Design and Fabrication of Drawing Die for Fly Press

B. Joga Rao, K. Sai Sudheer, M. Sekhar, K. Siva, G. Eswar Naved

Abstract: Press working is defined as a non -chip removal manufacturing process by which various components are made from sheet metal. There are various types of components are produced from sheet metal operation. The main aim of this project is to "Design and fabrication of drawing die used in the fly press". The design aspects of drawing die is accomplished in CATIA v5 and ansys 15.0 software. As coming to the manufacturing of drawing die, drawing die are manufactured in hot-chamber process which has the capacity to cast high melting point materials. The press tool leads to different operations namely blanking, drawing, trimming, bending, lancing, perforating, curling and shaving operations. Generally, drawing operation is the process of producing cylindrical objects. There is a vast use of press tools in industries like defense, textile, automobile, aircraft and food processing. The press machine is of the hand-operated fly press.

Keywords: CATIA, press, die, design, fabrication.

I. INTRODUCTION

Drawing is a sheet metal working process which is used to produce cup shaped parts which are cylindrical in shape by the application of tensile force on the sheet metal by the the punch. The lower part is called as die which have the cavity of cylindrical shape to produce the desired output part. Actually, there are two classifications in drawing operation. They are sheet metal drawing and tubes, wire drawing. Sheet metal drawing is process in which plastic deformation of sheet metal can be achieved. [1] Deep drawing of non-axisymmetric cross-section cups from thin sheet metals has been increasing significantly, especially for the manufacture of mechanical components. [2] High rate production industries generally prefer press machines. Mostly, Presswork operation is carried out with sheet metals that have a thickness of 3mm. [3] The sheet metal is generally fed in between the punch and die. The punch carries reciprocating movement. The die part is stationery.

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***** Correspondence Author

B. Joga Rao*, Associate Professor, Department of Mechanical Engineering, Godavari Institute of Engineering & Technology (A),Rajahmahendravaram, Andhra Pradesh, India

K. Sai Sudheer, UG Scholars, Department of Mechanical Engineering, Godavari Institute of Engineering & Technology (A), Rajahmahendravaram, Andhra Pradesh, India

M. Sekhar,UG Scholars, Department of Mechanical Engineering, Godavari Institute of Engineering & Technology (A), Rajahmahendravaram, Andhra Pradesh, India

K. Siva, UG Scholars, Department of Mechanical Engineering, Godavari Institute of Engineering & Technology (A), Rajahmahendravaram, Andhra Pradesh, India

G. Eswar Naved, UG Scholars, Department of Mechanical Engineering, Godavari Institute of Engineering & Technology (A), Rajahmahendravaram, Andhra Pradesh, India

Low carbon steel is used as sheet metal because of its good strength and formality characteristic. The main function of the punch is to strike the sheet metal and make sheet metal to the desired shape. The striking power is dependent on tons capacity of the machine. The shape and dimensions of the product depending on the design and dimensions of the die block. The guide block is a supportive block that works as an intermediate between the punch and dies block. The main function of the guide block is to oppose the shear forces. [4] The process in which the required shape of a piece is obtained through the involvement of uniaxial or biaxial stretch of the metal sheet can broadly be termed as sheet metal forming.[5] There are many factors which affect the deep drawing process. The factors included are lubrication, geometry, properties of material. There are some failures which may cause during this process are earing, necking, tearing, wrinkling and surface finish is poor. Compressive stresses are cause wrinkling defect through buckling. Tensile stresses cause tearing and necking.

II. LITERATURE REVIEW

[1] vedat savas and omer sacign. According to their paper, there many number of variables which affect the deep drawing process are shape of balnk, punch radius and die radius and the material formabilty charactestics and etc.
[2] D. Swapna et al. According to their paper Conventional Deep Drawing is the process of conversion of a flat material (blank) into a hollow part. The movement of outer annulus radially inward when the punch moves downwards. The blank holder force restricts the wrinkling defect which means upward folding of flange. [3] Bhaduri et al. According to his paper the deep drawing operation is produced from sheet metal having thickness less than 3 mm. Deep drawing is used to produce various shapes like square, cylindrical, and etc. [4] Adnan I. O. Zaid. According to his paper, The decrease in drawing force when the die profile radius increases and increases when the punch profile radius increases.Wrinkling is caused due to buckling force. [5] Chandra Pal Singh et al. According to his paper, There are some parameters which affect the final product are blank holding force, die pressure, punch pressure, effect of friction and etc.

