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Explicit Analysis of Punch and Its Operation on Sheet

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ABSTRACT

Explicit analysis of the punching of a sheet is conducted in the present work. Punching involves parts like, punch which apply 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 situation. From the literature conducted it has been found that very few amounts of research have been conducted on the punching press operation of a sheet. Velocity and fixed support as types of boundary conditions have been considered, velocity has been given to the punch while die and holder have been kept fixed. Different values of velocity have been studied to study its effect on the deformation, strain and stress generated on the sheet. Two types of material have been studied, steel and aluminium. From the results it has been found that for amount of stress generated in the sheet made of aluminium is less compared to the steel. With increment in the punch speed gap between the stress generated in the aluminium sheet and steel sheet is increases which represent larger chances of failure. For low values of punch speed amount of deformation generated in the steel sheet is more compared to the aluminium sheet, but with increment in speed a reverse nature has been observed which represent less chances of failure of aluminium sheet compared to steel sheet. It can be concluded that for low punching speed operation steel is good while for high punching operation aluminium is good.

Keywords: die, holder, punching press, sheet

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INTRODUCTION

Punching press is the procedure of cutting metal plates into shapes required. It involves various stages like shearing stage, penetration stage and fracture stage. The sheet metal operation in punching press is divided into two parts, cutting operations and forming operations. Figure 1 shows the components of a punching operation. It includes parts like, punch which apply 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 [1].

Naik and Mandavgade in year 2012 studied the effect of FEA implementation in hydraulic cotton lint bailing machine for optimization of top and bottom frame. Chauhan and Bambhania in year 2013 designed and analysed frame of a 63 tonne power press machine using finite element method of an industry. Kaushik in year 2013 studied the hydraulic press design and fabrication for a punching operation. They concluded that hydraulic press operation is most efficient and economical for aviation related problem. Khichadia and Chauhan in year 2014 reviewed mechanical press frame design and analysis. They modelled the geometry in CAD software and conducted the analysis using a FEA tool [2-5]. Parthiban et al in year 2014 conducted design and analysis of ‘C’ type hydraulic press structure and cylinder. Rathod and Rajmane in year

2014 studied punching machine operation and Raut et al in year 2014 carried out the solution on designing of flywheel in different shape. Ravi in year 2014 conducted computer aided design and analysis of a power press 10 tonne capacity under static condition. Shweta et al in year 2014 conducted the design of 120 ton mechanical press for air booster operation. Khandekar in year 2015 conducted design optimization and analysis of structure frame for heavy duty metal forming hydraulic press [6-10]. More and Kulkarni in year 2015 analyse and optimize the 200 tone C type hydraulic press using ANSYS software. Ram et al in year 2015 studied mechanical press machine setup process enhancement in metal-mechanic area for an elevators company.

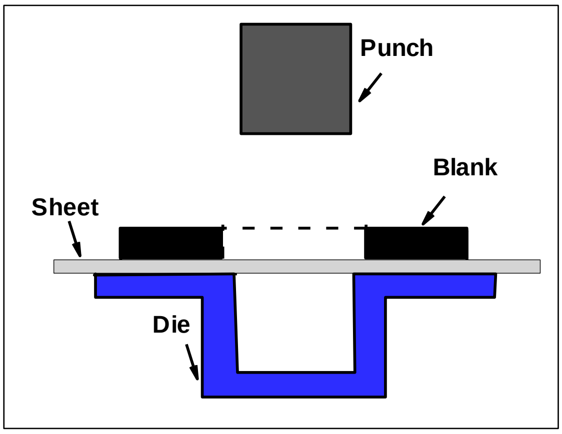


Fig. 1. Punching press operation layout.

Modelling

Punching includes parts like, punch, sheet, die and holder. First die has been created, then sheet, then blank holder and in last punch has been created. Figure 2 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 [11-12]. Bottom is the die which actually holds the output part which can be extracted from it after the punching operation.

