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Modelling and Design of Punch and its Operation on Sheet

Maneesh Kumar*, Trilok Chauhan
Department of Mechanical Engineering, ITM University, Gwalior, Madhya Pradesh, India

Abstract

Punching of a sheet is widely used in manufacturing industries due to its applications. It can be used to give the required shape or to process a hole. It can be very large or small depending upon the application required. A lot of household items are being made by punching operation. Punching involves parts such as punch which applies the force and is motion, sheet on which load is being applied, blank die which gives the shapes to the sheet and blank holder which holds the sheet on its position. The present work focuses on the survey of the earlier work done on the punching operation. Modelling of the punching assembly is conducted in the present work. During punching operation which parts come under maximum load, and different types of stresses developed during the punching operation were also studied and reviewed in the present work.

Keywords: *Punching, sheet, blank die, blank holder, finite element analysis (FEA)*

****Author for Correspondence*** E-mail: pv597989@gmail.com

INTRODUCTION

In punching, press shearing is the procedure of cutting metal plate without producing the chip. The material is stressed and force applied on a metal sheet can be done by the punch and die. Shearing consist of three stages—plastic deformation, penetration and fracture. In plastic deformation, force is applied by the punch tool on the metal work piece, the force tends to deform the metal into the die opening then the elastic limit increases with the increase in load. This stage starts to transform the metal in a radius form on the lower edge called plastic deformation of material. In penetration, load further increases and the punch starts to penetrate the material to a certain depth and starts to force the metal or material of sheet into the die portion; this stage consists of a bright surface finish on both the strips and the blank. This stage is called penetration stage. In fracture stage, when load increases on material beyond the plastic limit the material starts fracturing from both the upper and lower cutting edges and the load on the punch increases continuously, the fracture extends and causes complete separation.

Press can be classified according to frame, delivering power mechanism, working area size, number of stations utilized for heavy production and mass production. The sheet metal operation in punching press is divided into two parts—cutting operations and forming operations. In cutting operations the metal work piece is stressed up to ultimate strength point and the shear stresses develops into the metal sheet while forming operations are used to change the shape of metal sheet as per the requirement with the help of force applied on the metal due to which stress is developed below the ultimate strength point; there is no cutting of metal in whole operation only the surface profile of the work piece is changed to get the product shape. Cutting operations include process such as blanking, punching, notching, perforating, trimming, shaving, slitting and lancing. Forming operation includes process such as bending, drawing and squeezing.

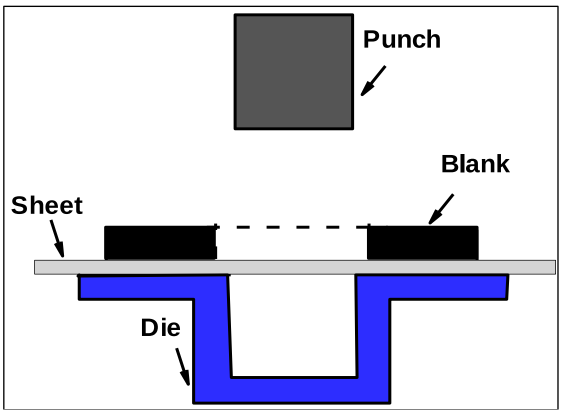

Fig. 1: *Punching Press Operation Layout.*

Figure 1 shows the components of a punching operation. It includes parts such as, punch which applies the force and is in motion, sheet on which load is being applied, blank die which gives the shape to the sheet and blank holder which holds the sheet in position.

Naik and Mandavgade [1] in the year 2012 studied the effect of finite element analysis (FEA) implementation in hydraulic cotton lint bailing machine for optimization of top and bottom frame. They targeted their study towards reducing the bending stresses, reducing the cost, increasing the safety and to design the process successfully into a structural shape optimization problem. They used topology for optimization of the problem by taking the weight as an objective function. Software ANSYS was used for this work and found 13% reduction in frame.

Chauhan and Bambhania [2] in the year 2013 designed and analysed frame of a 63 tonne power press machine using finite element method of an industry. Material used by them were ST 42 W, which have a maximum tensile strength of 540 MPa, maximum allowable stress of 105 MPa, Young's modulus of 2100 GPA and density of 7850 kg/m^3. They utilized CAD for modelling of the geometry and imported it in the FEA software and found that thickness of the machine can be reduced by 25%. Kaushik in the year 2013 [3] studied the hydraulic press design and fabrication for a punching operation. He concluded that hydraulic press operation is most efficient and economical for aviation-related problem. They used a sheet and drilled five number of cut in the sheet; they have used wiping die for bending sheets. They have utilized hydraulic machine which can perform two operations, bending and piercing, made of cast iron material. For punch they utilized EN31, for punching die they utilised EN30, mild steel for punch holder and copper, aluminium and brass for product.

Khichadia and Chauhan [4] in the year 2014 reviewed mechanical press frame design and analysis. They modelled the geometry in CAD software and conducted the analysis using a FEA tool. They used grey cast iron as a material of the press frame. They studied different parameters such as stress distribution, deformation occurs, optimization of the press, ergonomics, stiffness and rigidity of the operation.

