

# Experimental, Design and Development of different punch and die for head light reflectors

Amrut Chandanshive<sup>1</sup>, Shitole J.S.<sup>2</sup>

<sup>1</sup> ME Student, Mechanical Engineering, DGOIFOE, Maharashtra, India

<sup>2</sup> Assistant Professor, Mechanical Engineering, DGOIFOE, Maharashtra, India

## ABSTRACT

*In the sheet metal industry die is the most significant instrument required for production. It is difficult to keep up exactness with precision in sheet metal industry on the off chance that we don't have precisely planned press device. These press apparatuses are utilized to fabricate the items from the crude material for example sheet metal. The plan of die cast the dust is to a great extent relying upon material of sheet metal, thickness of sheet metal and unpredictability of structure and tasks. Present work is completed to structure the pass on which can play out the punching activity, to produce the different shape at bottom with (circular, square and hexagonal) shape of front light reflectors. So here we are designing the punch and compound die of mild steel sheet having one mm thickness of aluminium alloy sheet metal. The CAD Model of punch and die with punch base as circular, square and hexagonal shape is designed using CATIA V5 R20 software and then its nonlinear analysis will be performed using the ANSYS Software. Further the testing will be done using the UTM and theoretical results are compared with the practical results.*

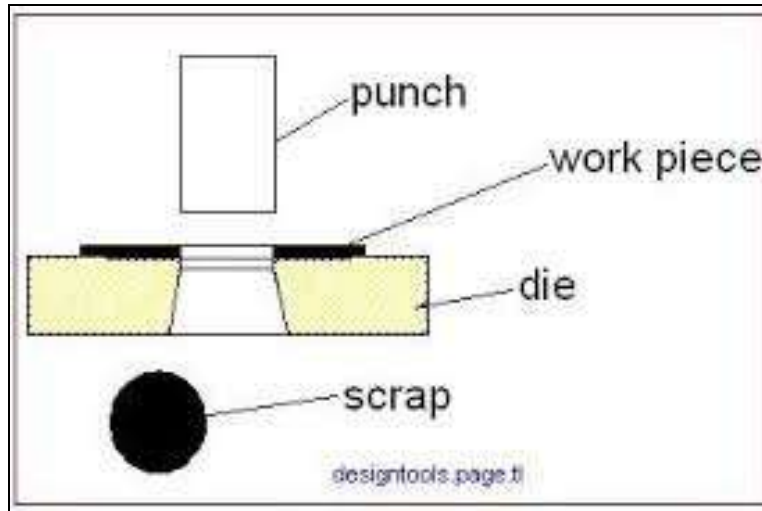
**Keyword:** - CAD Model, UTM, Structural Optimization

## 1. INTRODUCTION:

Punching is a forming process that uses a punch press to force a tool, called a punch, through the workpiece to create a hole via shearing. Punching is applicable to a wide variety of materials that come in sheet form, including sheet metal, paper, vulcanized fibre and some forms of plastic sheet. The punch often passes through the work into a die. A scrap slug from the hole is deposited into the die in the process. Depending on the material being punched this slug may be recycled and reused or discarded. Punching is often the cheapest method for creating holes in sheet materials in medium to high production volumes. When a specially shaped punch is used to create multiple usable parts from a sheet of material the process is known as blanking. In metal forging applications the work is often punched while hot, and this is called hot punching. Slugging is the operation of punching in which punch is stopped as soon as the metal fracture is complete and metal is not removed but held in hole.

In mathematics and science, a nonlinear system is a system in which the change of the output is not proportional to the change of the input. Nonlinear problems are of interest to engineers, biologists, physicists, mathematicians, and many other scientists because most systems are inherently nonlinear in nature. Nonlinear dynamical systems, describing changes in variables over time, may appear chaotic, unpredictable, or counterintuitive, contrasting with much simpler linear systems. Typically, the behavior of a nonlinear system is described in mathematics by

a nonlinear system of equations, which is a set of simultaneous equations in which the unknowns (or the unknown functions in the case of differential equations) appear as variables of a polynomial of degree higher than one or in the argument of a function which is not a polynomial of degree one. In other words, in a nonlinear system of equations, the equation(s) to be solved cannot be written as a linear combination of the unknown variables or functions that appear in them. Systems can be defined as nonlinear, regardless of whether known linear functions appear in the equations. In particular, a differential equation is linear if it is linear in terms of the unknown function and its derivatives, even if nonlinear in terms of the other variables appearing in it.



