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Design, Analysis of Punch and Die for Blanking, Piercing and Forming tools to Produce Chain Guide Mounting Bottom Bracket

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ABSTRACT

In this paper Design and analysis procedure to develop Blanking, piercing and forming press tool for Chain guide mounting bottom bracket is discussed. Press tool is a device used for producing sheet metal components in large volume by applying an external force with the help of a machine tool called press. Press tool operations are divided in to cutting, non-cutting and hybrid press operation.. The components manufactured using this process and it gives high dimensional accuracy therefore automobile engineering and aircraft firm depend largely on press tools components. Chain guide mounting bottom bracket is a part which is used in brake assembly unit of automobiles. Sequence of operation is planned initially and then press tool is designed and analyzed. The purpose of carrying out analysis is to prevent the costly tryouts and thus optimize the quality and rate of production.

Keywords *- Press tool, CAD/CAE, FEM, Analysis.*

1. INTRODUCTION

The Press Tools are special type of tools which are custom built to produce the sheet metal parts. In this process raw material is used in the form of sheet metal and the sheet is squeezed between the punch and die to undergo the operations like blanking, piercing, bending, drawing etc. Usually engineering implicational work parts, automotive and aircraft related components are manufactured using press tool process. Since the application of these components lies in engineering applications like automotive and aircraft sector these products needs to meet high quality standards. Therefore at most care has to be taken in the designing stage itself. High skill set is required to survive in tooling sector.

Using the software for designing, drawing and analysis, and it will be highly beneficial to carry out the project works. By integrating CAD and CAM it saves lot of time so we can easily eliminate costly tryouts and error process. Press tool is extremely precise and high volume production rate. Based on functional requirement of any given metal component, it may be most cost effective and repeatable manufacturing process.

2. COMPONENT STUDY

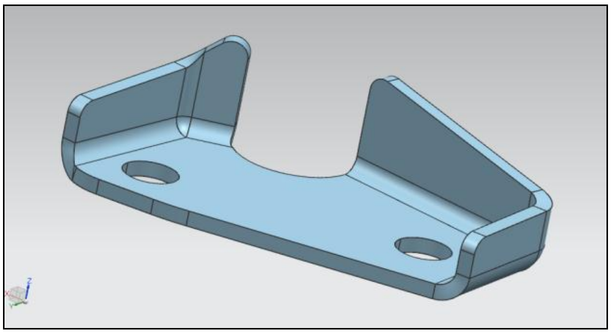


Fig 1: 3D Component Model

Material	IS:513 Cold Rolled low Carbon Steel
Thickness	2mm
Length of the component	55mm
Width of the component	34mm
height	15mm
Production rate	6,00,000/year

Table 1: Component Details.

After getting the work, the 2D drawing received by the customers than redrawing is done by using CAD software to identify the missing dimensions, and then necessary inputs will be incorporated in it. The conceptual drawing of the tool is done in Auto Cad and the bill of material is prepared then the material is ordered. Machining is started based on the data of detailing.

3. PRESS TOOL DESIGN

Press Tool design is one of the most skill full work, Because all the components which are produced using press tool will be demanded high dimensional accuracy and tolerances therefore most care should be taken while designing the press tool components.

3.1 Important considerations in Press Tool Design Several points have to be taken into considerations during press tool design process.

- All the parts that are designed should have the capability to with stand the heavy forces.
- There should be safety and ease of both operator and technician.
- Sufficient space should be provided to load the stock.
- Die set should be made of proper material.

3.2 Material Selection

Important design consideration is one should also know about the proper material selection for the different components of a die set various types of tool steels with their suitability for components of die set. Material or selected tool steel should be very harder than component material to resist wear and strong to bear load and at the same time die set components may have very complicated shape, design and need very accurate sizing. Most of them are manufactured by machining and then finishing operations. Their manufacturing involves processing of tool steel to make these components, and then these are hardened by different hardening methods like water hardening, oil hardening, air hardening. D2 steel is an air hardening tool steel with high carbon and chromium. It has good wear resistant properties. It has hardness between 55-62 HRc and it is machine able in annealed condition. It has tiny distortion on precise hardening. Chromium content gives corrosion resisting properties.

