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Laser Marking of Circular Grid Pattern for Plotting Strain Variation of Deep Drawing of Cylindrical Component

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Abstract

Laser marking is used in marking logos and batch code on metal products, mostly used for a permanent marking. By using this technology, we are creating circular grid marking completely covering the sheet. This will help us to plot the major and minor strains by the elongations formed after drawing the cup the circles will elongate at various points of cup. Circular marking of 5mm diameter is used. CAD model and assembly of this deep drawing is done using CATIA V5.

Keywords—laser marking;cicular grid;strain variation;CATIA V5.

Introduction

Deep drawing is a sheet metal formation process where the sheet metal forms into various shapes by forcing the sheet metal into the die cavity with the help of a punch. Here the sheet metal is constrained by the blank holder such that punch force acts at the center of the blank and takes the shape of the die. A sheet metal can be drawn into cylindrical, conical and rectangular box shape components. few complicated shapes both axis-symmetric and nonaxis-symmetric components are drawn in various no of stages to meet its required complex shapes. Both the die and punch experience wear from the forces applied to the sheet metal. The process of drawing the part sometimes occurs in a series of operations, called draw reductions. In each step, a punch forces the part into a different die, stretching the part to a greater depth each time. After a part is completely drawn, the punch and blank holder can be raised and the part removed from the die. The portion of the sheet metal that was clamped to the blank holder may form a flange around the part that can be trimmed off. The tensile forces applied to the sheet cause it to plastically deform into a required part. Deep drawn parts are characterized by a depth equal to more than half of the diameter of the part. These parts can have a variety of cross-sections with straight, tapered, or even curved walls, but cylindrical or rectangular parts are most common. Deep drawing is most effective with ductile metals, such as aluminum, brass, copper, and mild steel. Examples of parts formed with deep drawing include automotive bodies and fuel tanks, cans, cups, kitchen sinks, and pots and pans.

1.NOTATIONS OF DEEP DRAWING

To project the interaction parameters in forming a cylindrical cup the following fig 1.1 notations have been used.

D_0**:** Diameter of a circular sheet blank.
t_0 : Thickness of the circular sheet blank.
R_d : Corner radius of the die opening.
Dp: Punch diameter.
R_p: Corner Radius of the punch.
C: clearance

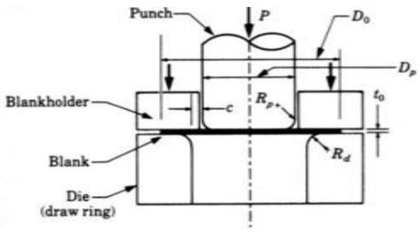

figure 1.1

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2.Deep drawing parameters:

Diameter of the sheet blank D_o=102 mm
Thickness of the sheet t_o=1 mm
Corner radius of the die opening R_d= 3mm
Punch diameter $D_{p=}$ 70.285mm
Corner radius of punch R_p=5mm
Clearance c=1.25(t_o)=1.25mm

3.DRAWING FORCE:

The maximum drawing force $F_{d,max\ required}$ to form a round cup can be expressed has follows

$\mathbf{F_{d,max}=n\pi dts_u}$

$\mathbf{S_u}$ $_{is}$ the tensile strength of the sheet**, d** is the diameter of the punch, **t** is the thickness, $_n$**=** $\mathbf{S_D/S_u}$**,** is the **ratio** of draw stress to tensile strength of the work material.

4.DRAWING RATIO:

Draw ability can also be termed has limiting drawing ratio. According to this it is the ratio diameter D of the large blank that can be drawn to the diameter of the punch d.

LDR=D/d.

5.Material properties:

The sheet metal material taken is **St 14**

E(Gpa)	Yield stress(Mpa)	Poisson's ratio	Density(kg/m^3)
210	**190**	**0.3**	**7850**

TABLE 1.

The strength coefficient, k = 638.96
Strain hardening exponent, n=0.3

6.Modelling and Assembly in CATIA V5 R20

Modeling and Assembly in CATIA V5 R20

The CATIA V5-R20 is the cad software used to 3d model the components of deep drawing. The modeling in CATIA is very much effective. The geometry is simple and does not take much time. Select the mechanical design and part or product is selected first if we select part geometry only part can be saved but in a product, multiple part geometry can be created and assembled and saved has a product. The sketch based features like a pad, pocket, shaft and various features are used to generate the 3d model.