**Fig 1** Punching operation

### 1.1 Problem Definition:

For quality manufacturing accurate design of die is prerequisite. But the accurate design of the die demands investment of high cost and time. No sheet metal industry can work without die, so it also involves high material requirement which ultimately add up into the overall cost of the set up. Conventionally design of the die is done based on force analysis and then its validation is done after manufacturing. We need to eliminate this excessive time and cost requirement. Hence, we need a cost-effective design for punching of headlight reflectors along with the help of both analytical and experimental approach.

### 1.2 Objectives:

- To prepare CAD design of existing die to using CATIA V5.
- Analyzing the equivalent stress generated and deformation occurred over the die surface with the help of ANSYS Software.
- To understand the effect of punching process over the die structure.
- Experimental testing will be perform using UTM and strain gauge.
- Finally compare the results between theoretical values obtained from ANSYS software and practical values obtained from the experimental testing.

## 2. LITERATURE REVIEW

“Experimental and numerical analysis of failures on a die insert for high pressure die casting” by R. Markežiča, I. Nagličb, N. Molea, R. Šturma Author does comprehensive study of failures on a used insert of a die for high pressure die casting of mild steel alloy AISi9Cu3Fe. The analysed insert was made of hot work tool steel Dievar, heat treated and plasma nitrided according to specifications. Before the start of analysis, the insert was subjected to 170,000 die casting cycles. X-ray diffraction, light microscopy, scanning electron microscopy and hardness measurement methods were used for experimental analysis of soldering, corrosion, erosion and thermal fatigue failure modes on the insert. A special procedure, which combines use of commercial software MAGMA5.3 and open source software CalculiX, was developed for numerical calculations of temperature fields on the insert. Experimental and numerical results showed strong dependence between die surface temperatures and die failure modes. Hardness drop, nitride diffusion layer removal and microstructural changes were observed at more thermally affected areas. Surface crack with a thin oxide and thicker soldered layer was identified and analysed.

From this study author conclude the result that, an increase in the occurrence of wear and damage mechanisms with increasing temperature in the surface layer was detected. Results show also an increase in surface hardness drop rate with increasing temperature in the surface layer. Adequate die surface hardness is one of the main die characteristics that help to prevent initiation and propagation of die wear and damage mechanisms. By knowing the change of die surface hardness during the die casting process, the accuracy of die life predictions would be improved and new methods for die lifespan prolongation could appear. Researchers focused on determining the effect of thermal loading conditions during the die casting process on die surface hardness and prediction of change in surface hardness with increasing number of casting cycles.

“Failure analysis of shot–sleeves used in brass high pressure die–casting process” by

DorraAbida, Ahmed Ktaria, DhouhaMelloulia, NedjaGafsia, Nader Haddara In this study failure investigation of shot sleeves are conducted on a two cases used in brass die casting and made up of AISI H10 tool steels to study their failure mechanisms. The chemical composition of the shot–sleeves material and the hardness profiles were evaluated. A preliminary examination of shot–sleeves reveals the presence of cracks network on their inner surfaces which proves that thermal fatigue was probably the main cause of their failure. A Meticulous investigation of these damaged surfaces reveal the presence of an additional small zone cited in the vicinity of the plunger entry side. This zone presents several scratches sign of abrasive wear. Then, the measurement of the cracks length and their linear density along longitudinal and transversal cuts of the damaged shot–sleeve sample are carried out. From this study author find out the results that the observed cracks network can be divided into two zones. The first one was the most damaged in terms of cracks density and length given that it is the first zone which enters in contact with the molten metal and the cracks network examined in the second zone appears to be superficial.

The failed shot sleeve was at first investigated by the determination of chemical composition, microstructures and hardness. The cracks surface network, observed at the inner surfaces of all the examined shot–sleeves, were shown the presence of three different zones: (i) entered piston, (ii) entrance of the molten metal and (iii) exit of the molten metal. These zones differ by their feature, cracks network density and depths. The longitudinal section shows that the second zone possesses the maximum values of cracks depth. The cross section shows that the maximal cracks lengths are situated in the vicinity of the shot–sleeve centre ( $\theta \approx 0^\circ$ ). According to the foregoing discussion it is clear that thermal fatigue is the first cause of shot–sleeve damage. However other phenomena like oxidation and erosion of the shot-sleeve inner surface because the increases of the damage rate mainly in the casting zone.