Property	**Value**	**Units**
Elastic Modulus	210000	N/mm^2
Poisson’s Ratio	0.3	-
Shear Modulus	7900	N/mm^2
Mass Density	7700	Kg/m^3
Tensile Strength	1736	N/mm^2
Compressive Yield Strength	2150	N/mm^2
Yield Strength	2150	N/mm^2
Thermal Expansion Coefficient	1.04e-005	1/K
Thermal Conductivity	20	W/(m-K)
Specific Heat	460	J/(Kg-K)

Table 2: Properties of D2 Material.

4. TOOL DETAILS

4.1 Blanking Tool Calculation

Blanking is a basic and initial operation which is done in the press tool process. Here rear pillared press tool is designed and the guide pin is diagonally located so operator easily feed the strip. And Shear force required to blank the sheet is calculated to get the press tonnage. Press tonnage means total capacity of the press machine to be selected for blanking considering all the criteria. Clearance is calculated and incorporated while designing of punch and die.in the blanking tool is design like a compound tool so in this cause two blank parts produces in a single shot.

1. Shear Force Calculation

Shear Force = Length of Cut x Thickness x Shear Strength … (01)

Shear Strength=280 N/mm^2

Shear Force= 208.5908 x 2 x 280 =116810.8480N =116.8180 KN

2. Total Shear force =2 x Shear force … (02)

=2X116810.8480

=233621.6960N =233.6216 KN

3. Stripping Force = 20% of total shear force … (03)

= 0.2X33621.6960

= 46724.3392N = 46.7243 KN

4. Press Force=Total shear force + Stripping force … (04)

= 233621.6960+46724.3392

= 280346.0352 N = 280.3460 KN

5. Press tonnage/Capacity = Press Force / Press efficiency … (05)

=233621.6960/0.70

=333745.2800N =333.7452 KN =34.02Tons

6. Cutting Clearance = 8 % of sheet thickness … (06)

= (8/100) x 2 = 0.16 mm/Side

4.2 Piercing Tool Calculation

Here rear pillar and rear secondary guide pins are used to design the piercing stage tool which is designed to operate easily for loading and unloading the part.

1. Shear Force Calculation

Shear Force = Length of Cut x Thickness x Shear Strength … (07)

Shear Strength=280 N/mm2

Shear Force = 21.9940 x 2 x 280 = 12346.6400N

2. Total Shear force =2 x Shear force … (08)

=2X12316.6400

=24633.2800N =24.6332 N/mm2

3. Stripping Force = 20% of total shear force … (09)

=0.2X24633.2800

=4926.6560N =4.9266 KN

4. Press Force=Total shear force + Stripping force … (10)

= 12316.6400+4926.6560

= 29559.9360 N=29.5599 KN

5. Press tonnage/Capacity = Press Force / Press efficiency … (11)

=29559.9360/0.70
=42228.40N =42.2284 KN=4.3046Tons

4.3 Forming Tool Calculation

Forming is the third operation that is carried out. Forming operation takes place along a nonlinear or curved axis rather than straight axis as in bending. Here rear pillared press tool is designed so operator easily load and unload the part. And the 3D model of the forming Total force required to bend the sheet metal is calculated using the formula. The type of forming is like L bending which is similar to 90^0 bending.

1. Forming Force = t x h x Us /1000 … (12)

Forming Force = Component thickness (mm) x Forming length in X and Y axis (mm) x Ultimate tensile Strength (N/mm2)
= 2 x (41.8875+15) x 560
= 63714N=63.7140 KN = 6.4948Tons