Parthiban *et al.* in the year 2014 [5] conducted design and analysis of 'C' type hydraulic press structure and cylinder. They targeted their study to improve the performance of the press by redesigning the press frame and cylinder. They utilized CATIA for geometrical modelling of the problem and they used ANSYS for FEA analysis. They utilized mild steel as a material of the frame because of its ductility and soft nature properties. They modified the press by giving a fillet of 5 mm to reduce the stress concentration problem. They found out that after the modification in the fillet radius from 25 mm to 15 mm, the overall thickness got reduced and overall weight of the assembly also got reduced.

Rathod and Rajmane in the year 2014 [6] studied punching machine operation and Raut *et al.* in the year 2014 [7] carried out the solution on designing of flywheel in different shape. Ravi in the year 2014 [8] conducted computer aided design and analysis of a power press 10 tonne capacity under static condition. He utilized Pro-E software for modelling of the geometry and used ANSYS software for FEA. He used steel as a material of the power press and varied the frame thickness and bed thickness to analyse their effect on the deflection and stress generated. He found that results generated by the software were within the limits.

Shweta *et al.* in the year 2014 [9] conducted the design of 1200 ton mechanical press for air booster operation. A pressure intensifier or booster is a device which increases the existing pressure to perform the operation at high pressure and works without the hydraulic power unit. Advantages of this operation is that the device can give pressure for long duration of time, very high pressure up to the range of 50000 psi can be achieved which is not possible for conventional pump, and it saves the required space and weight as compared to the high pressure driven pumps.

Khandekar in the year 2015 [10] conducted design optimization and analysis of structure frame for heavy duty metal forming hydraulic press. More and Kulkarni [11] in the year 2015 analysed and optimized the 200 tone C type hydraulic press using ANSYS software. Ram *et al*. in the year 2015 [12] studied mechanical press machine setup process enhancement in metal-mechanic area for an elevators company. The work results from a master thesis project were conducted during a period of five months.

MODELLING

Punching includes parts such as, punch, sheet, die and holder. First die has been created, then sheet, then blank holder and in last punch has been created. Figure 2 shows the line drawing of the die drawn in the design modeller. Dimension of each horizontal and vertical line have also been shown in the Figure 2. To create this line drawing, first two horizontal lines have been drawn, and then two vertical lines then another two horizontal lines have been drawn by going to the “Draw tool bar–Line”. Then the dimensioning has been done as shown in the Figure 2 by going to the “Dimension tool bar”.

Now to create circular section fillet has been used, for this go to “Modify–fillet”. Figure 3 shows the revolved view of the die. This can be obtained by “revolving” option available in the tool bar, near to extrude. Select the “Revolve” then select the axis (Details of revolve) around which axis you want to revolve the geometry, you can also go for options like Add material and add frozen depends on your geometry in the “Details of revolve –Operation”.

To design the sheet first we select the “new plane” option then “generate” option. This creates a new plane where one can draw the sheet. We can draw the sheet either by line option or by rectangle option. We select rectangle option because to create a rectangular sheet rectangle option is easy. We go to “draw tool–rectangle” and create a rectangle of irregular dimensions. Then we do the dimensioning (45 mm length and 2.5 mm height) as shown in Figure 4. Now we use the “Revolve” option as explained while drawing the “die” geometry (Figure 5).