“An IoT based framework for energy monitoring and analysis of die casting workshop” by Erhengchen, Huajun Cao, Qinyi Heb, Jiahao Yan, Salman Jafar, This study is depending on IoT for analysis and monitoring of die casting. In order to reduce the impact on resource shortage and environmental pollution caused by the massive use of energy, meeting the requirements of the fierce market competition, manufacturing enterprises must strengthen the awareness of the energy utilization in the workshop. As a widely distributed manufacturing system, die casting workshop consumes lots of energy with low efficiency. Due to the dynamic and complicated of energy usage, an effective energy monitoring and analysis method is still lacked in die casting workshop. This study divides the die casting workshop into die casting machine level, die casting task level, and die casting workshop level and it proposes an energy monitoring and analysis system including data acquisition layer, data transmission layer, data storage layer, data processing layer, and data display layer based on Internet of Things (IoT) technology. A set of indicators, such as energy per process in die casting workshop, energy per part in die casting task, and energy per part in die casting machine, and so on, were calculated to interpret the energy data and evaluate the performance of a die casting workshop through data mining. With the application of the proposed system in a die casting workshop,

enterprise managers can easily find potential opportunities for energy consumption reduction, and energy efficiency improvement, and propose ways to reduce energy consumption cost.

### 3. DESIGN CALCULATION

Calculations for force analysis-

- Name of the component- Headlight reflector.
- Material- M.S.
- Thickness of material- 1mm(20Gauge)
- Shear strength- 400Mpa- 400N/mm<sup>2</sup>
- Yield Strength- 1532 N/mm<sup>2</sup>
- Mass density- 7700 Kg/m<sup>3</sup>
- Inner diameter to punch=Inner diameter for drawing process= 40 mm
- Outer diameter for drawing process= 150 mm

1)Shear force for piercing-

$$\text{Shear Force} = \text{Perimeter} * \text{Thickness of sheet metal} * \text{Shear Stress}$$

$$= 3.14 * 40 * 1 * 400$$

$$= 50.265 * 10^3 \text{ N}$$

2)Force required for drawing operation-

$$\text{Drawing Force} = \text{Perimeter} * \text{Thickness of sheet metal} * \text{Yield strength} * [(D/d) - C]$$

$$= 3.14 * 40 * 1 * 1532 * [(150/40) - 0.064]$$

$$= 709.616 * 10^3 \text{ N}$$

3)Stripping Force-

$$\text{Stripping force} = \text{Shear force} + \text{Drawing force}$$

$$= 50.265 * 10^3 + 709.616 * 10^3$$

$$= 759.88 * 10^3 \text{ N}$$

Stripping force is considered as the 10% of above calculated force,

$$\text{Stripping force} = 0.1 * 759.88 * 10^3$$

$$= 75988 \text{ N}$$

4)Total force required to form the headlight reflector from plane sheet is given as,

$$F = \text{Shear Force} + \text{Stripping force} + \text{Stripping force}$$

$$= 50.265 * 10^3 + 709.616 * 10^3 + 75988$$

$$F = 835.86 * 10^3 \text{ N}$$

$$1 \text{ Ton} = 9806.65 \text{ N}$$

Hence the 85.23 Ton press is required to punch and draw the plane sheet of M.S. to make the headlight reflector.

### Calculation for clearance between punch and die-

Now the diameter of punch for cutting =40 mm

Now we need to give some clearance between the punch and die, so that material gets cut out effectively,

Clearance (C)=0.0032\*t\*(Shear strength) ^ (1/2)

$$(C)=0.0032*1*(400) ^ (1/2)$$

$$(C)=0.064 \text{ mm}$$

Hence diameter of die  $d_{\text{die}}=d+2*C$

$$=(40)+(2*0.064)$$

$$d_{\text{die}}=40.128 \text{ mm}$$

Dimensions of punch diameter used to cut out the material=40 mm

Dimensions of punch diameter used to cut out the material=40.128 mm

## 4.FINITE ELEMENT ANALYSIS

Step 1: Details of material namely copper, steel, grey cast iron, composite material, fluid domain material is defined in engineering data. i.e. ANSYS default material is structural steel.