2. Pad Force = 25% of forming force … (13)
   = 0.25 x 6.4948
   = 1.6237 Tons

3. Total force = Forming force + Pad force … (14)
   = 6.4948+1.6237
   = 8.1185 Tons

4. Press Selection = Forming Force / Press efficiency … (15)
   = 8.1185 / 0.7
   = 11.5978 Tons

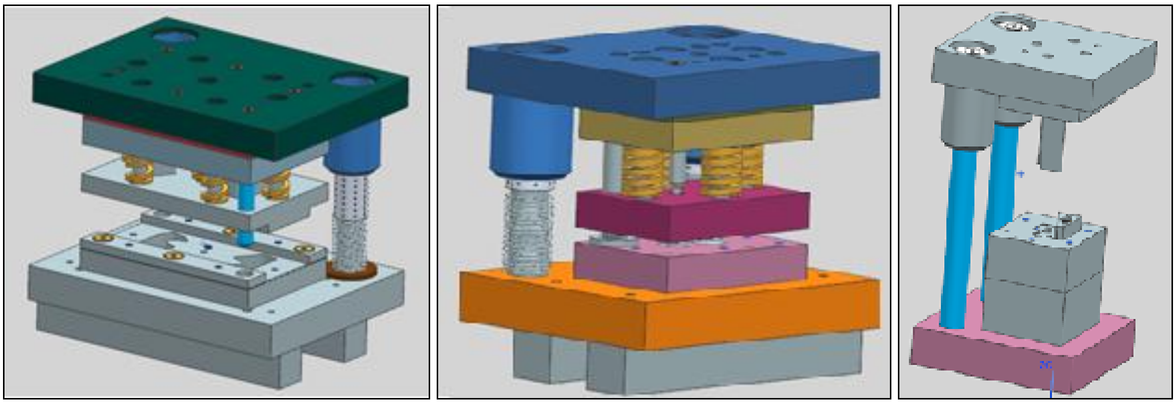


Fig 2: D Models of Blanking, Piercing and Forming Tools.

5. PUNCH AND DIE ANALYSIS

After completion designing and modeling, the press tool is must analyzed. Punch and Die analysis is carried under computer aided engineering software to ensure that the designed tool is safe. Punch and Die are the parts which undergo repeated loads in press tools, which is normally expensive too. Usually D2 or OHNS (oil hardened non shrinking steel) material is used for punch and die parts. It is very essential to carry out the analysis in order to prevent practical tryouts. Tryouts are always costly and also time consuming, instead if the parts are analyzed using computer aided engineering software it provides an opportunity to improve the design of the part prior to manufacturing. Hence based on the analysis result necessary material or geometrical changes are incorporated.

5.1 Punch and Die Analysis of Blanking Tool with 34 ton load

Blanking Punch and Die is considered for the analysis. Initially modeling is done then boundary conditions and suitable material is applied to the die. The below fig shows the Von-Mises stress, Static displacement and Static strain of die under the applied loading condition. The orange and blue color in the plot indicates the maximum and minimum stress distribution respectively.

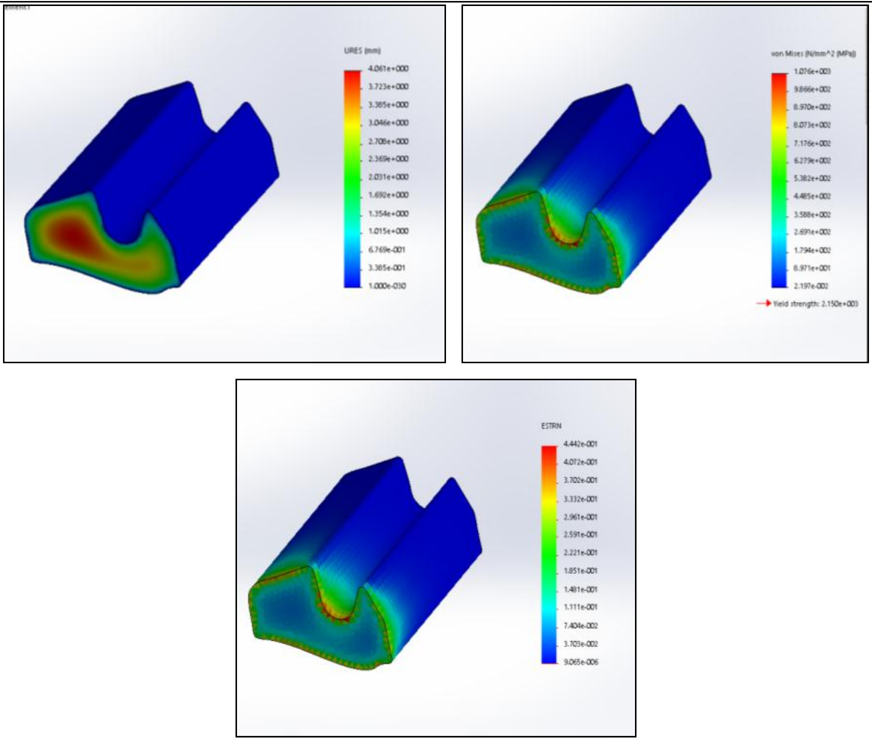


Fig 3: Von-Mises Stress, Static Displacement and Static Strain of Blanking Punch.