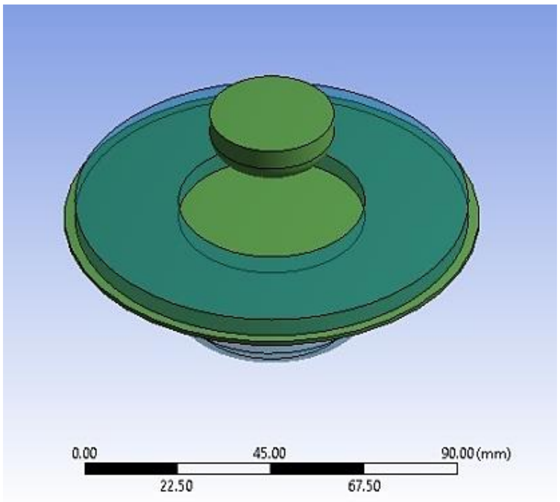


***Fig. 2.** Punch assembly (punch, holder, sheet and die).*

***Table 1.** Material properties.*

Property	Steel	Aluminium
Density (kg/m^3)	7850	2770
Young's modulus (Pa)	2.2e11	7.1e10
Poisson's ratio	0.3	0.33
Shear modulus (Pa)	7.69e10	2.67e10

Boundary Conditions

Two types of boundary conditions considered in the present work are velocity and fixed support. Velocity has been given to the punch while die and sheet holder have been kept fixed. Table 2 shows the values of punch speed considered (Figure 3).

***Table 2.** Punch speed.*

S. n.	Punch speed (mm/s)
1	7000
2	8000
3	9000
4	10000
5	11000
6	12000
7	13000

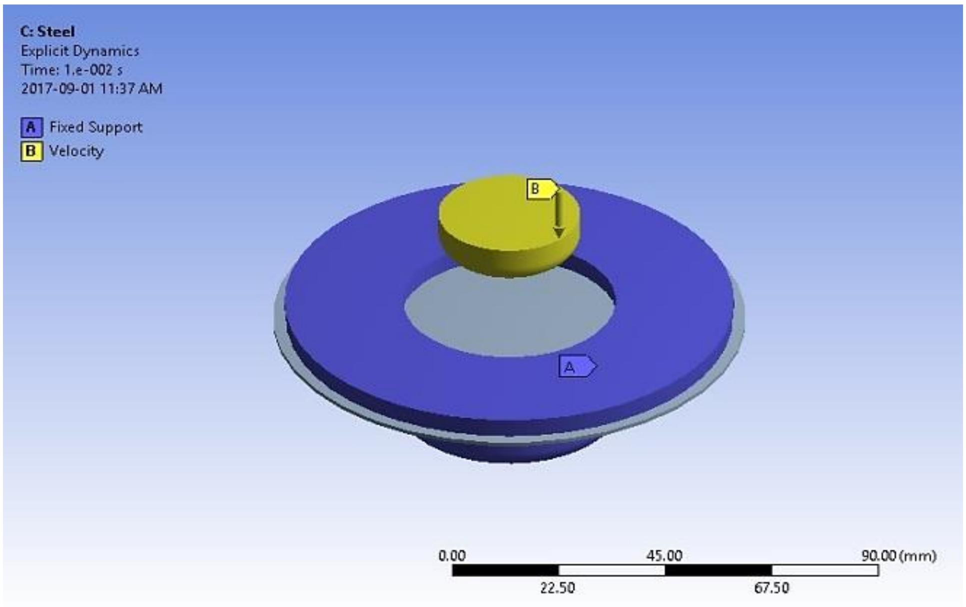
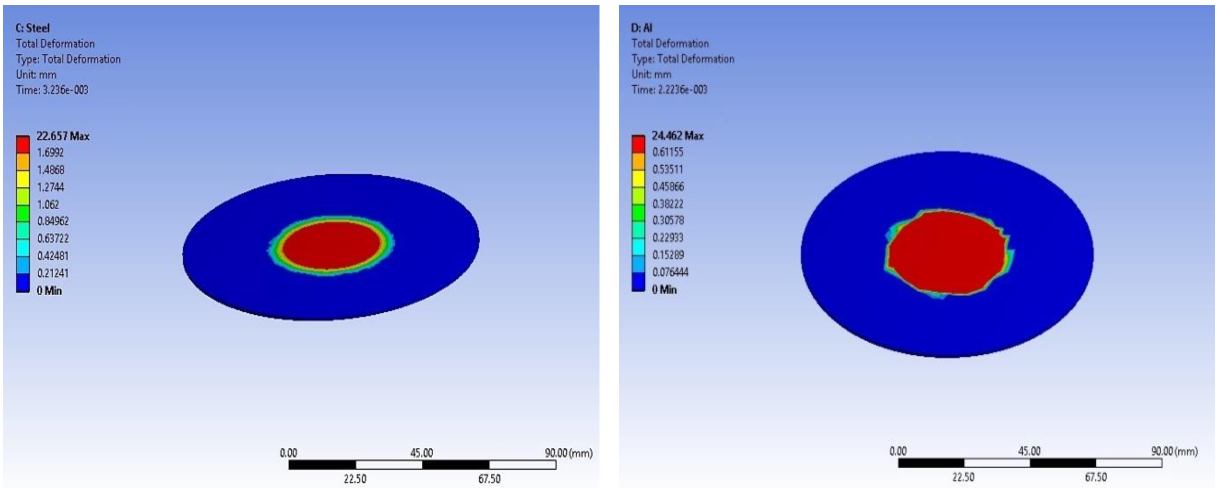


Fig. 3. *Applied boundary conditions*.