The components required for deep drawing are:
1. DIE.
2. Sheet metal.
3. Blank holder.
4.Punch.

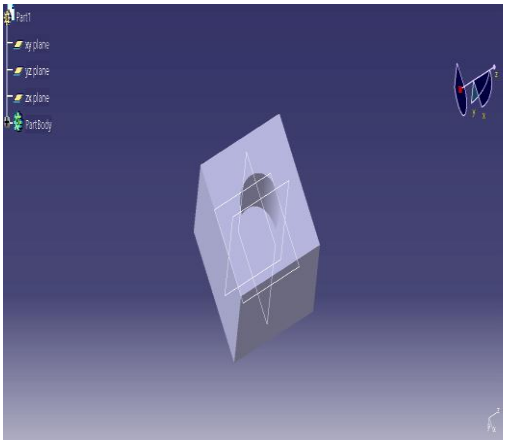

fig 6.1 DIE

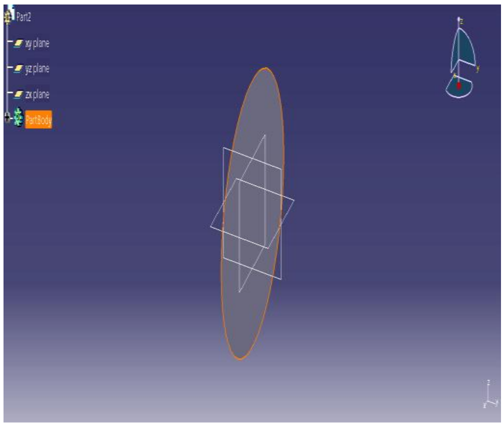

fig 6.2 Sheet metal

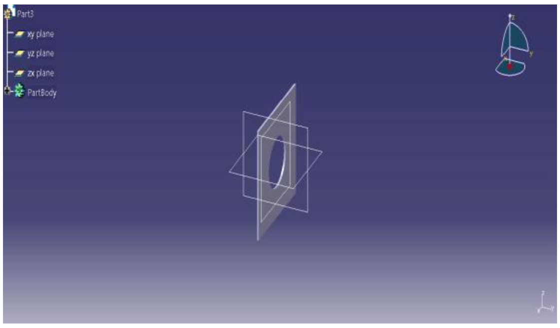

fig 6.3 BLANK HOLDER

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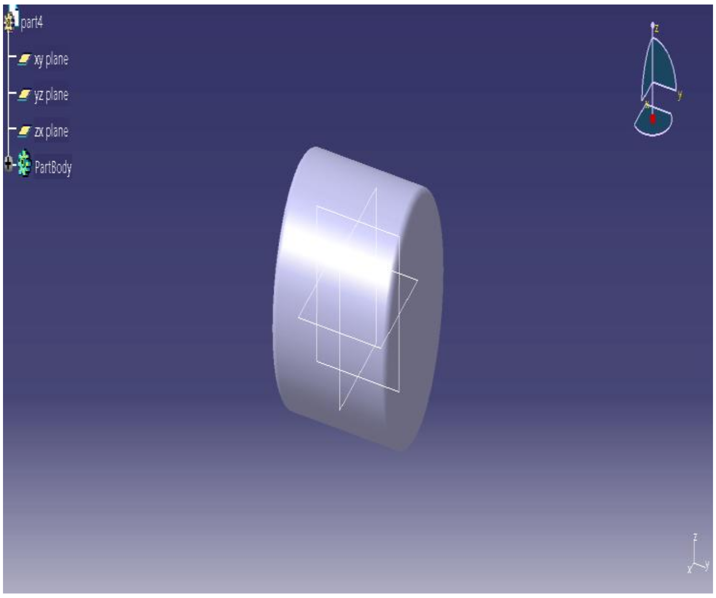

fig6.4 PUNCH

Select the mechanical design and now click the assembly. Right click on product and select existing components and select the saved file and import and now using constraints toolbar fix the part and then using the contact constraints and update which will complete the first step of assembly.

Repeat the process and complete the assembly.

