# Finite Element Analysis of Punching Press Operation: Meshing Effect

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*Abstract*— Effect of the meshing methods on nodes and elements numbers during meshing of punching press operation has studied. FEA is a great way of studying the stresses, strains and deflection generated before going to real practices. Meshing serves significant role towards the correct solution from FEA. Effect of the meshing methods like patch independent, patch conforming and sweep have studied in the present paper. Modelling of the punching assembly which includes punch, sheet, blank holder and die has accompanied first then the meshing methods have applied to study the nodes and elements number. Three element sizes 10mm, 5mm and 1mm have been considered. Analysis of meshing methods dictates that the decrement in element size increases the nodes and elements number which provides fine meshing. Results also shows that sweep meshing method can be better with low element size. Patch independent method has found to give more number of nodes and element or fine meshing.

***Key words:*** Finite Element Analysis, Meshing Effect

## I. Introduction

Punch press can be defined as a machine used to make hole in metal sheet and creating the required work piece with the help of punching press tool. This machine may be smaller or larger or CNC type and produces one and more work piece in one time. The force tool is used in this machine called punch as shown in figure 1 this punch tool generally made by hardened steel or tungsten carbide, it attached to the reciprocating arm of machine and other most part of this machine are die which attached or clamped onto the bed and anvil.

When punch apply the force to work piece which is mounting in die, unwanted part of sheet metal starts shear out to make it in a blank as per the tool dimensions or required dimensions. Punching press machines known by its tonnage. Press machines currently utilizing in production industries have 30-ton capacity which may vary from 2000 to 2500 ton.

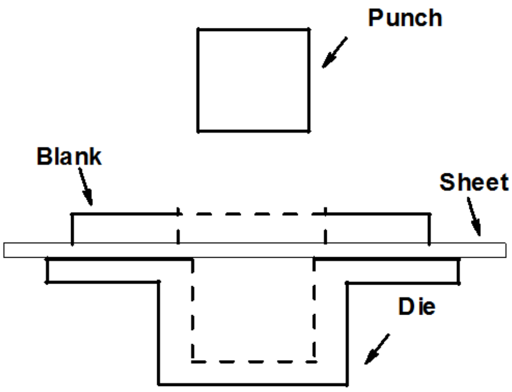


Fig. 1: Punching press operation layout

## II. The Characteristics of Punching Press

The punch press machine can be classified according to frame i.e.

### A. *'C' Type Frame:*

They also known as portal or bridge type frame, sizes of punch press machines are larger with either 'C' type frame or bridge type frame. In the 'C' type frame hydraulic ram mounted on the top of the frame.

'C' frame type press machine consists bed plate mounted on the bottom to hold the die, and to fixing the die bolts used in this machine so the plate contains 'T' slot in which 'T' bolts inserts to kept the die

### B. *According to The Mechanism of Delivering Power to The ARM:*

Delivering power may be of mechanical, electro-mechanical, hydraulic types. Delivering power to the arm for by mechanical mechanism is manual, electro-mechanical mechanism driven by the electrical energy and hydraulic mechanism driven by the hydraulic press force by the compressible fluids.

### C. *According to Size of Working Area:*

It depends on the machine size and the volume of production required. In which machine size varies to different machines like CNC, turret, and 'C' frame type etc.

### D. *Single Station and Multiple Station Used for Heavy Production, Mass Production:*

### E. *Force Rating Depends On the Sheet Metal Thickness or Work Piece Dimension. Force Rating Consist Cutting Force and Press Force:*

We can calculate cutting force by:

$$(Cutting\ force) F_C = l \times s \times \tau_{max}$$

Where 'l' is the length of perimeter 's' is the sheet thickness and τ max is the shear stress develops in metal sheet.

And the press force calculates by:

$$Press\ force = Cutting\ force + stripping\ force$$

Stripping force always 10% to 20% of cutting force

## III. Literature Review

Naik and Mandavgade1 (2012) incorporated design process successfully into a structural shape optimization problem. They targeted their study towards reduction of bending stresses caused by bending of frame. Reduction of cost and Improvement in safety was another aim of their work. Software ANSYS was used for this work and found 13% reduction in frame.

Chauhan and Bambhania2 (2013) designed & analysed frame of a 63 tonne power press machine using Finite Element method. Kaushik3 (2013) studied about the hydraulic and bending punching machine. In this he introduce a special purpose hydraulic model of Punching and Bending machine and we have showed theoretically how the hydraulic model of special purpose punching machine economically and exactly works. First of all he done a survey of literature review of the machine, and market survey for the working and constructional detailed. He calculated the formulas for the design of the different parts of hydraulic cylinder so that He can calculate the capacity of the hydraulic punching and bending machine and finally fabricate the machine to perform the operation on the aluminium sheet to produce the final product. This machine is use for multipurpose punching at a single time of stoke of ram/plunger. And with the combination die two operation are performed simultaneously. So we can say that the hydraulic system of special purpose punching and bending machine is quite economical as compare to the other alternative.

