Distribution of Radial Stresses in Deep Drawing Process

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Abstract- Deep drawing is one of the sheet metal forming processes; 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. In hydro assisted 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 pressure is generated in fluid due to punch movement with in 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. The blank holder pressure is controlled by the radial pressure of fluid and these are equal for uniform deformation of blank to obtain required shape and also elimination of failure of blank in deformation. In this paper, the radial stresses are evaluated through caster oil medium for magnesium alloy using FEA and also the radial stress distribution of magnesium alloys and fluid pressure were studied.

***KEYWORDS:** Deep Drawing Process, viscosity, radial Stress and fluid pressure*

I. INTRODUCTION

1.1 Deep Drawing Process & Its Importance

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 radiused punch. As the blank is drawn radially inwards the flange undergoes radial tension and circumferential compression. 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.

Radial tensile stress on the flange being drawn is produced by the tension on the cup wall induced by the punch force. Hence, when drawing cups at larger draw ratios, larger radial tension are created on the flange and higher tensile stress is needed on the cup wall [1-8].

Bending and unbending over the die radius is also provided by this tensile stress on the cup wall. In addition, the tension on the cup wall has to help to overcome frictional resistance, at the flange and at the die radius. As the tensile stress that the wall of the cup can withstand is limited to the ultimate tensile strength of the material, in the field of deep drawing process the special drawing processes such as hydro-forming, hydro-mechanical forming, counter-pressure deep drawing , hydraulic-pressure- augmented deep drawing [9-12].

1.2 Hydro - Deep Drawing Process

It is the combination of all hydro forming processes like, hydro-static, hydro-dynamic, hydro mechanical & hydro forming processes. In this process shown in Fig.1, both the die chamber (female chamber) and the punch chamber (male chamber) are filled with a hydraulic fluid and these two are connected with by pass as shown in 2d-figure below. Initially fluid will be at rest (static condition), also the blank will be in rest on the supports of the die chamber, when punch moves downwards with certain velocity (dynamic condition), the fluid in the punch chamber gets kinetic energy and it exerts some pressure on the blank and for further movement of the punch the liquid with more velocity hits the blank & then it moves into the die chamber through the by-pass provided.

Like this it moves continuously for the further punch displacement & in die chamber more pressure will be created because of the continuous fluid flowing through by-pass. Because of the pressure difference between the die chamber (high pressure) and punch chamber (low when compared with die chamber), the fluid present in the die chamber exerts pressure on the blank and it lifts the blank for the equilibrium condition (shown in fig). Then fluid rushes and escapes from the gap between the blank & die.

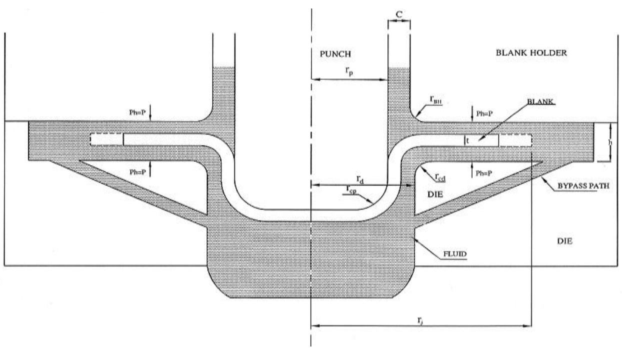

Fig.1 Hydro - Deep Drawing Process

II. METHODOLOGY OF EVALUATION

Thus avoiding the direct metal contact between the blank, blank holder & die. So less friction force, the cup produced will be of wrinkle less.

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Because of the continuous in-contact of the liquid (in die chamber) with the blank the cup produced is of wrinkle less & of uniform thickness. 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. 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.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 on set of material failure and reduces the wrinkles formation. In fluid assisted deep drawing process the radial stresses and hoop stresses are developed in the blank due to punch force and fluid pressure applied on it. The radial stresses are evaluated in terms of viscosity of fluid, blank geometry, and process parameters for magnesium alloy. So the viscosity phenomenon is considered for evaluation of the Radial Stresses.

2.1 Process Parameters Used In Ansys

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

Radial pressure of fluid = P
Punch speed u = 15 mm/sec,
Height Between Blank holder & Die, h =12 mm,
Thickness of blank t = 4 mm,
Radius of blank r_j = 80 mm,
Type of materials used is Mg Alloy (AZ31B-0)
Type of fluid used is castor oil
Viscosity μ = 0.985N–sec/ m^2

2.2 Finite Element Analysis

In this study Ansys-Flotran CFD is chosen to determine the fluid pressure. For this Analysis, fluid named castor oil is taken. The 2D geometric model of Hydro Deep Drawing Process drawn in Ansys - Flotran CFD & geometric model of blank is shown in Fig.2 & 3 respectively.