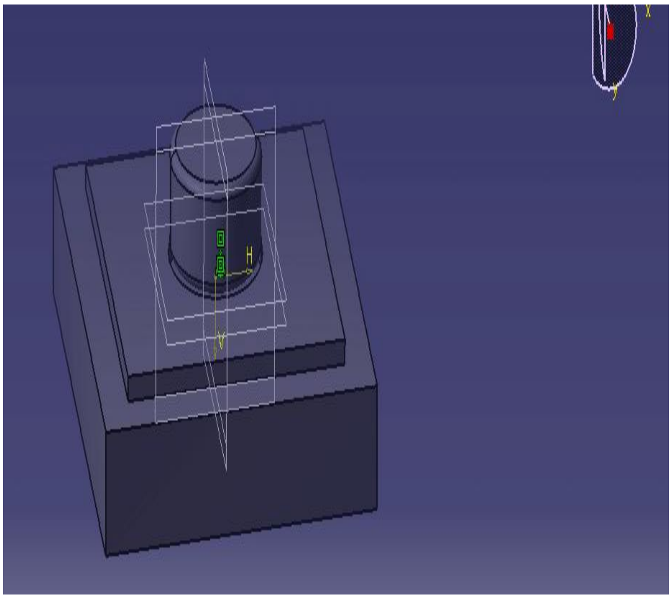

fig 6.5 Assembly

7.Experimentation

7.1 Laser marking on sheet

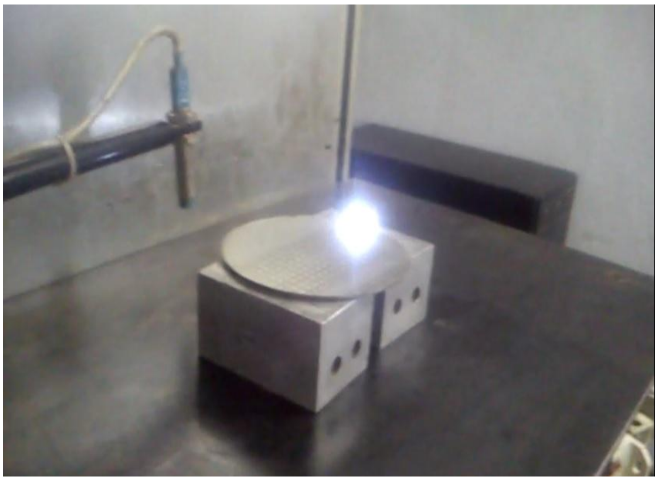

Fig 7.1 laser marking on sheet

The laser marking machine is used for marking of labels, codes, and logos on the products especially on metals with small markings. The marking machine used here has the marking range of area of a square of side 150mm. The machine is attached to the computer where a machine software reads the CAD data and it consists of GUI where we can create the image or code or logo which should be laser marked. The sheet was exactly placed in the center of the marking range of the laser with help of the auto position sensor visible in the image. Once the sensor points and scans the whole area of the sheet. It starts from the center of the sheet.

The grid pattern data was given in AutoCAD. LASER marking is very much cheap and which can mark up to the depth of 0.01mm. The diameter of the circle in the grid is 5mm.

7.2 Circular grid analysis:

The circular grid of 5mm diameter are laser marked on sheet. Before drawing the sheet metal circles marked are uniform after drawing the circles will elongate into ellipse causing major and minor axis. This phenomenon of elongation can use to find major and minor strain from the center of the cup has it is an axisymmetric component. This strains can also be used to determine FLD (forming limit diagram).

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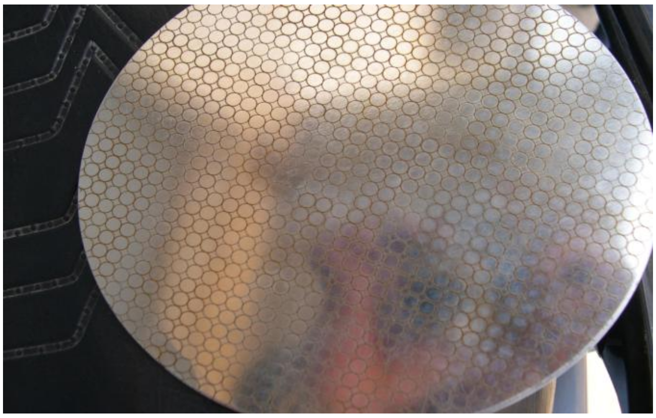