Khichadia and Chauhan4 (2014) reviewed mechanical press frame design and analysis. Parthiban et al5 (2014) fabricated 'C' type hydraulic press structure and cylinder. Rathod and Rajmane6 (2014) studied punching machine which has to be make holes of 30 holes/minute in a steel plate of 18mm thickness with space limitation in diameter of flywheel should not exceed 1000mm, hence it can be observed that the design of the flywheel is to be carried out (based) on the availability of space limitation and accordingly the fluctuation of energy, dimensions of the flywheel, stresses induced in the flywheel are determined.

Raut et al7 (2014) carried out the solution on designing of flywheel in different shape i.e. web type flywheel, straight elliptical arm and tapered arm flywheel by using 4,6,8 arm and design it into the pro e after using ANSYS software for F.E.M. method and then find out the maximum deflection value . In 4, 6, 8 elliptical or taper arm flywheels. And final solutions in this analysis is It is observed that existing flywheel i.e. web construction is having maximum weight. It is observed that, all taper arm resp. 4, 6, 8 arm are having mass less than elliptical arm flywheel. It is observed that, stresses are greatest in 4 arm flywheel still it is less than its maximum stress value with minimum overall weight.

Ravi8 (2014) analysed a power press of 10 tonne capacity under static condition. Shweta et al9 (2014) implementing the booster system to increase the pressure of press by a desired ratio. For this no extra power input is needed. The pressurized air from the main compressor is taken as input to booster. It saves a lot of power consumption. Further no major modification is required in the circuit. Only small space is required for booster, reservoir and valves. The press is a try-out press. Now the press can be used for pressure higher than company pressure. Design of Air Booster for 1200 Ton Mechanical Thus various pressures can now be applied for pressing the sheet metal. Thus we can decide for which pressure the sheet gets pressed to desired shape to obtain good.

Khandekar10 (2015) conducted design optimization and analysis of structure frame for heavy duty metal forming hydraulic press. More and Kulkarni11 (2015) analyse and optimize the 200 tone C type hydraulic press using ANSYS software. Ram et al12 (2015) studied mechanical press machine setup process enhancement in metal-mechanic area for an elevators company. The work results from a master thesis project conducted during a period of five months. The Single-Minute Exchange of Die (SMED) methodologies were applied to reduce the setup times observed at the beginning of the project. Mahajan and Tuljapure13 (2016) designed 2.5 tons hydraulic punching machine as per requirement of the company. Initially finite element analysis of only 'C' frame is done.

## IV. Modelling, Result and Discussion

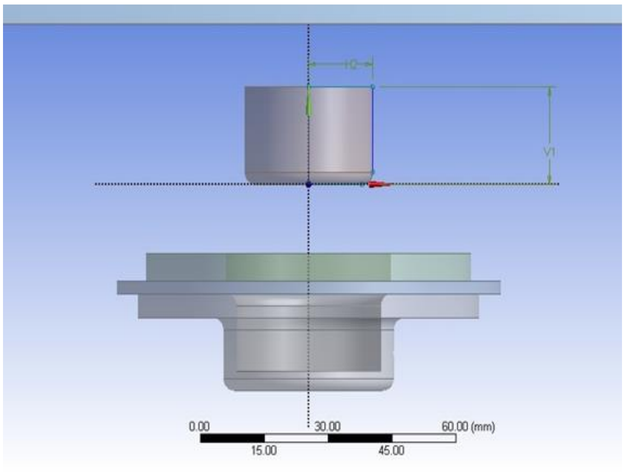


Fig. 2: Model of the punching operation (Front-view)

Figure 2 and 3 represents the modelling of a punching press assembly. One can notice the different parts involves 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.

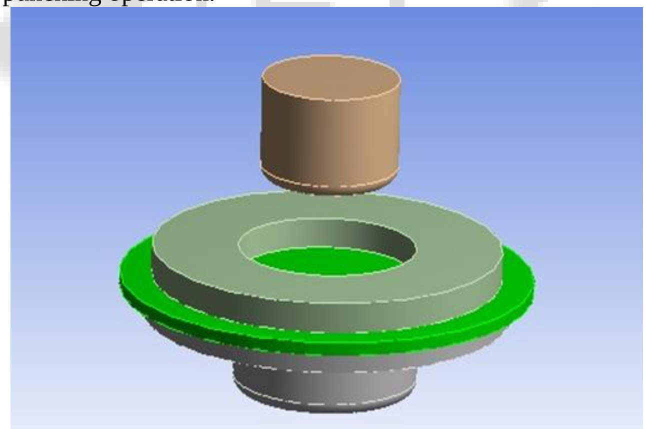

Fig. 3: Model of the punching operation (ISO-view)

In finite element analysis (FEA) meshing plays a vital role in the accurate solution. Three different element sizes 10mm, 5mm and 1mm have been considered. Three different meshing methods like patch conforming, patch independent and sweep have considered. Analysis of meshing methods dictates that the decrement in element size increases the number of nodes and elements which provides fine meshing. Results also shows that sweep meshing method can be better with low element size. Patch independent method has found to give more number of nodes and element or fine meshing.