Static Analysis Results of Blanking Punch

Type	Von-Mises Stress, N/mm^2	Static Displacement, mm	Static Strain
Maximum	1.07×10^{3}	4.016	4.442×10^{-1}
Minimum	3.192×10^{-2}	0.001	9.065×10^{-6}

Table 3: Static Analysis Results of Blanking Punch.

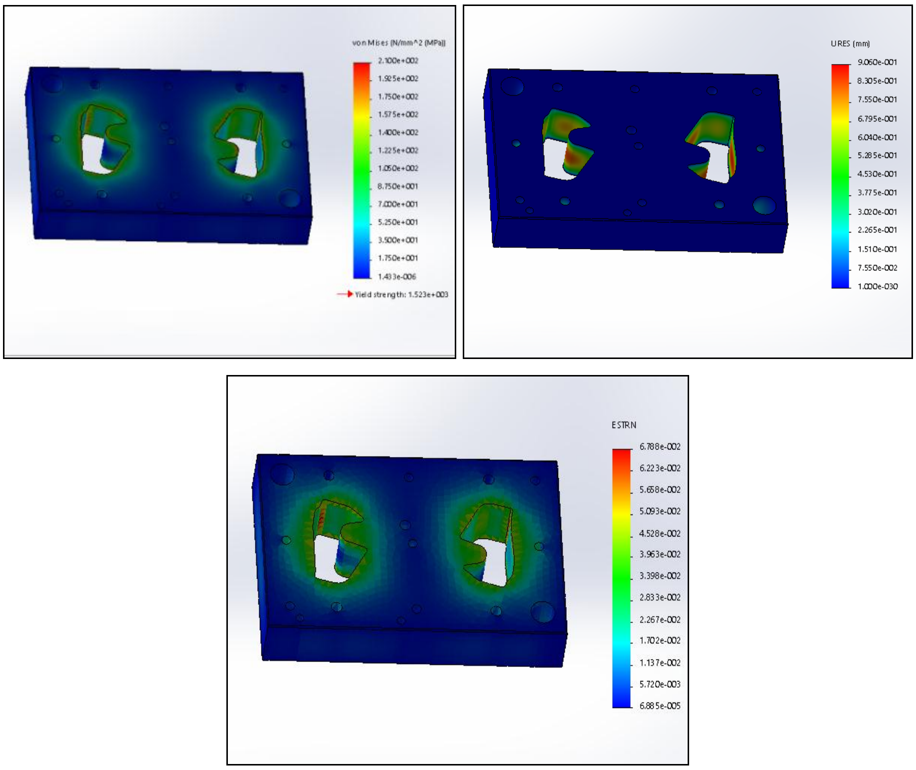


Fig 4: Von-Mises stress, Static displacement and Static strain of blanking Die.

Static Analysis Results of Blanking Die

Type	Von-Mises Stress, N/mm^2	Static Displacement, mm	Static Strain
Maximum	2.166 $x10^2$	0.906	6.788$x10^{-2}$
Minimum	4.433$x10^{-6}$	0.001	6.885$x10^{-5}$

Table 4: Static Analysis Results of Blanking Die.

5.2 Punch and Die Analysis of Piercing Tool with 5ton Load

Piercing Punch and Die is considered for the analysis. Initially modeling is done then boundary conditions and suitable material is applied to the die. The below fig shows the Von-Mises stress, Static displacement and Static strain of die under the applied loading condition The orange and blue color in the plot indicates the maximum and minimum stress distribution respectively.