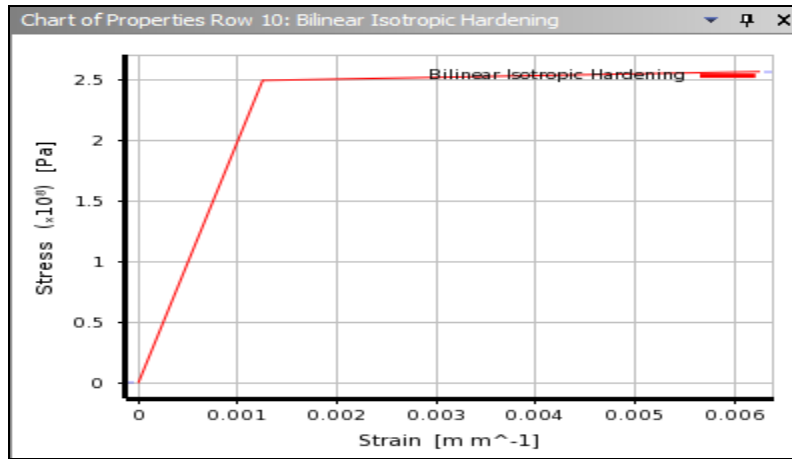
Step 2: Import of geometry created in any CAD software namely CATIA, PRO E, SOLIDWORK, INVENTOR etc. in geometry section. If any correction is to be made it can be created in geometry section in Design modeller or space claim.

Step 3: In model section after import of component

- Material is assigned to component as per existing material
- Connection is checked in contact region i.e. bonded, frictionless, frictional, no separation etc. for multi body components.
- Meshing or discretization is performed i.e. to break components in small pieces (elements) as per size i.e. preferably tetra mesh and hexahedral mesh for 3D geometry and for 2 D quad or tria are generally preferred.

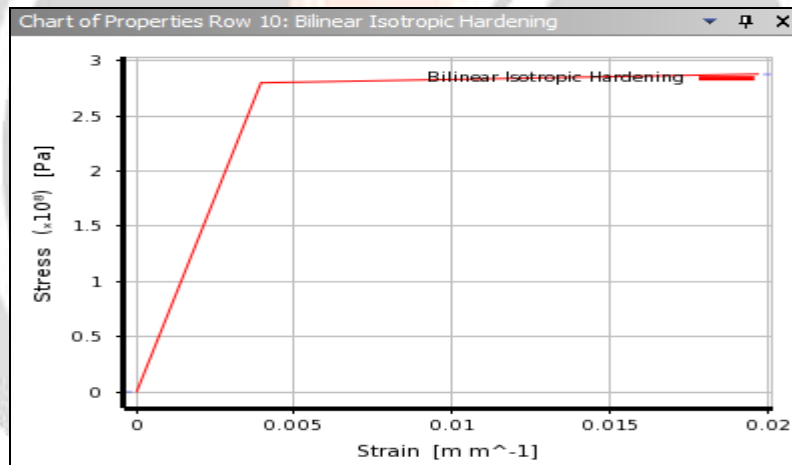
Step 4: Boundary condition are applied as per analysis namely in fixed support, pressure, force, displacement, velocity as per condition.

Step 5: Now problem is well defined and solve option is selected to obtain the solution in the form of equivalent stress, strain, energy, reaction force etc.



**Fig-2** Bilinear material properties graph

- In present research punch and die is to be constructed by structural steel material
- Aluminum sheet metal of 1 mm thickness is considered for analysis.
- The major objective is to perform dual operation is single stroke namely sheet metal will obtain the shape of punch along with end shape of circular, square and hexagonal shape of punch as per requirement to save time and compound die casting is used.



**Fig-3** Bilinear material properties graph

- In present explicit dynamic analysis is performed with fixed support at base die and impact of punch with certain velocity to determine the shape of press work punch with respective stress distribution.