III. PROBLEM DEFINITION

By using the ancient manufacturing processes, the time required for making such sheet metal products take much time, labor cost is more and dimensional characteristics are not accurately obtained. Due to these drawbacks, we utilize the advanced and efficient method deep drawing for creating similar parts in mass production with greater dimensional accuracy.

Sheetmetal products have a high demand from various industries like automotive, construction and heavy industries such as oil and food industries, etc.

IV. PHASES OF THE PROJECT

- Designing the drawing die in CATIA v5 software.
- Calculations of the die in the manufacturing.
- Analysis of die and punch in ansys15.0 software.
- Fabrication of drawing dies used in the fly press.

V. DESIGN OF DIES

This is the process of creating a model in the shape of the product to be manufactured. For designing die, CatiaV5 software is utilized. Dies are mostly used in manufacturing industries for mass production which involves making similar components having greater precision.

The below-stated steps are followed for modeling the die:

- Firstly, the opening of the CATIA software is carried out
- Drawing the line diagram for the part with the help of line command
- Dimensioning of the created line diagram
- Creating the surface for the line diagram
- Trimming of unwanted material from the surface
- Developing the projections for the component with holes
- Creating a cylindrical block for a cavity to produce the desired shape
- Draw the line diagram of punch
- Dimensioning the punch as per the object produced in die- block
- Revolve the part of the punch

A. DIE BLOCK

The die block is designed using CatiaV5 software which is having a rectangular cross-section of dimensions length of 165mm, a width of 130mm and 20mm thickness. Other details die material mild steel.

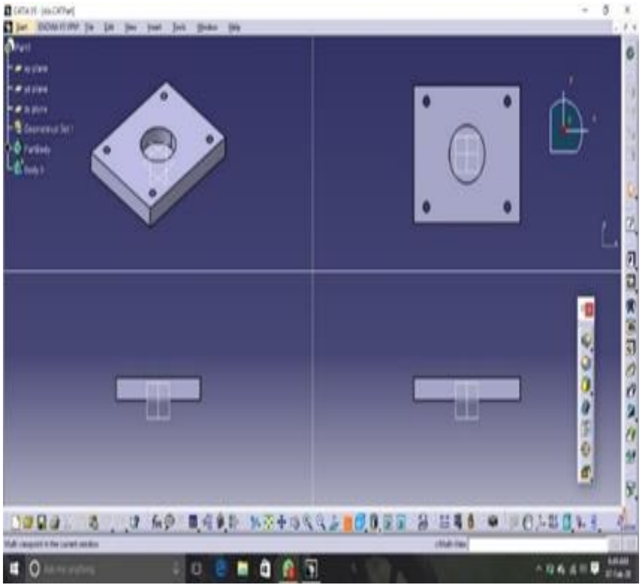

Fig 1: Representation of 3-Dimenstional Die for drawing operation in Catia v5.

B. PUNCH

The design of punch is carried out in CATIA v5 software. The dimensions of punch are the diameter of punch is 55mm and the height of punch is 20mm.

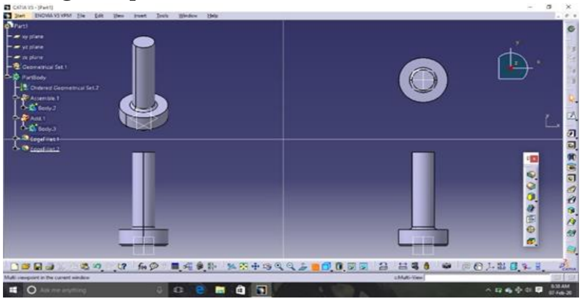

Fig 2: Representation of 3- dimensional punch for drawing operation in Catia v5.

C.GUIDE PLATE

For the design of the guide plate, it is required to design on CATIA v5 software. The dimensions of the guide plate are the length of 165mm, the width of 130mm, thickness of 3mm and has a hole of the diameter of 57mm at its center.