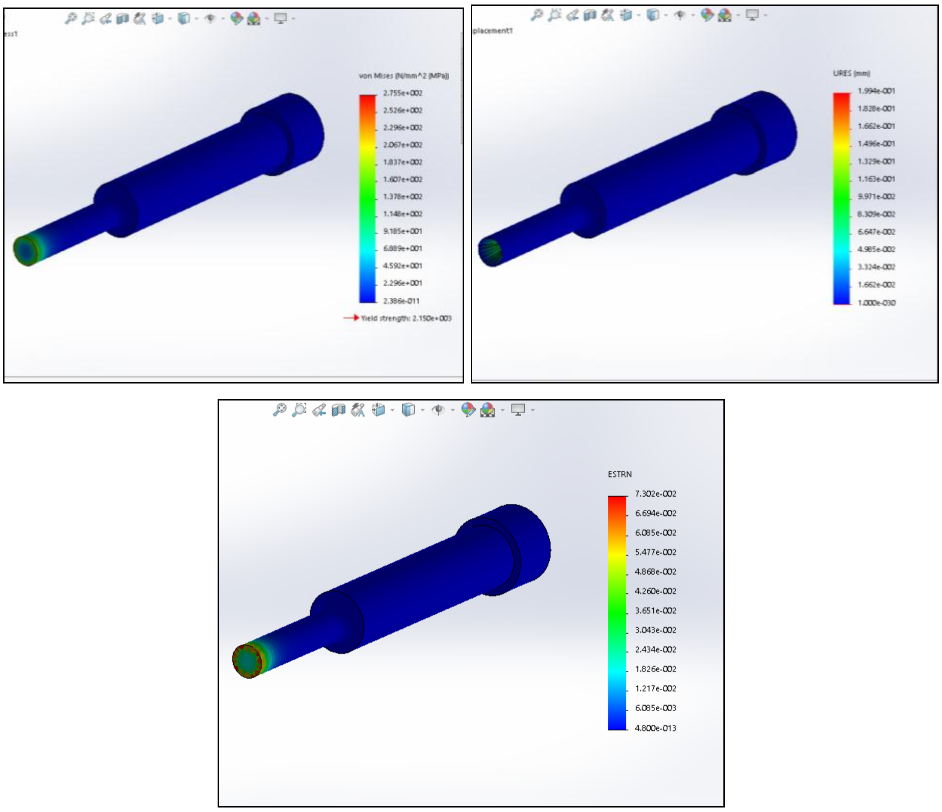


Fig 5: Von-Mises stress, Static displacement and Static strain of Piercing punch.

Static Analysis Results of Piercing Punch

Type	Von-Mises Stress, N/mm^2	Static Displacement, mm	Static Strain
Maximum	2.755 $x10^2$	0.199	7.302$x10^{-2}$
Minimum	2.386 $x10^{-1}$	0.001	4.800$x10^{-6}$

Table 5: Static Analysis Results of Piercing Punch.