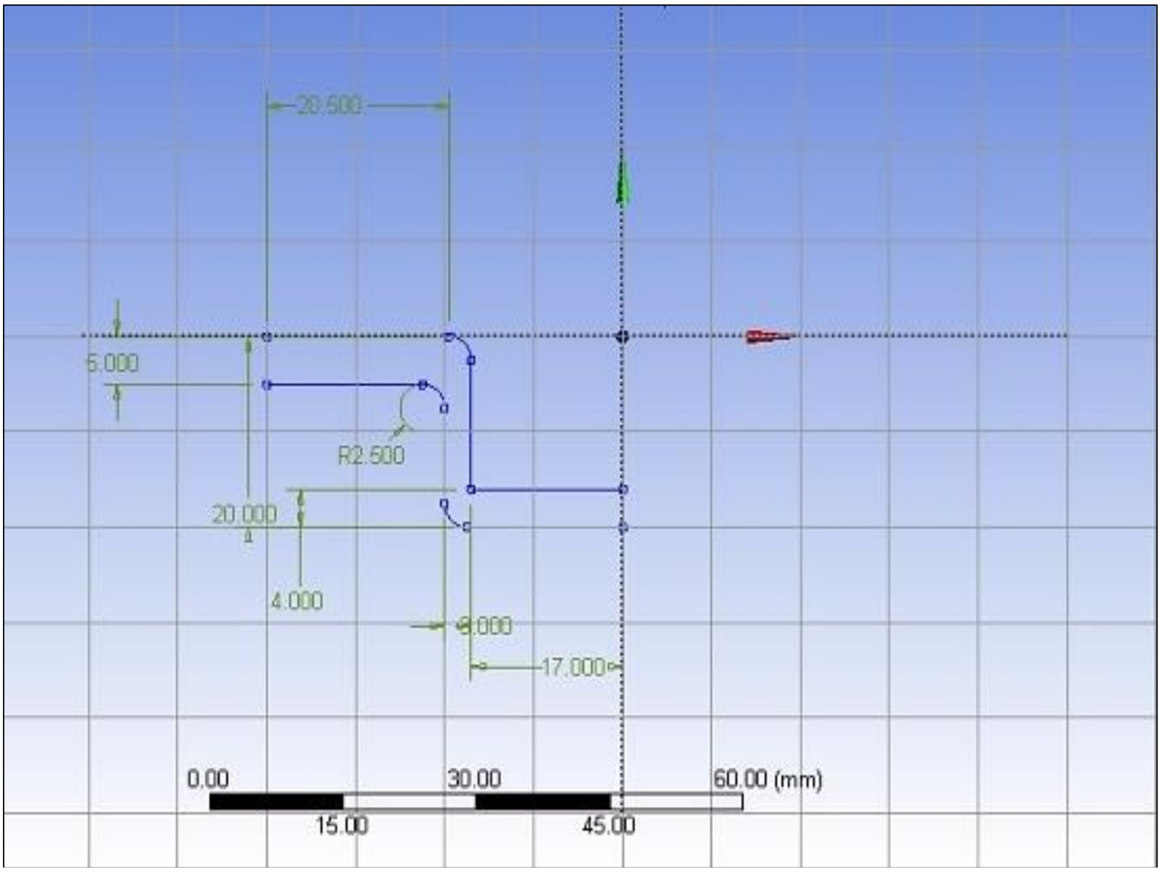

Fig. 2: *Die (Line Drawing).*

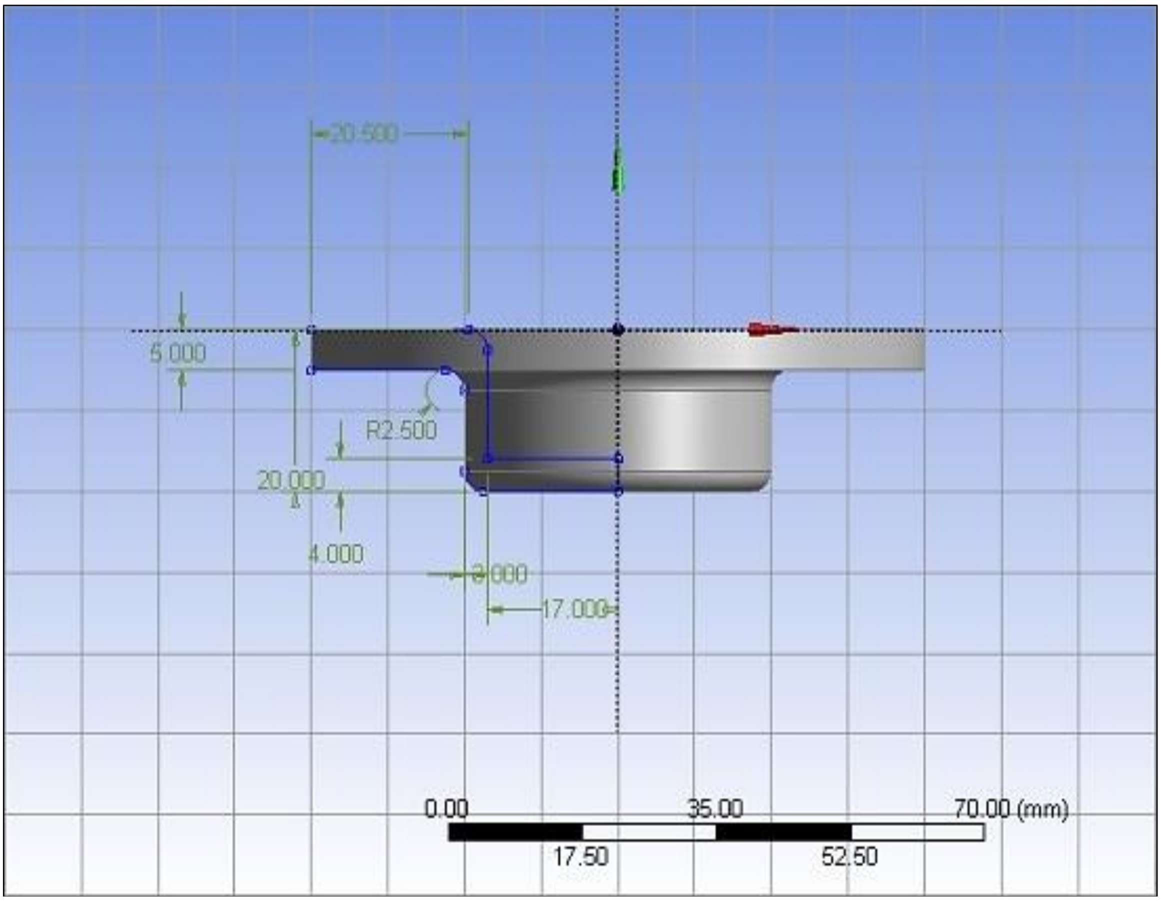

Fig. 3: *Revolved Die (Front View).*

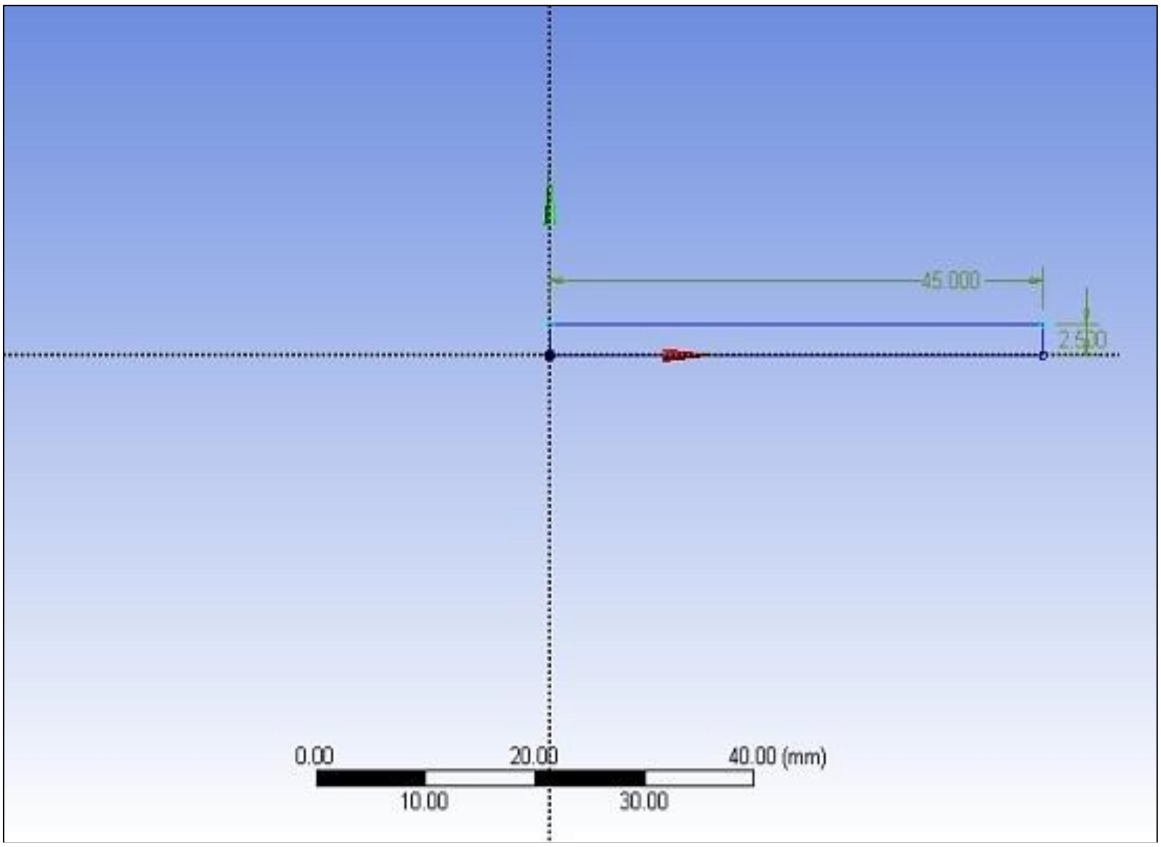

Fig. 4: *Sheet (Line Drawing).*

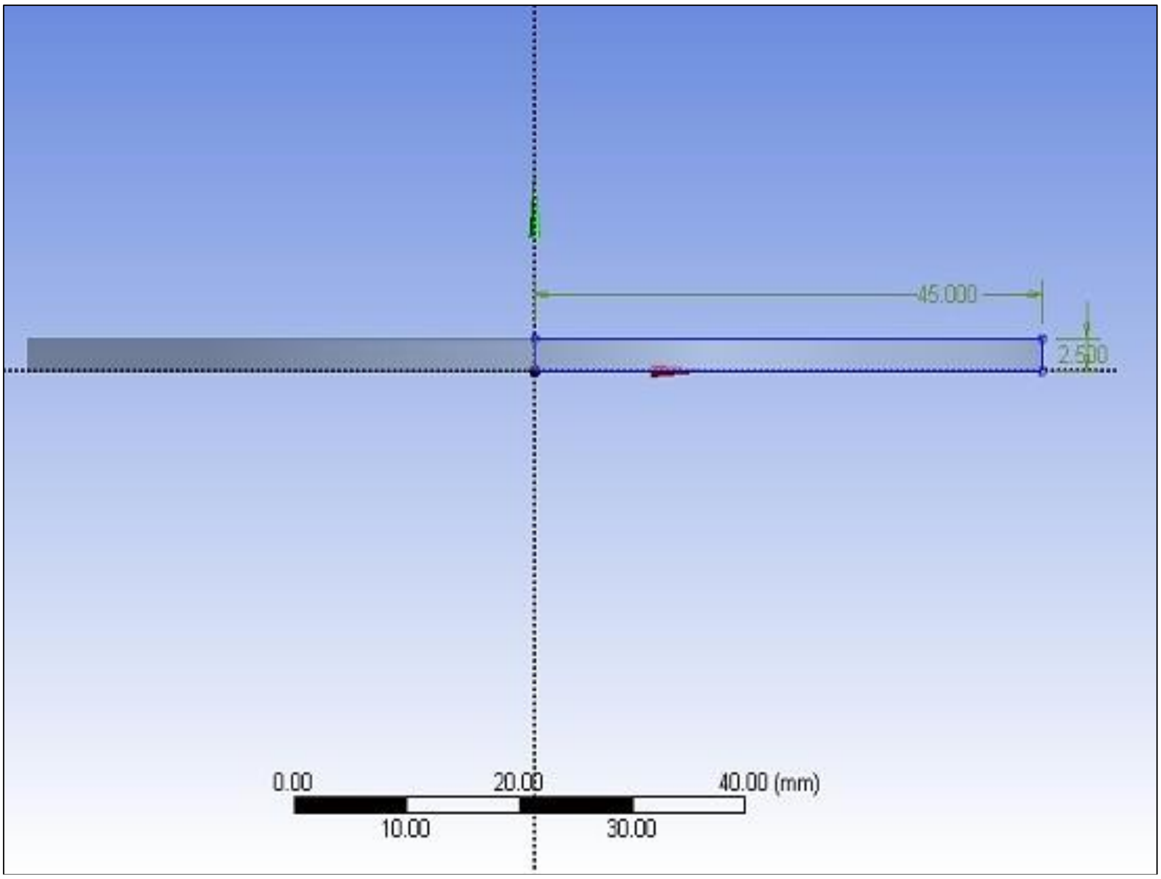

Fig. 5: *Revolved Sheet (Front View).*

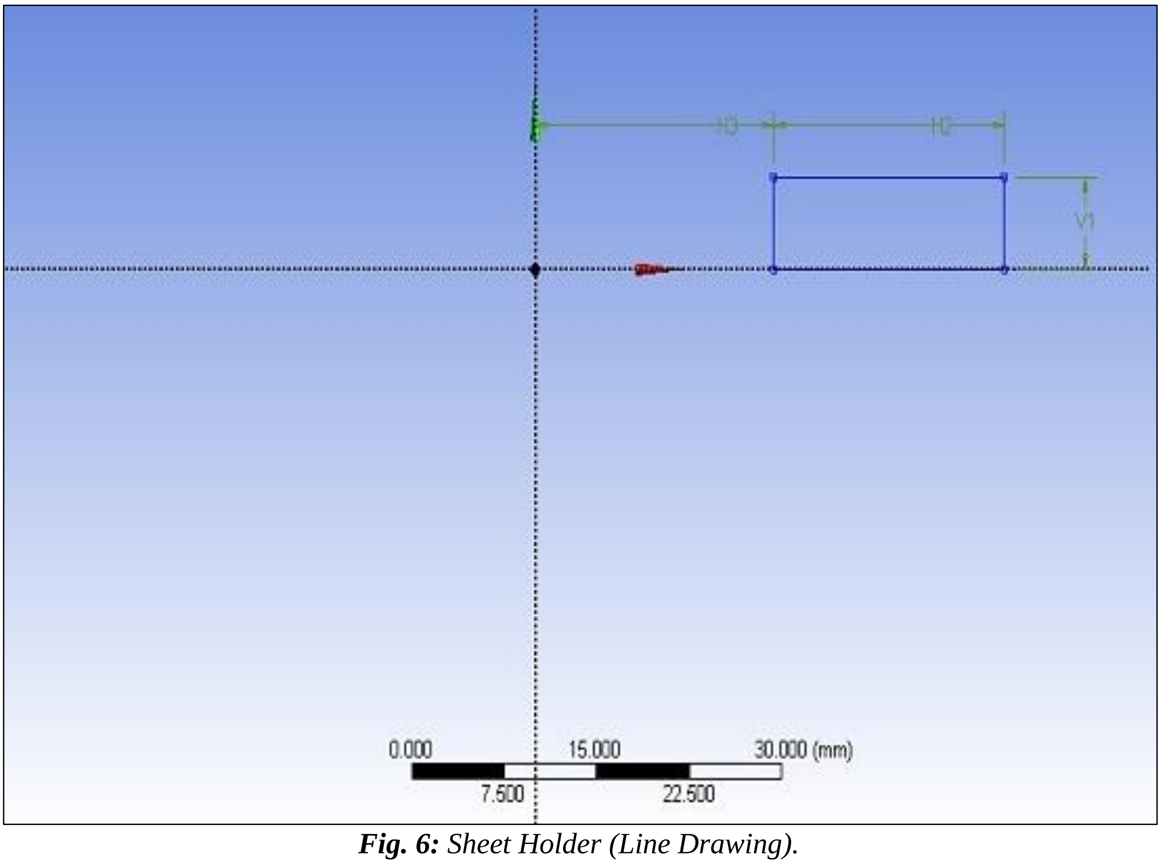

Fig. 6: *Sheet Holder (Line Drawing).*

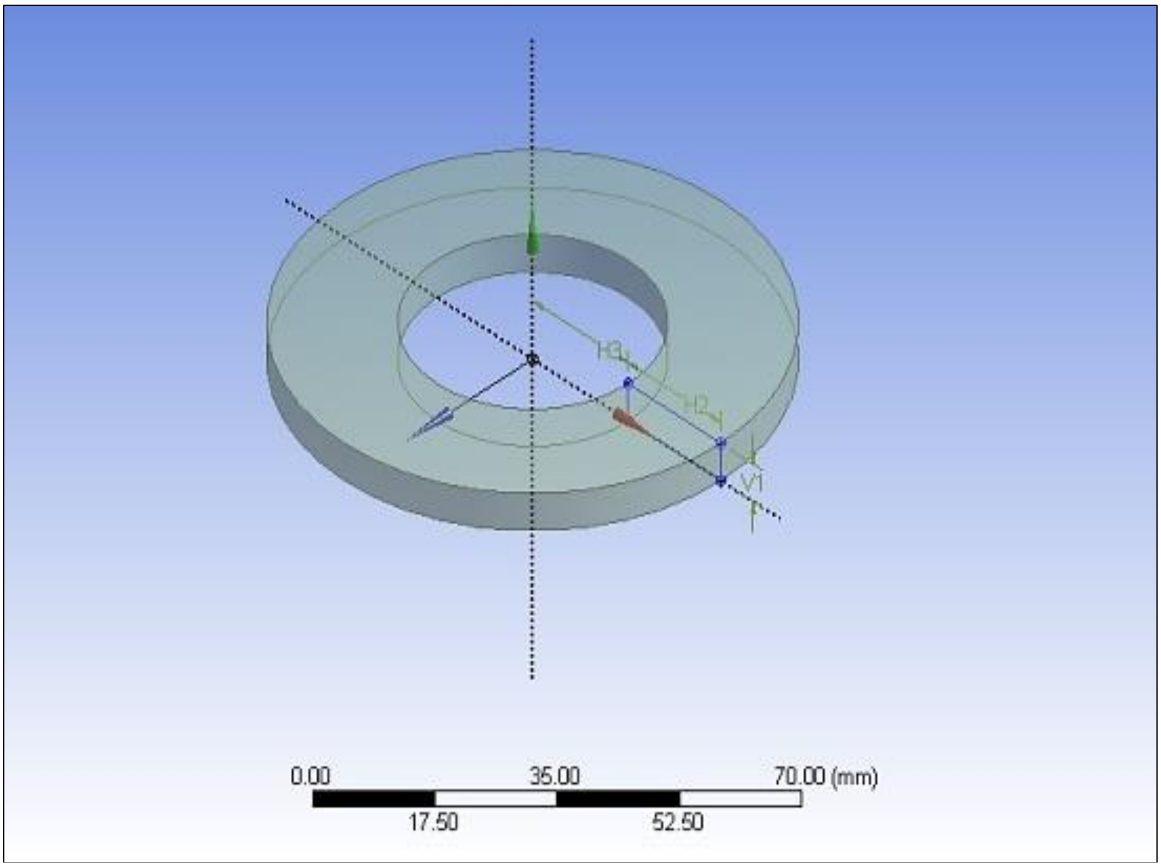