RESULT AND DISCUSSION

Analysis of the total deformation, equivalent stress and equivalent strain has been conducted here. Different values of punch speed considered in the study have been shown in the Table 2. Results have been represented in the un-deformed sheet and deformed sheet. Colour scale on the left-hand side represents the amount of total deformation, equivalent stress and equivalent strain generated. Red colour represents the maximum generated value while blue colour represents the least generated values. Figure 3 represents the total deformation generated in the sheet. Variation of the punch speed with total deformation generated in the sheet has been plotted in the Figure 4. From the figure it can be observed that with increment in the punch speed total deformation generated is increasing. It can also be observed from the Figure 4 that for low value of punch speed total deformation generated in steel sheet is less compared to the aluminium sheet, but with increment in speed a reverse nature has been observed which represent less chances of failure of aluminium sheet compared to steel sheet.



(a) *(b)*

Fig. 3. *Total deformation of steel and aluminium. (a) Steel, (b) aluminium.*

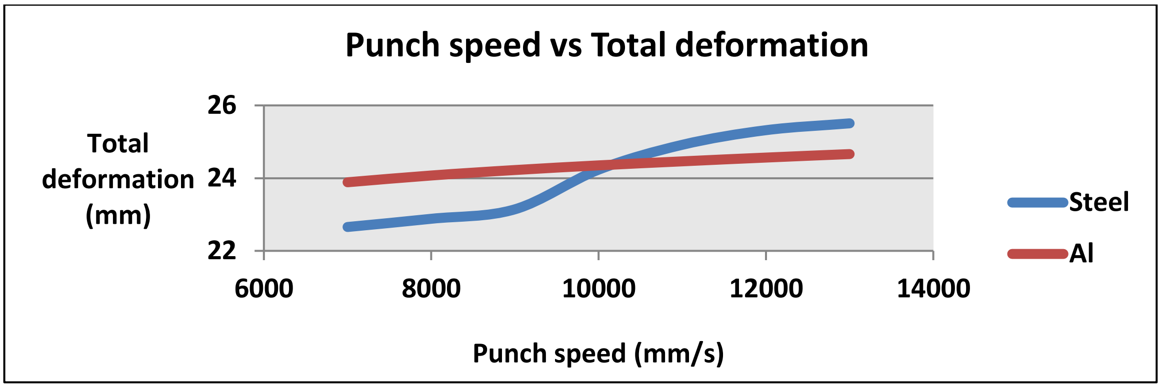


Fig. 4. *Variation of punch speed with total deformation.*

Figure 5 represents the equivalent stress generated in the sheet. Variation of the punch speed with equivalent stress generated in the sheet has been plotted in the Figure 6. From the figure it can be observed that with increment in the punch speed equivalent stress generated is increasing. It can also be observed from the Figure 6 that equivalent stress deformation generated in steel sheet is high compared to the aluminium sheet, but with increment in speed this deviation of stress generation between the steel sheet and aluminium sheet increases. Figures 7 and 8 show the strain generation in the sheet. Trend of strain is same as that has been observed for deformation.