When punch moves downwards fluid creates Radial pressure on the blank & that pressure is uniform on the entire radius of the blank. Because of the Axi-symmetry, here a 2D- model of the hydro-forming process is drawn and then fluid analysis is carried out. So the pressure got from this Analysis for Caster oil is ranging from 101.489-165.24 N/m^2 shown in fig. 4

This pressure is taken as input load in structural analysis (on blank) and determined various Radial Stress values at r = 45, 55, 65, & 75mm for Magnesium alloy AZ31-B-0

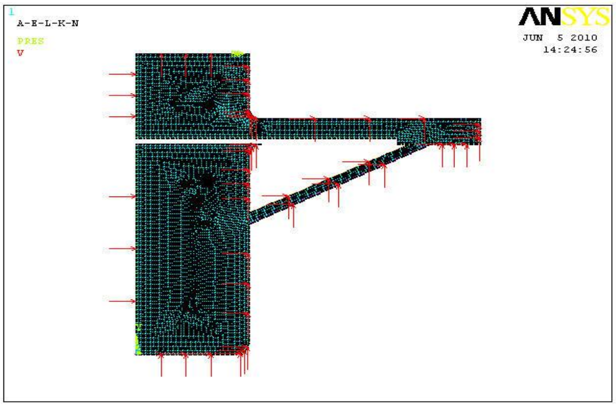

Fig.2 Geometric Model of process of Ansys-Flotran CFD

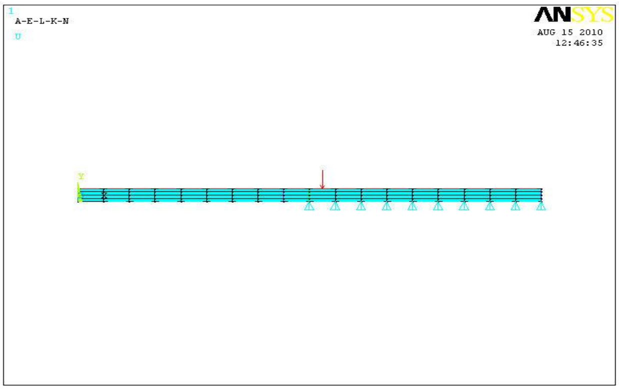

Fig.3 Geometric Model of Blank

III. MAGNESIUM ALLOYS & ITS DESCRIPTION

Magnesium is the highest of the commercially important metals, having a density of 1.74 gm/cm^3 and specific gravity 1.74 (30% higher than aluminum alloys and 75% lighter than steel). Like aluminum, magnesium is relatively weak in the pure state and for engineering purposes is almost always used as an alloy. Even in alloy form, however, the metal is characterized by poor wear, creep and fatigue properties. Strength drops rapidly when the temperature exceeds 100^0C, so magnesium should not be considered for elevated – temperature service. Its modulus of elasticity is even less than that of aluminum, being between one fourth and one fifth that of steel. Thick sections are required to provide adequate stiffness, but the alloy is so light that it is often possible to use thicker sections for the required rigidity and still have a lighter structure than can be obtained with any other metal. Cost per unit volume is low, so the use of thick sections is generally not prohibitive.

For engineering applications magnesium is alloyed mainly with aluminum, zinc, manganese, rare earth metals, and zirconium to produce alloys with high strength – to-weight ratios. Applications for magnesium alloys include use in aircraft, missiles, machinery, tools, and material handling equipment, automobiles and high speed computer parts. On the other positive side, magnesium alloys have a relatively high strength-to-weight ratio with some commercial alloys attaining strengths as high as
300 Mpa.

High energy absorption means good damping of noise and vibration. While many magnesium alloys require enamel or lacquer finishes to impart adequate connection resistance, this property has been improved markedly with the development of high purity alloys. For this analysis Magnesium alloy considered namely, AZ31B-0

Composition of AZ31B-0

Material		Min-Max *Composition %*
Al	:	2.5-3.5
Zn	:	0.7-1.3
Mn	:	0.2-1.0
Mg	:	Balance

Mechanical Properties AZ31B-0

Elastic Modulus (Gpa)	:	45
Yield Strength (Mpa)	:	140
Ultimate Tensile strength (Mpa)	:	240
Poisons Ratio	:	0.35
Hardness	:	400-600 Hv (Rc36-55)

Fluid Used in ANSYS FLOTRAN-CFD & its Properties

Caster oil:

Density	:	960 Kg/m ^{3}
Viscosity	:	0.985 N-sec/m ^{2}

Structural Analysis Properties used in Ansys

Magnesium Alloy	:	AZ31B-0
Elastic Modulus	:	45 Gpa
Poisson's Ratio	:	0.35

IV. RESULTS & DISCUSSION

4.1 Pressure acting on the r_j = 80mm blank

After Flotran CFD, the pressure which is arrived for Caster oil for the r_j = 80 mm blank size under u = 15 mm/sec is shown in Fig 4. The Maximum pressure arrived here is 150.594 N/m^2. But the pressure acting on the blank is 101.609 N/m^2. This pressure is the cause for the deformation of blank (cup formation). Thus this pressure is taken as the input pressure load for r_j = 80 mm blank in the Structural Analysis, to determine the Radial Stresses at each radius r= 45, 55 ,65 & 75 mm from the axis of centre of the blank.