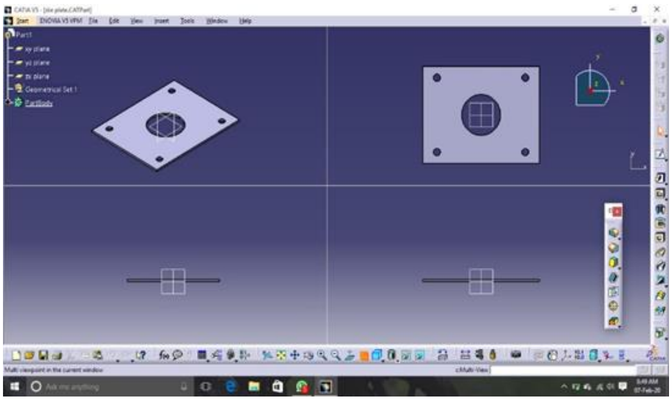

Figure3. Representation of 3- dimensional guide plate in Catia v5

VI. PROPERTIES OF ALUMINIUM

Table1: Aluminum properties

Mechanical properties	Values (metric)
Brinell Hardness	121
Ultimate tensile strength (M pa)	420
Yield tensile strength (M pa)	350
Modulus of elasticity (G Pa)	200
Poisson's Ratio	0.25
Thermal conductivity (W/MK)	44-52
Specific Heat capacity (J/g℃)	0.47
Machinability	65%

VII. PROPERTIES OF MILD STEEL

Table 2: Mild steel Properties

Material properties	Values
Atomic number	13
Atomic weight (g/mole)	26.92
Crystal structure	FCC
Melting point (ºC)	660.2
Boiling point (ºC)	2480
Density	2.6898
Modulus of elasticity (G pa)	68.3
Poissons ratio	0.34
Coefficient of linear expansion (0-100ºC) (×10-6/ºC)	23.4

VIII. EXPERIMENTAL CALCULATION

1. **Corner radius**

there is no set of guidelines to follow for finding the corner radius on the punch, it is necessary to provide a radius of four to ten times the sheet thickness or blank thickness.

Corner radius = 7.5×1= 7.5mm

2. **Draw radius on die**

= 4×1= 4mm

3. Diameter of blank

$$D=\sqrt{(d-2r)^2+4d\times(h-r)+2\pi r\times(d-0.7r)}$$

$$\sqrt{(\mathbf{55}-\mathbf{15})^2+\mathbf{4}\times\mathbf{55}\times(\mathbf{20}-\mathbf{7.5})+\mathbf{2}\boldsymbol{\pi}\times\mathbf{7.5}(\mathbf{55}-\mathbf{0.7}\times\mathbf{55})}$$

=82mm

4.side clearance between punch and die

=1.125×1

=1.125

5.Drawing force

=π×d×t×s(D/d-C)

=π×55×1×248×(82/55-0.6)

=16.5166 KN

6. Height of shell

=(82^2-55²)/(4×55)

=20mm

7. Clearance

Ideally, the clearance between punch and die should be equal to the blank thickness.

8. percent reduction

P=100(1-d/D)

= 100(1-55/82)

=33%

Where D= Diameter of blank
D= Diameter of punch
R= Corner radius
S= Yield strength
H= Height of shell
C= Clearance factor

ANALYSIS OF DIE WITH RESULTS

The analysis is the method used to know the actual behavior of the model created in the design. In this project, Ansys15.0 static structural tool is used with help to calculate the equivalent stress, shear stress, total deformation, and mild steel as solid. The properties of aluminum and mild steel are given in Table 1, Table 2. The below procedure to be followed to analyze the die.

- Importing the geometry file into the static structure.
- Generate the mesh for the geometry file having nodes and elements as fine
- Opened the setup window
- Clicked on general set the units
- Created the materials in engineering data as mild steel.
- Right-click on static structural and click on insert and apply the force.
- The required fields were given under boundary conditions
- Run the calculations with several iterations to be performed.
- Results were seen with required options that are shear stress, equivalent stress and total deformation.