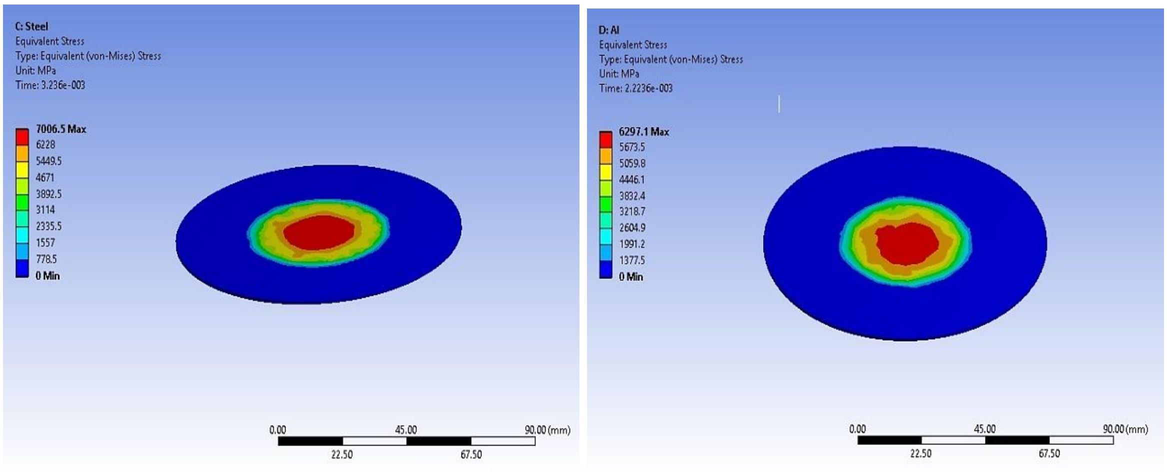


Fig. 5. *Equivalent stress of steel and aluminium.*

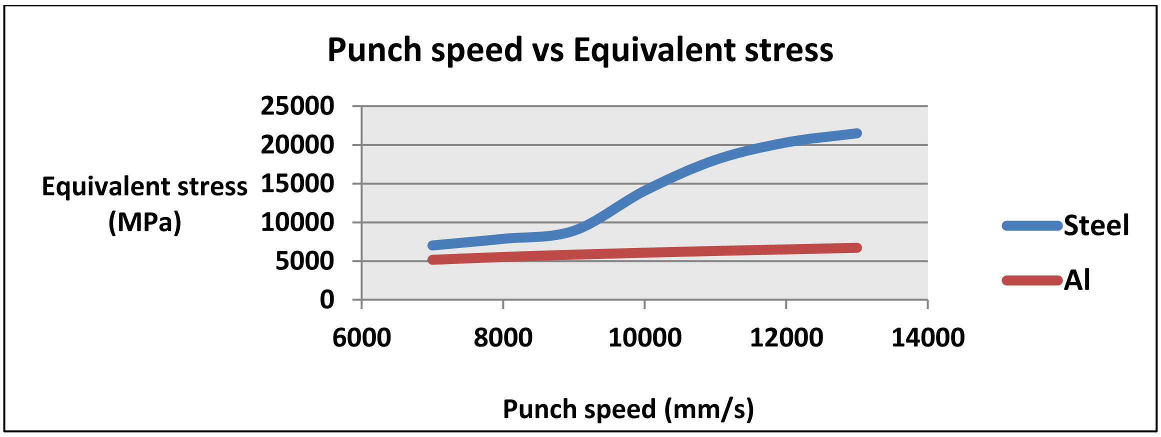


Fig. 6. *Variation of punch speed with equivalent stress.*

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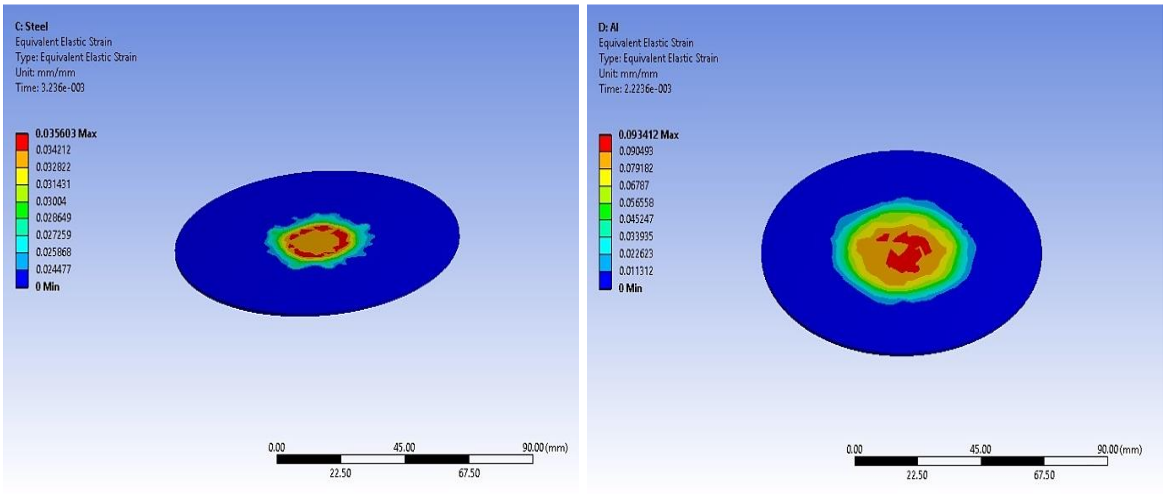