Table 1 represents the conclusion of the different meshing methods adopted to study their effect on the number of nodes and number of elements.

 

| Method (Element size) | Number of nodes | Number of elements |
|---|---|---|
| Off (automatic) | 6500 | 9245 |
| Off 10mm | 901 | 1005 |
| Off 5mm | 2860 | 3211 |
| Off 1mm | 128448 | 206781 |
| Patch conforming 5mm | 2071 | 3875 |
| Patch independent 5mm | 2429 | 5604 |
| Patch conforming 1mm | 105224 | 242028 |
| Patch independent 1mm | 138570 | 427962 |
| (Sweep/Automatic) 5mm | 2860 | 3211 |
| (Sweep/Automatic) 1mm | 132525 | 210171 |

Table 1: Number of Nodes And Elements For Different Meshing Methods Considered

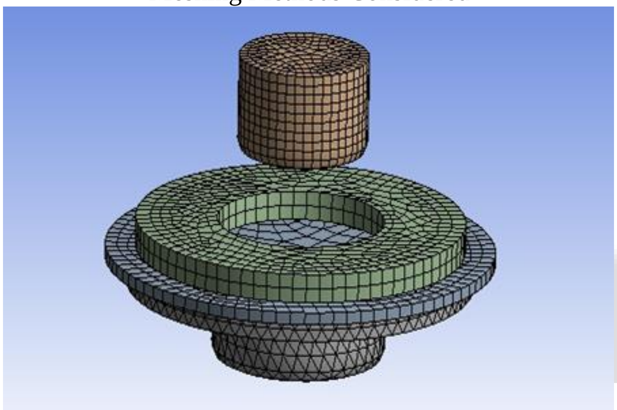

Fig. 4: Automatic meshing

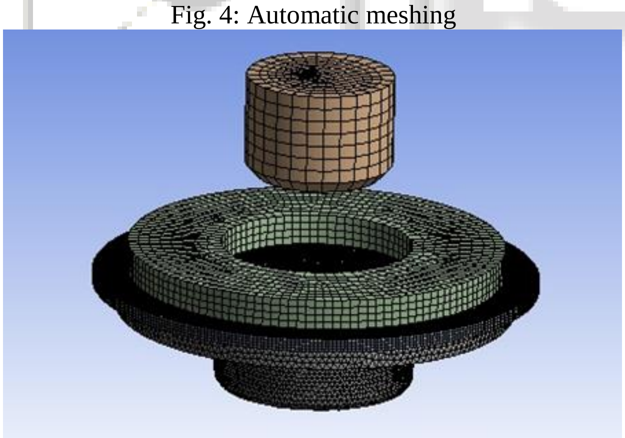

Fig. 5: Proximity and curvature meshing

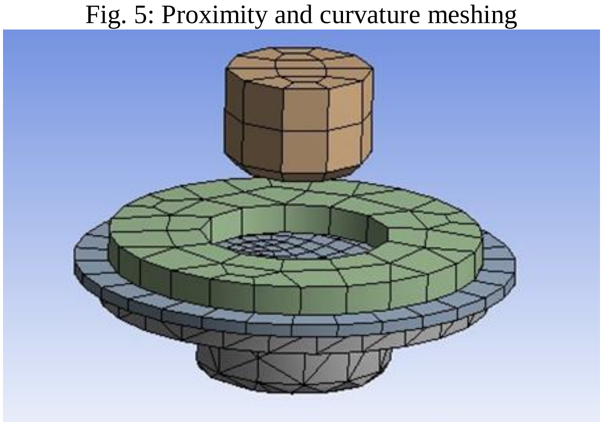

Fig. 6: Automatic 10mm

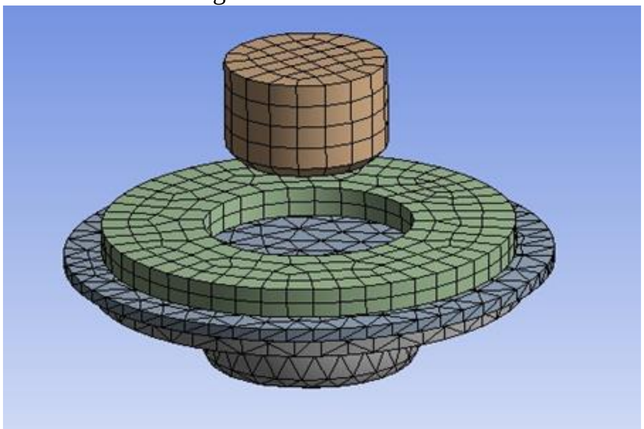

Fig. 7: Patch conforming (5mm)