Fig 7.2 laser marked sheet

7.3 DEEP DRAWING PRESS

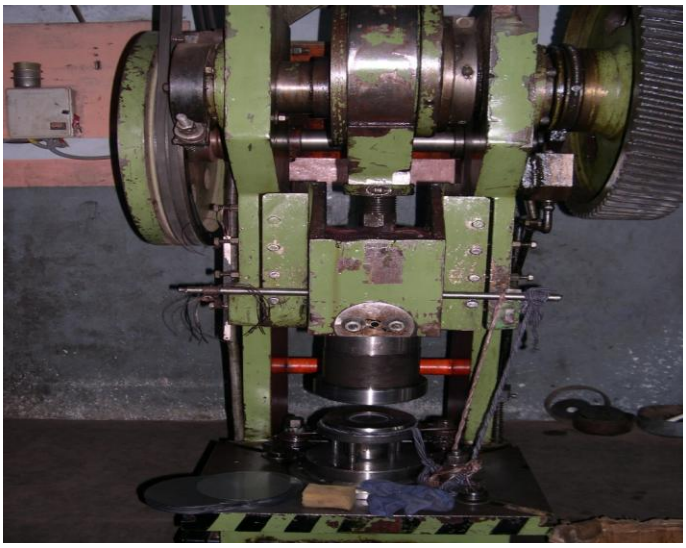

fig 7.3 Mechanical press

The Press used here is a mechanical press of maximum capacity 70-ton capacity. This mechanical press is effective in drawing the same component multiple no of times and used in small scale industries. Here the force required to draw the component is set manually by trial and error method. The lubrication is applied on every sheet to reduce friction.

8.RESULTS

The cups formed with laser marking will give a clear view of elongations. The distance between the major and minor axis is carefully measured under microscope. This will help us to find major and minor strain variation at the chosen points in the fig 8.3. To reduce time effort, we didn't measure strains from distance from the center has for axisymmetric cup but instead we chosen selected points. figures 8.1,8.2 are formed cups. The plotting of results is done in excel sheet, strain variation is plotted at chosen points in fig 8.4.

fig 8.2

fig 8.2

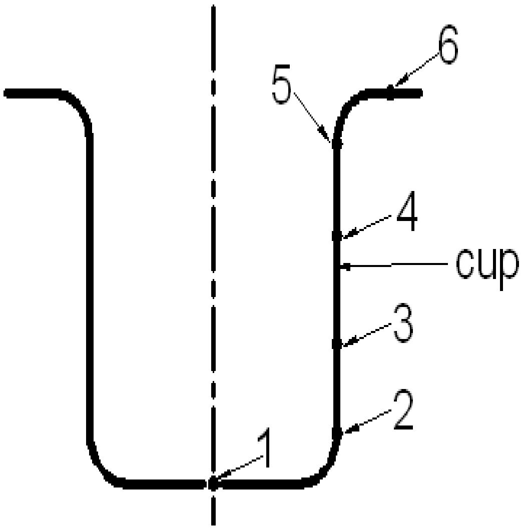

fig 8.3

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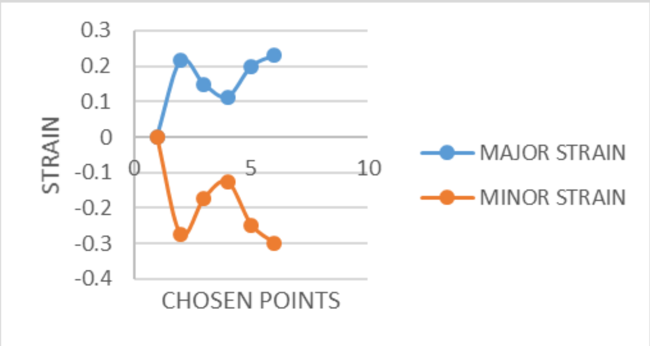

FIG 8.4

The point 1 in fig 8.3 there is no elongation and maximum elongation at point 6 where compression force acts. This strains can also help in plotting thickness and FLD.

9.CONCLUSION

The over lapping of the circle between two circles boundaries is reduced completely. There is zero damage occurred to sheet due to marking or it effected the die or punch. The other marking procedures like chemical etching will affect the sheet metal properties. The failures are very less except on aluminum because the marking depth 0.01 varies in the sheet because aluminum special properties.

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