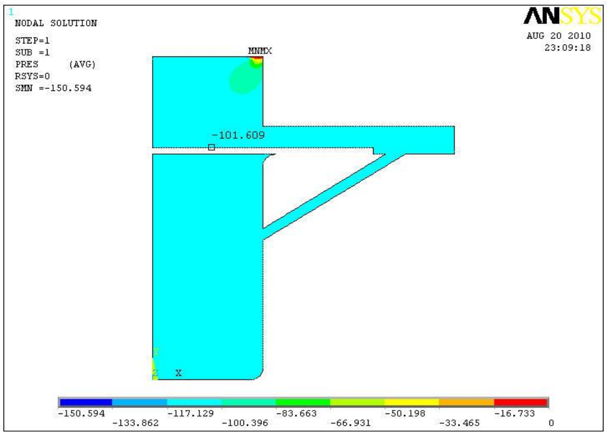

Fig. 4. Pressure Distribution in Fluid Forming for = 80 mm blank

4.2 Radial stress distribution in AZ31B-0 alloy of Rj = 80mm blank

In Ansys Flotran-CFD Analysis, the Pressure obtained for Caster oil for r_j = 80 mm size blank under the punch velocity u = 15 mm/sec is taken as the input load (i.e., P = 101.609 N/m ^{2}) in Ansys Structural Analysis for the same size blank (i.e r_j = 80 mm). Due to this Load, the Radial stresses are developed in blank material. Fig.5 shows the Radial stresses at radius r = 45, 55, 65 & 75mm from the center axis of blank of r_j = 80mm. Due to viscosity of fluid, the shear forces are acted on the blank surface during the fluid assisted deep drawing process, so the radial stresses are decreases with increasing of the radial distance of the blank from the job axis.

Radial stresses are also depends up on process parameters, yield stress of alloys and fluid pressure. From the magnesium alloy (AZ31B-0) of blank size r_j = 80mm with caster oil viscosity, it is observed that the range of radial stresses are 103 Mpa – 28 Mpa.

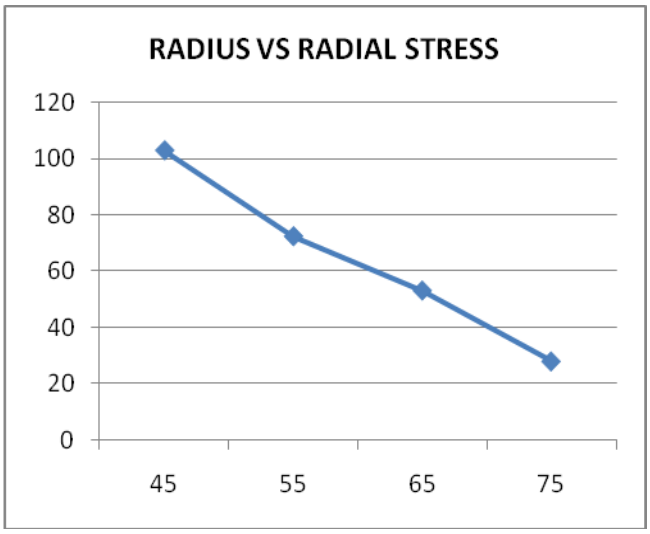

Fig.5 Radial Stress distribution for r_j = 80 mm blank

V. CONCLUSIONS

The radial pressure of fluid acting on blank surface of alloys is equal to blank holding pressure & 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 increases with increasing the radius of blank of magnesium alloy (i.e increases if radius r_j of the blank increases). But radial stresses are decreasing with increasing of radial distance (*r*) from the vertical axis of job (i.e decreases with increasing the radial distance with in the same job). These effects are due to viscosity of caster oil acted on the blanks of magnesium alloys during the forming process. 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 (at edges of blank). So the radial stresses are inversely proportional to the radial distance from job axis.

The higher values of radial stresses give the minimizing the drawing time and higher in forming limits. These radial stresses are used to get better results of formability of magnesium alloy. Radial stresses are increased with the increasing the blank size [radius r_j], so the corresponding deformations also increased.

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