A. ANALYSIS OF DIE

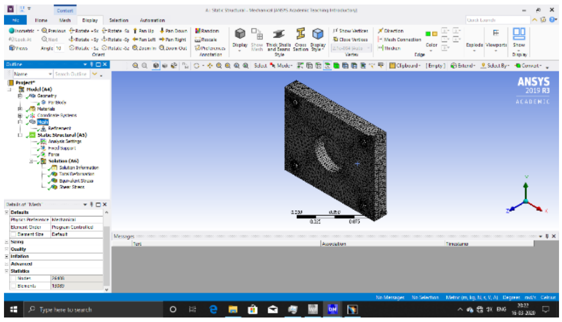

Fig 9. The meshing of die part

Figure9. Represents the meshing of die part with relevance as fine and the meshed part having elements of 13089 and nodes of 26408.

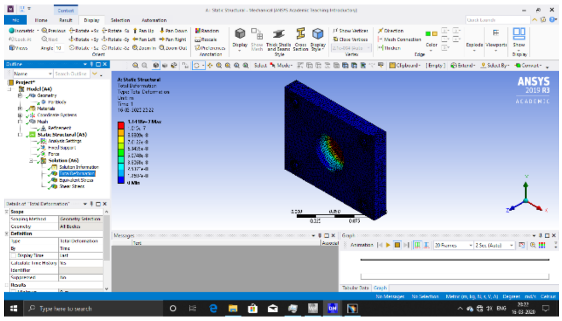

Fig10. Total deformation of die part

Figure 10 represents the total deformation of the die. The total deformation is the vector sum of all directional displacements of the system. The minimum deformation is 0 and the maximum deformation is 1.1418e-7

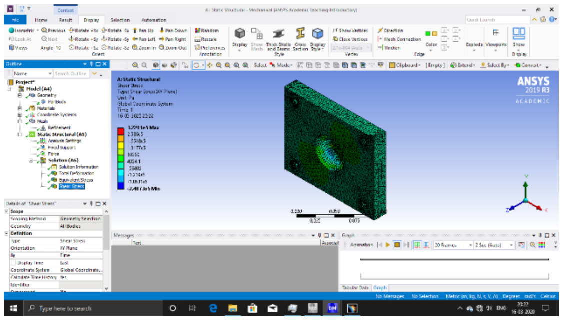

Fig 11. Shear stress affecting the die part

Figure11 represents the shear stress affecting the die. Shear stress is a force that causes layers or parts to slide upon each other in the opposite direction. The minimum shear stress is 2.4873e5 and the maximum shear stress obtained is 3.2021e5 respectively.

B. ANALYSIS OF PUNCH

The procedure followed for the analysis of die is similar to the analysis of punch.

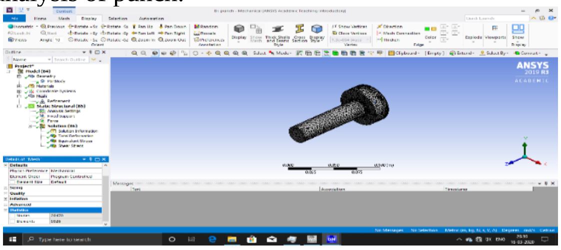

Fig12. Meshing of punch

Figure 12 represents the meshing of punch and the meshed part of punch having nodes of 20470 and elements of 9926 respectively.