### SQAURE PUNCH

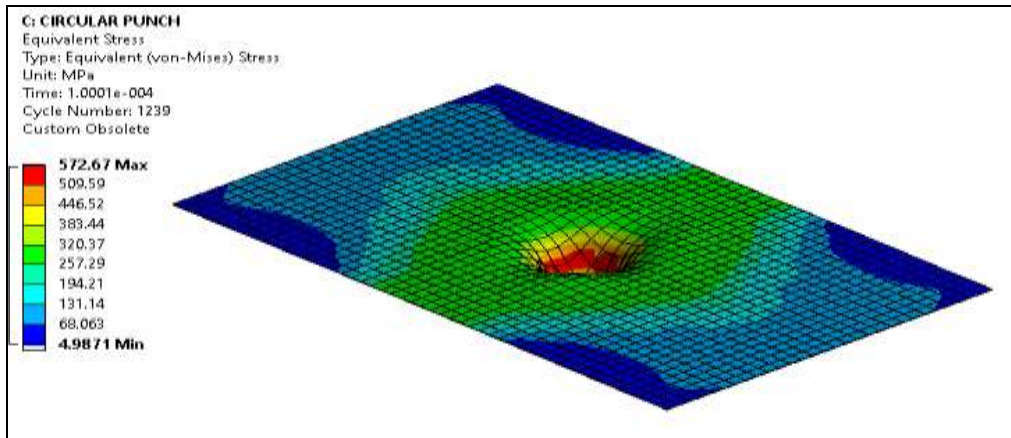


Fig-4 Equivalent stress for Square punch

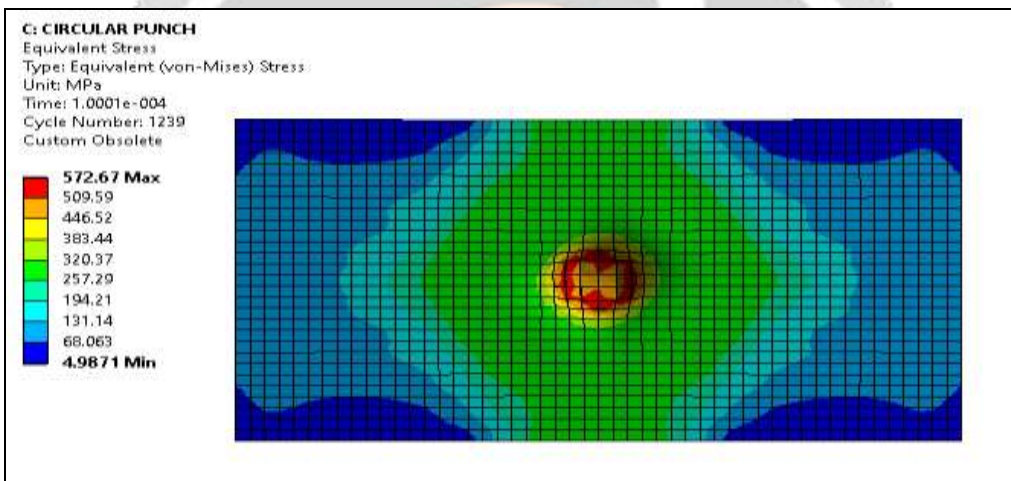


Fig-5 Geometry imported in ANSYS

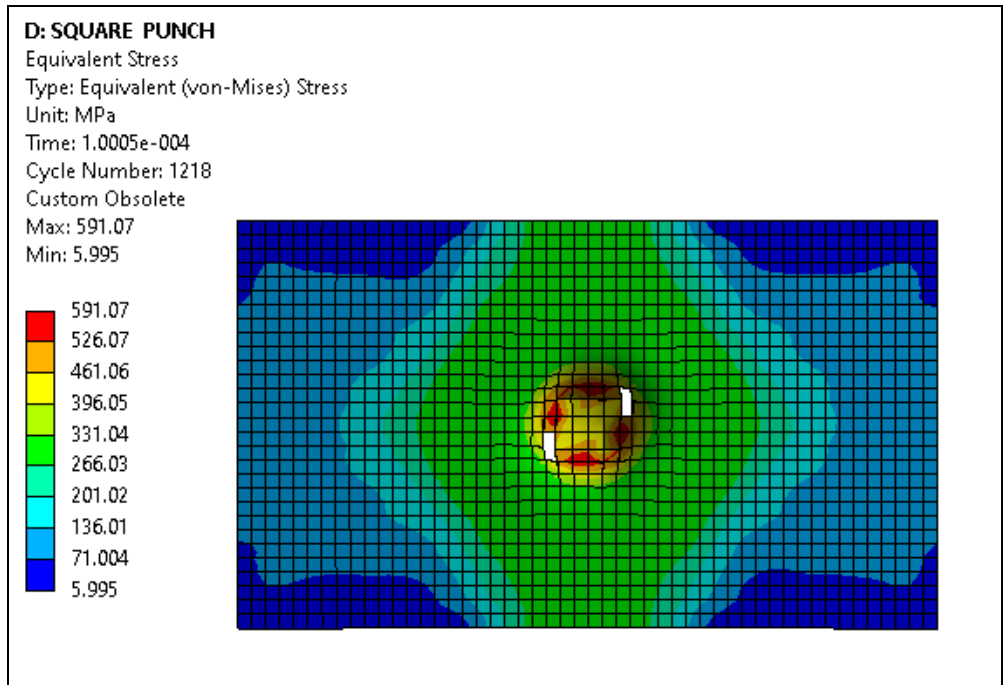