Fig. 7: *Revolved Sheet Holder (Isometric View).*

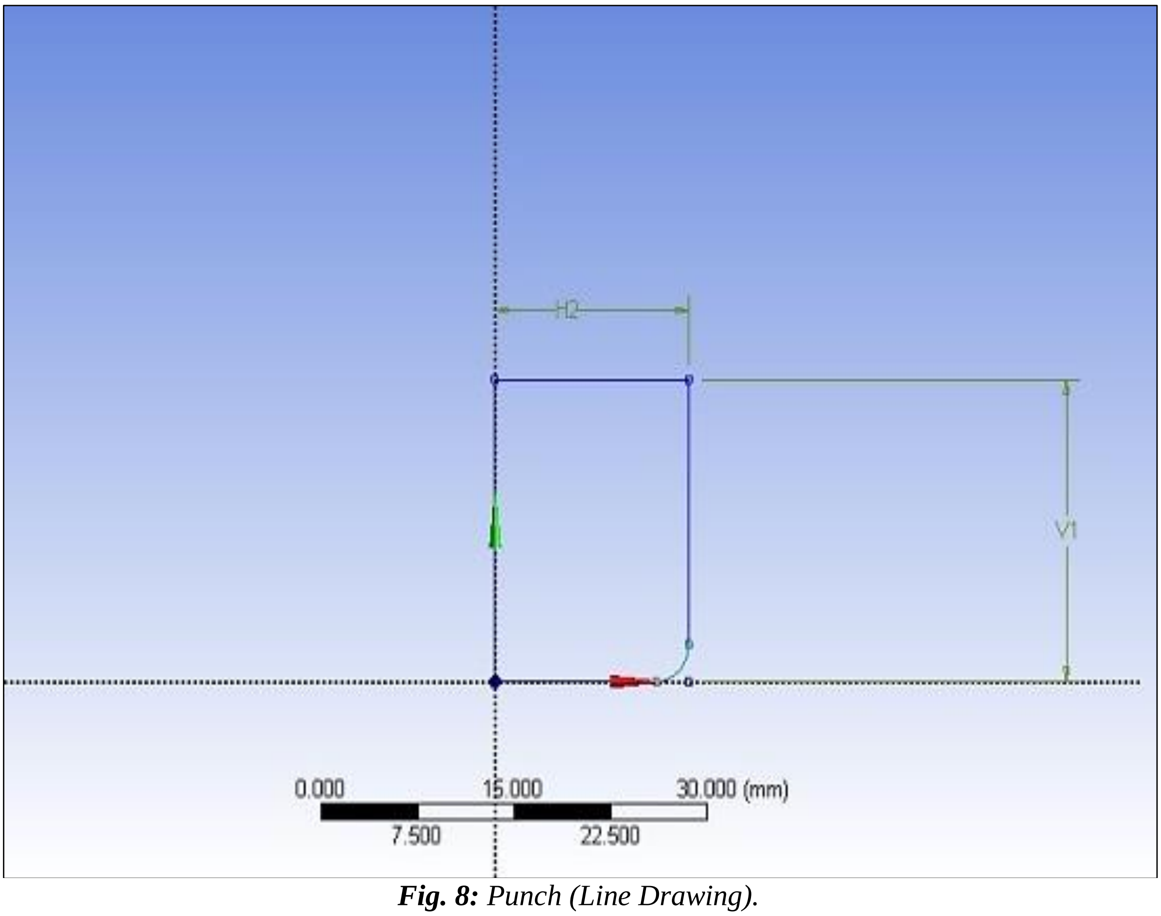

Fig. 8: *Punch (Line Drawing).*

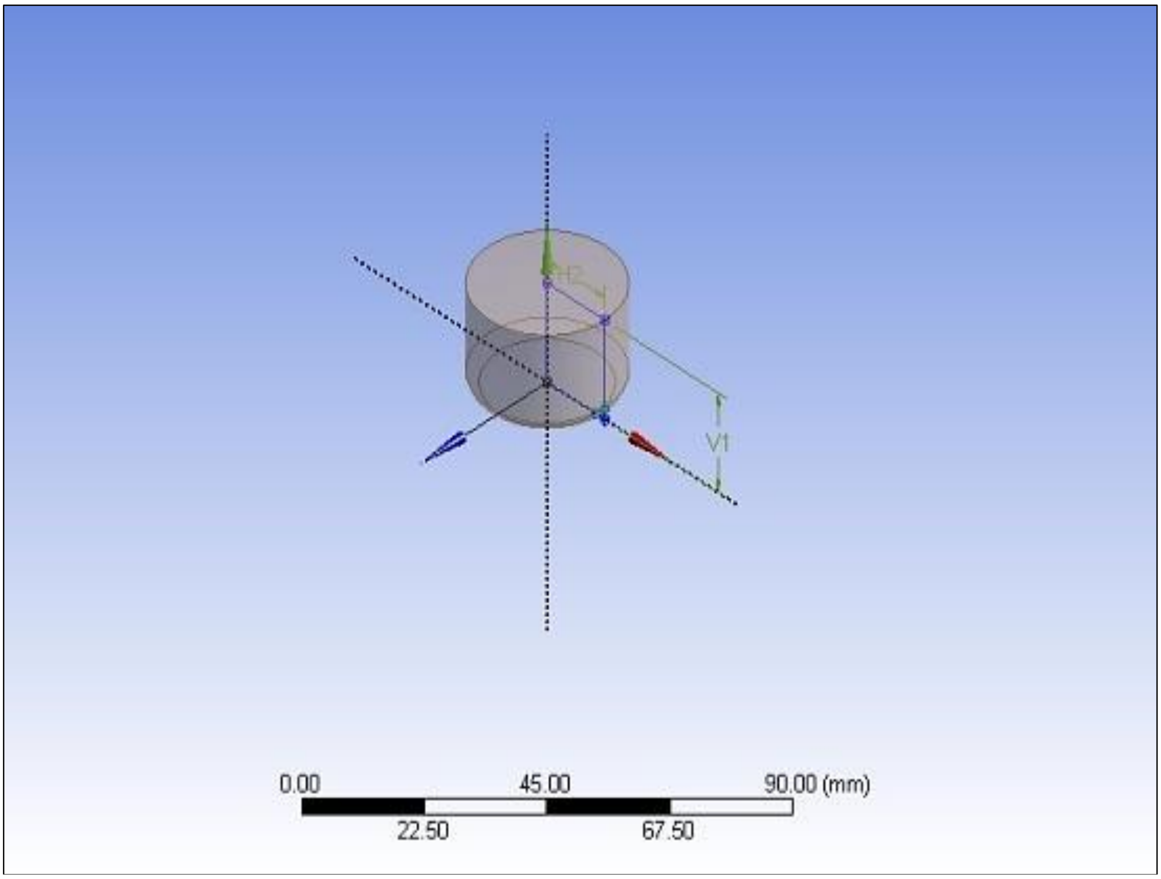

Fig. 9: *Punch (Isometric View).*

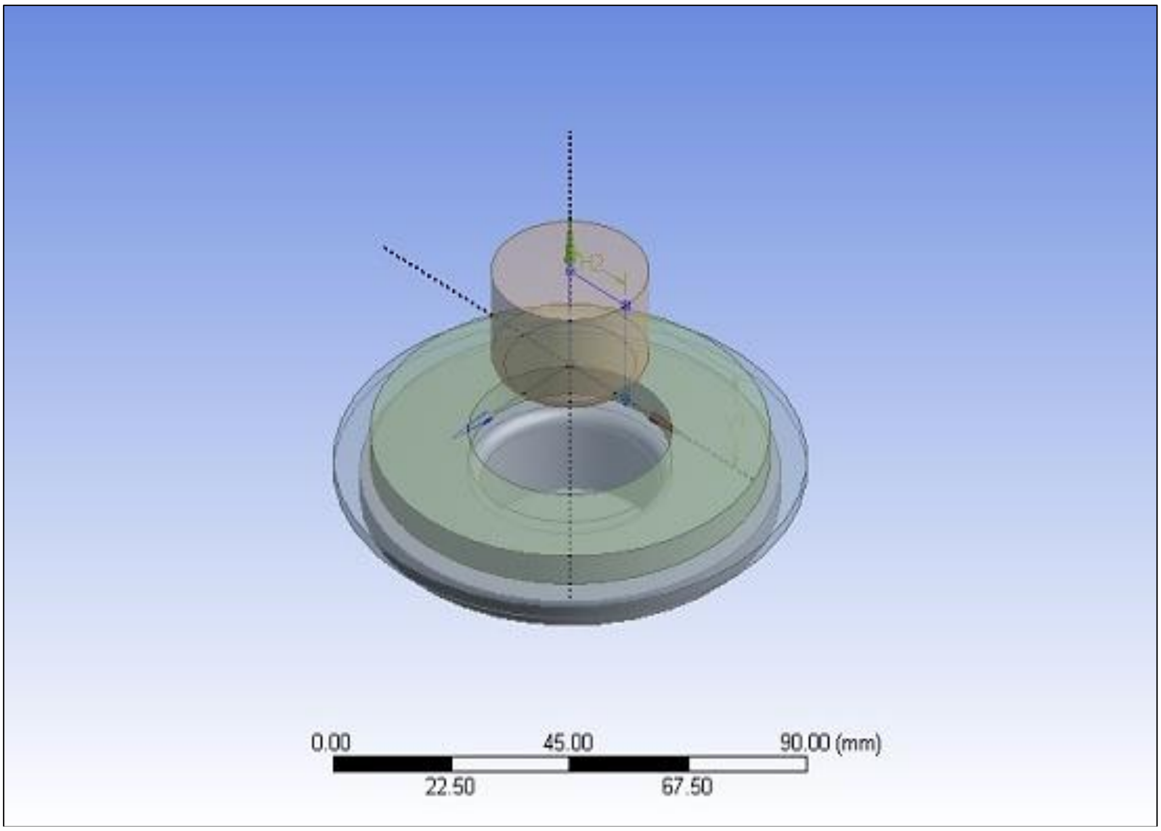

Fig. 10: *Die, Sheet, Sheet Holder and Punch (Isometric View).*

To draw the holder first we select the new plane then new sketch as explained above. We draw a rectangle at some distance from the vertical axis. This distance has