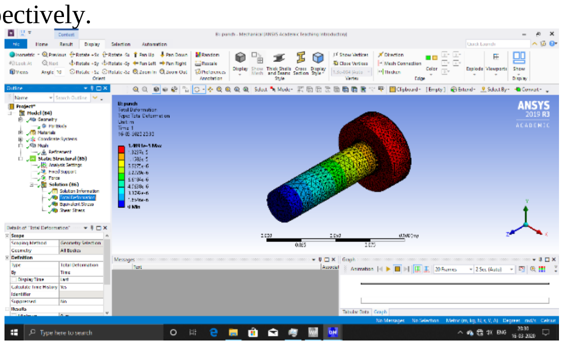

Fig 13. Total deformation of punch

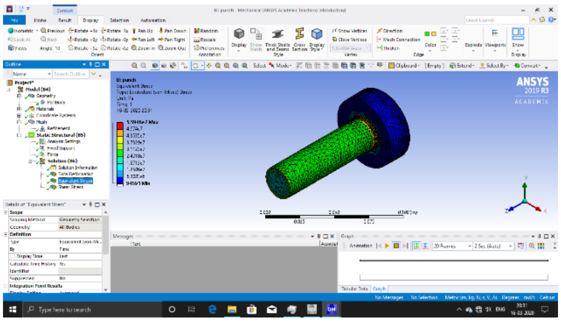

Fig 14. Equivalent stress of punch

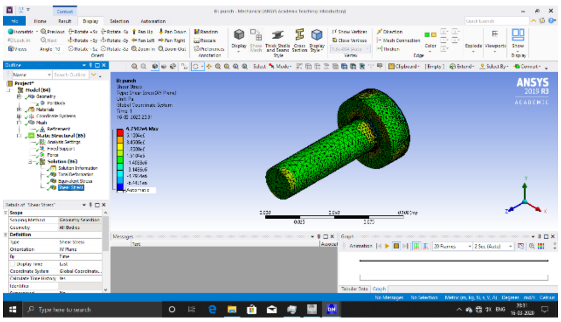

Fig 15. Shear stress of punch

Figure 15 represents the shear stress of punch and the Minimum shear stress is 0 and maximum shear stress is 6.750e6 respectively.

IX. FABRICATION OF DRAWING DIE

The manufacturing process includes various steps to be done and also involves the selection of efficient machines to complete the part, so the various machines and various operations used and performed are mentioned in detail below The metal blocks are made of the MS (MILD STEEL) material, which is a very widely used material, the process of cutting is made with a hack saw machine. Hack saw a machine is a tool that is used to cut solid materials with a metal sharpened blade. A lathe is a machine that rotates the piece on the axis to perform various operations like cutting, facing, knurling, deformation and more.

The drill bit is usually a rotary cutting tool, often multi-point. The workpiece is placed on the table where the workpiece holder is situated and then the drill bit is fixed to the chuck with the help of the chuck key. The drill bit size used here is 30mm. Filing operation is required here to shape the circular into a circular shape as it is not easily possible to produce circular shape on the metal block so we used files as the tools for the material removal of the metal block. Filing operations can be used on a wide range of materials as a finishing operation.

Fig 4: Die block having a cylindrical hole of the diameter of 57 mm with a corner radius of 7.5mm

Fig 18: punch having a diameter of 55mm

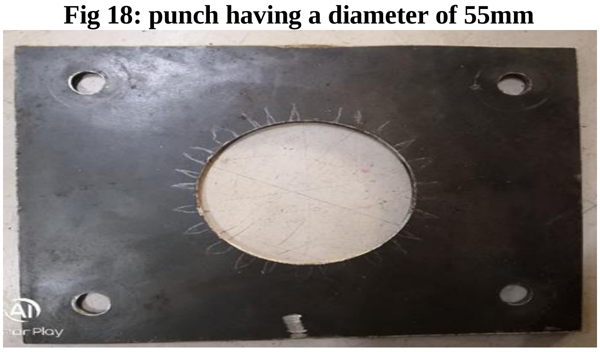

Fig7. Guide plate having a cylindrical hole of a diameter of 55mm

X. OUTPUT PRODUCT OF DIE

Fig8. Output product of die

XI. CONCLUSION

• It will benefit the industries which manufacture a smaller number of items on a huge scale. Also, it avoids much inventory management such as collecting information purchasing too many verities.

• Deep drawing produces shapes with closed ends. That avoids the need to cut and weld multiple pieces.

• This project only deals with simple shapes like cylindrical cups, but deep drawing can create more complex forms.

• It mainly focuses on the design, analysis and experimental calculations related to the project.

• After applying the force of 14KN on the cylindrical cavity of die, the minimum deformation is 0 and the maximum deformation is 1.1418e-7 as shown in figure [10] are obtained respectively.

• Die material steel has 248Mpa tensile strength which has more strength compared to aluminum metal.

• The minimum shear stress is 2.4873e5 and the maximum shear stress obtained is 3.2021e5 as shown in figure [11] when applying the force of 14kn on the cylindrical cavity of the die and when the other end is fixed.

• The blank holding force has a major influence in the deep drawing process.

• Wrinkling is the tendency to upward fold of wall or flange due to absence of blank holding force or minimum of blank holding force.

• To eliminate wrinkling defect in deep-drawn parts, it is necessary to use a blank holder. A constant pressure of blank holder is applied for the entire drawing action without any folds.

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