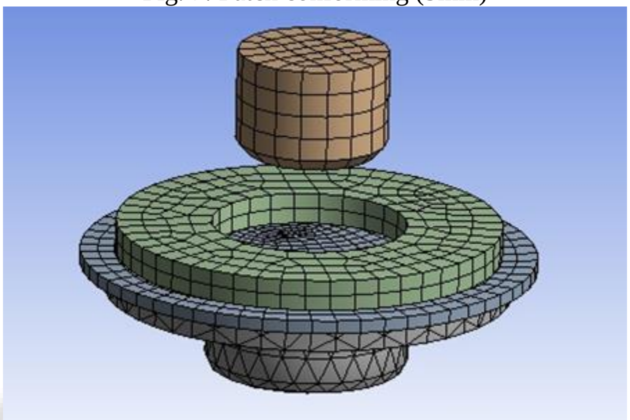

Fig. 8: Automatic 10mm

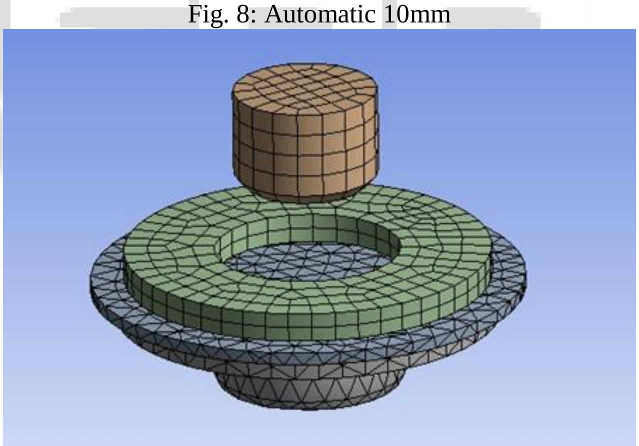

Fig. 9: Patch independent (5mm)

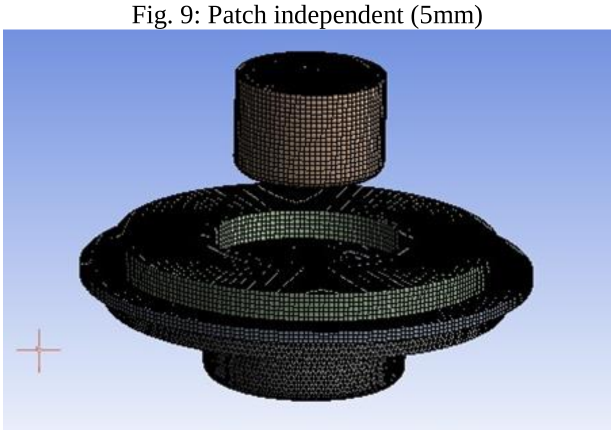

Fig. 10: Automatic 1mm

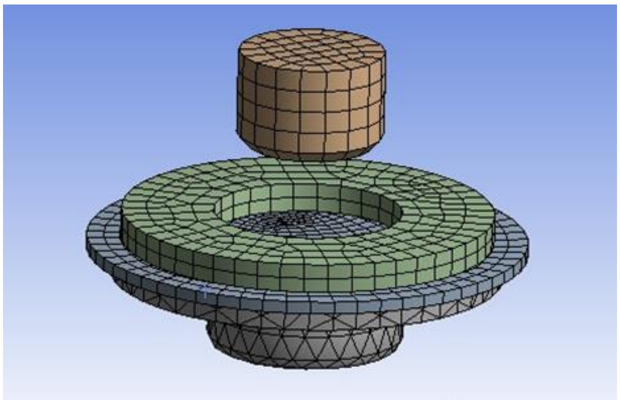

Fig. 11: Sweep (5mm)

## V. CONCLUSION

- FEA (Finite Element Analysis) method can be helpful in studying the punching operation.
- Element size and sizing meshing methods have used for appropriate meshing of the punching assembly.
- Fine meshing increases the time of the solution.
- Patch independent and patch confirming meshing methods are good.
- Results shows that Patch independent is best as per the number of nodes and elements.

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