been provided because as the punch will come down sheet holder should not come in the way of punch. Figure 6 shows the line drawing of the sheet holder drawn (19 mm length, 19 mm length and 6 mm height) and Figure 7 shows the isometric view of revolved sheet holder.

To draw the punch first a new plane has been created as explained above. Then the new sketch has been inserted. The new plane has been created at some height (20 mm) from the sheet holder. This has been obtained by creating a rectangle on the left side of the vertical plane and above the horizontal plane. Then the dimensioning has been done of the punch as shown in Figure 8. Revolved punch has been shown in Figure 9.

Figure 10 represents the modelling of a punching press assembly. One can notice the different parts involved in the punching operation. Part at the top is called the punch which applies the force and does the punching operation. Second part from the top is the blank holder which actually holds the sheet when the punching process occurs. Third part is the sheet on which the punching operation performs and which goes under deformation or change in the shape and size according to the arrangements made in the punching assembly. Bottom is the die which actually holds the output part which can be extracted from it after the punching operation.

CONCLUSION

- Punching operation has different application and its pre-analysis is necessary.
- FEA saves the material, time and cost and is a great way of analysis of the punching operation.
- Sheet needs to be analyzed in detail as maximum deformation and stress get generated in it.
- Material of the sheet and punch plays a vital role in the quality of the product produced.
- FEA is a good tool for analysis of punching.

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