Fig-6. Equivalent stress for square punch

**HEXAGONAL PUNCH**

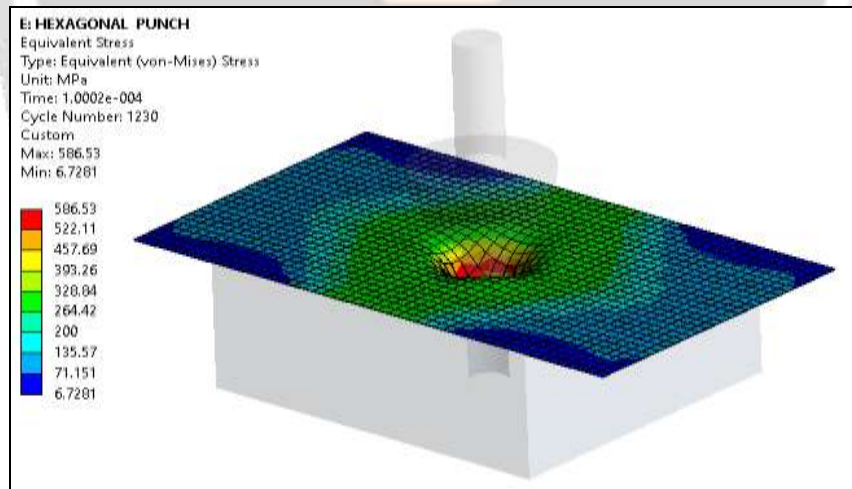
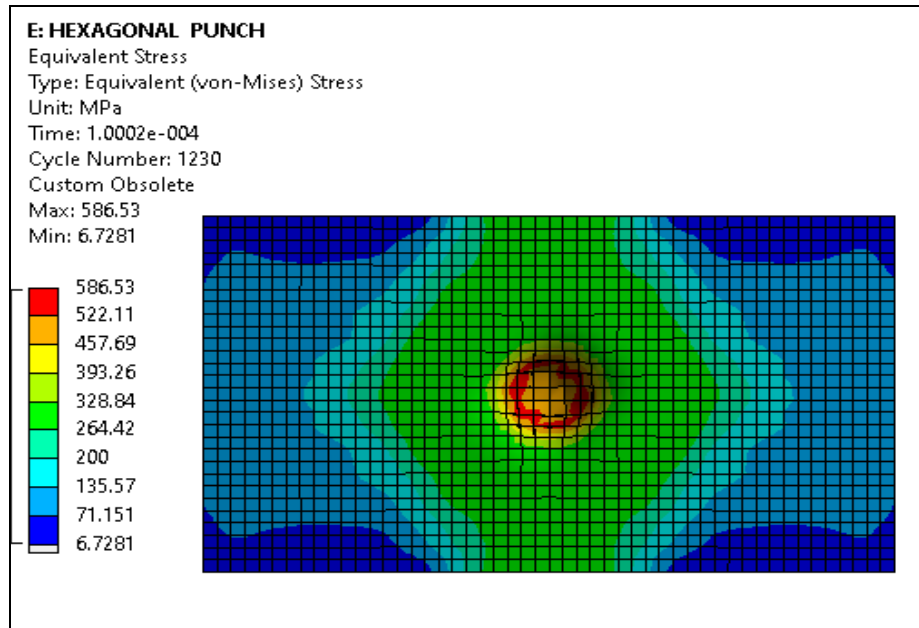
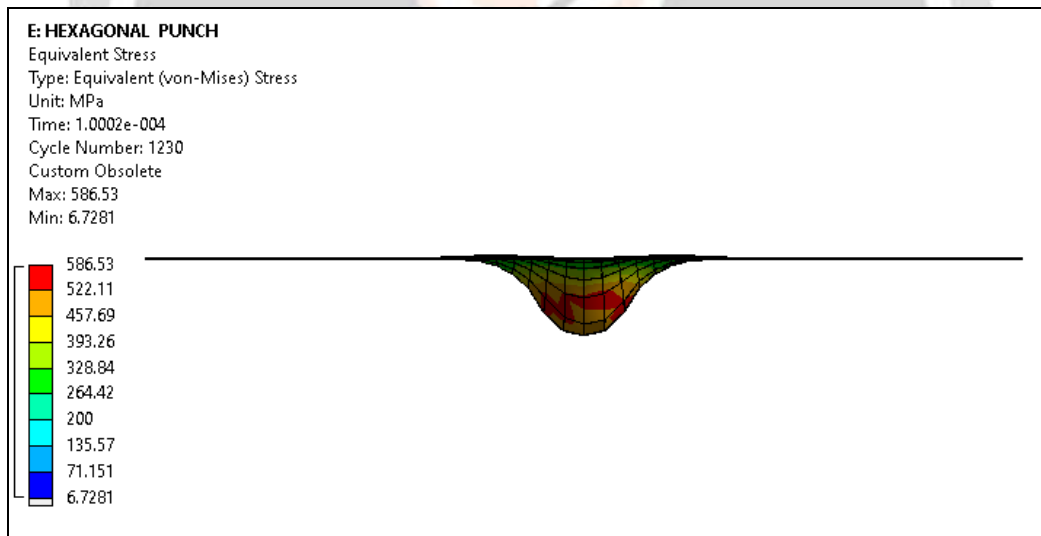


