresses is 117 Mpa – 43.2 Mpa.

Radial stress distribution in AZ31B-0 alloy of Rj = 100mm blank

In Ansys Flotran-CFD Analysis, the Pressure obtained for Caster oil for r_j = 100mm size blank under the punch velocity u=12 mm/sec is taken as the input load (i.e., P=130N/m^2) in Ansys Structural Analysis for the same size blank (i.e. r_j = 100mm). Due to this Load, the Radial stresses are developed in blank material. The radial stresses of magnesium alloy (AZ31B-0) blank of thickness, t = 3mm & r_j =100mm radius, with the radial distance r = 45, 55 , 65 & 75mm from the vertical center axis of blank are shown in table. From the magnesium alloy (AZ31B-0) of blank size r_j = 100mm with castor oil viscosity, the FEA results of radial stresses are shown in table 2. It is observed that the ranges of radial stresses are 121 Mpa – 53.6 Mpa.

Table 2 FEA values of Radial Stresses

Sr. No.	Radius of Blank r_j mm	Radius at a point, r mm	FEA Radial Stress Values, Mpa
1	95	45	117
		55	82.9
		65	60.5
		75	43.2
2	100	45	121
		55	91.2
		65	65.5
		75	53.6

From the table the for both the cases of blank radius the radial stresses are high at low radial distance and low at high radial distance for job axis. This is due to viscosity of fluids, the shear forces are acted on the blank surface during the fluid assisted deep drawing process Radial stresses are also depends up on process parameters, yield stress of alloys and fluid pressure.

In deep drawing process with fluid medium, the fluid pressure is the dominant parameter for failure and success of forming of cups from the cylindrical blanks. 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.

CONCLUSIONS

The radial stresses are increases with increasing the radius of blank of magnesium alloy. But radial stresses are decreasing with increasing of radial distance (r) from the vertical axis of job. These effects are due to viscosity of castor oil and its pressure acted on the blanks of magnesium alloys during the forming process. The radial pressure of fluid acting on blank surface of alloys is equal to blank holding pressure and is for uniform deformation of blank during the process. Due to this eliminated direct metal to metal contact between the Blank, die and blank holder which is there in case of conventional deep drawing. Thus, the wrinkling is eliminated in blank due to the blank supported by high pressurized viscous fluid. The radial stresses are high at, *r* is 45mm, low at r is 75mm and radial stresses are zero at *r* is equal to blank radius. The higher value of radial stresses gives the minimizing the drawing time and higher in forming limits. These radial stresses are used to get better results of formability of magnesium alloy. Based on fluid pressure, 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. Radial stresses are increased with the increasing the blank size i.e., radius r_j, so the corresponding deformations also increased.

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