Fig. 7. *Equivalent strain of steel and aluminium.*

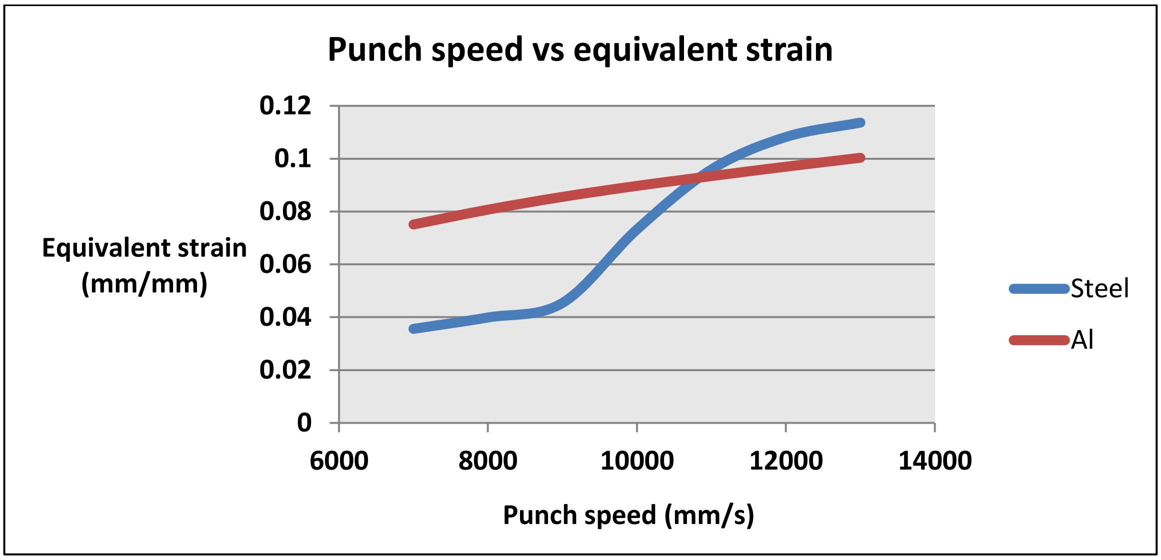

Fig. 8. *Variation of punch speed with equivalent strain.*

Figure 9 shows the deformed shape of the steel sheet and aluminium sheet, respectively. Stresses generated in the sheets have been represented in these figures.

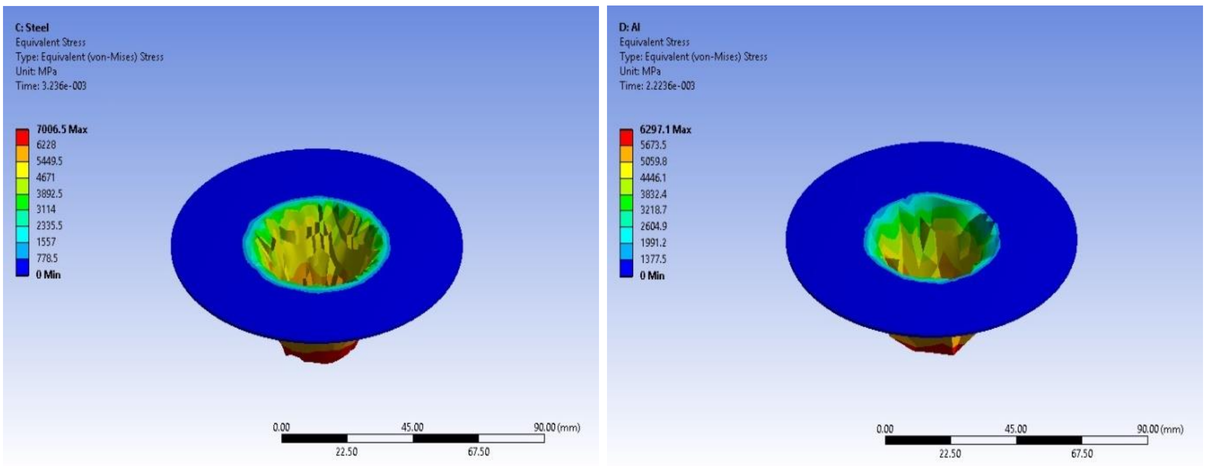

Fig. 9. *Deformed shape of steel and aluminium.*

CONCLUSION

- Explicit analysis gives insights of the punching operation before going to actual production process.
- Total deformation, equivalent stress and equivalent strain generated in the sheets increases with increment in the punch speed.
- For low values of punch speed steel sheets performs well compared to the aluminium sheets.
- For high spends punching operation aluminium is a good material compared to steel.
- FEA saves the material, time and cost and is great way of analysis the punching operation.

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