Fig-7 Geometry imported in ANSYS



**Fig-8** Geometry imported in ANSYS



**Fig-9** Equivalent stress for hexagonal punch

## 5.CONCLUSION

- In present research calculation and FEA analysis is presented along with design and development of head light reflector for press work of punch and die.
- It is observed from FEA results that stress formed on sheet metal are within the limit that is greater than yield but less than ultimate strength to form the shape of reflector.

## 6.REFERENCES

- [1] R. Markežiča, I. Nagličb, N. Molea, R. Šturma “Experimental and numerical analysis of failures on a die insert for high pressure die casting” *Engineering Failure Analysis* 95 (2019) 171–180
- [2] DorraAbida, Ahmed Ktaria, DhouhaMelloulia, NedjaGafsia, Nader Haddara“Failure analysis of shot–sleeves used in brass high pressure die–casting process” *Engineering Failure Analysis* 104 (2019) 177–188
- [3] Erhengchen, Huajun Cao, Qinyi Heb, Jiahao Yan, Salman Jafar “An IoT based framework for energy monitoring and analysis of die casting workshop” *Procedia CIRP* 80 (2019) 693–698
- [4] J.L.A. Ferreira, A.B.de S. Oliveira, A.B. Souza, V.G. Carloni, D.A. Leite “Structural integrity analysis of the main headlight reflector screws of the turbo-diesel engine crank shaft” *Engineering Failure Analysis* 12 (2005) 273–286
- [5] OzcanKocyigit “A novel Schiff base bearing dopamine groups with tripodal structure. Synthesis and its salen/salophen-bridged Fe/Cr(III) capped complexes” *Journal of Molecular Structure* 1034 (2013) 69–74
- [6] Chana Phutthananon, PornkasemJongpradist, PhatharaphongYensri, PitthayaJamsawang “Dependence of ultimate headlight reflectoracity and failure behavior of T-shaped deep cement mixing piles on enlarged cap shape and pile strength” *Computers and Geotechnics* 97 (2018) 27–41
- [7] J.P. Weiler, “A review of magnesium die-castings for closure applications” *Journal of Magnesium and Alloys* 7 (2019) 297–304
- [8] Yan Lua, Keith Ripplinger, Xuejun Huang, Yu Maoa , Duane Detwilerc, Alan A. Luo “A new fatigue life model for thermally-induced cracking in H13 steel dies for die casting” *Journal of Materials Processing Tech.* 271 (2019) 444–454
- [9] ChuangyeSu, Dejiang Li, Jie Wang, Renhai Shi, Alan A. Luo, Xiaoqin Zeng, Zhanhong Lin, Jin Chen “Enhanced ductility in high-pressure die casting Mg-4Ce-xAl-0.5Mn alloys via modifying second phase” *Materials Science & Engineering A* 773 (2020) 138870
- [10] Cheng Gua , Yan Lua , Emre Cinkilica , JiashiMiaoa , Andrew Klarnera , XinyanYanb, Alan A. Luo “Predicting grain structure in high pressure die casting of aluminum alloys: A coupled cellular automaton and process model” *Computational Materials Science* 161 (2019) 64–75