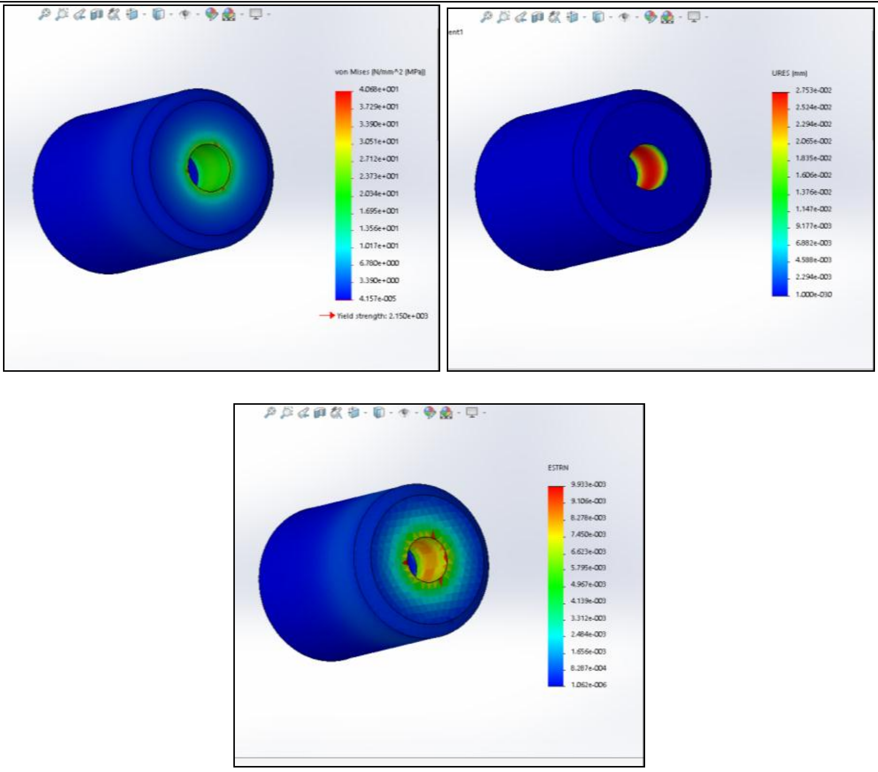


Fig 6: Von-Mises stress, Static displacement and Static strain of Piercing Die.

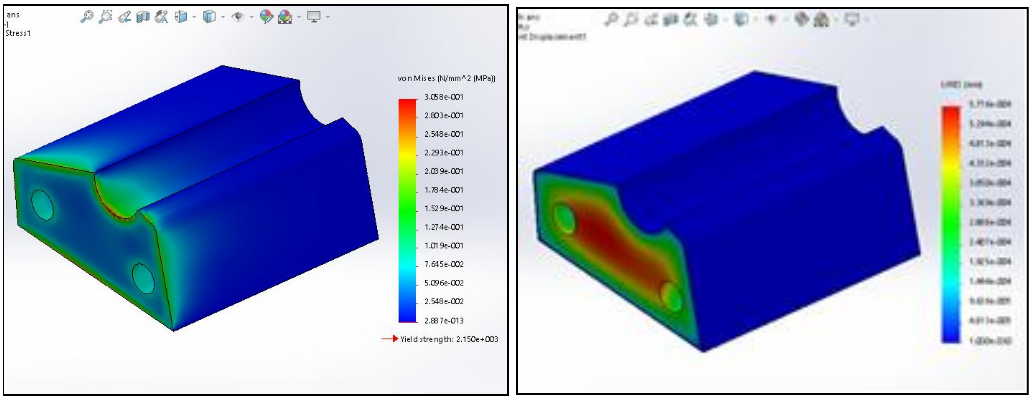
Static Analysis of Results Piercing Die

Type	Von-Mises Stress, N/mm^2	Static Displacement, mm	Static Strain
Maximum	40.68	0.00	$9.933x10^{-3}$
Minimum	$2.700\ x10^{-1}$	0.001	$1.062x10^{-6}$

Table 6: Static Analysis Results of Piercing Die.

5.3 Punch and Die Analysis of Forming Tool with 12ton load

Forming Punch and Die is considered for the analysis. Initially modeling is done then boundary conditions and suitable material is applied to the die. The below fig shows the Von-Mises stress, Static displacement and Static strain of die under the applied loading condition. The orange and blue color in the plot indicates the maximum and minimum stress distribution respectively.



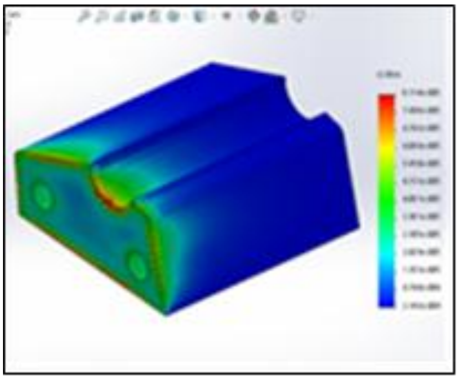


Fig 7: Von-Mises stress, Static displacement and Static strain of forming punch.

Static Analysis Result of Forming Punch

Type	von-Mises Stress, N/mm^2	Static Displacement, mm	Static Strain
Maximum	30.58	0.057	$8.11x10^{-5}$
minimum	$2.880x10^{-3}$	0.001	$2.143x10^{-9}$

Table 7: Static Analysis Results of Forming Punch.

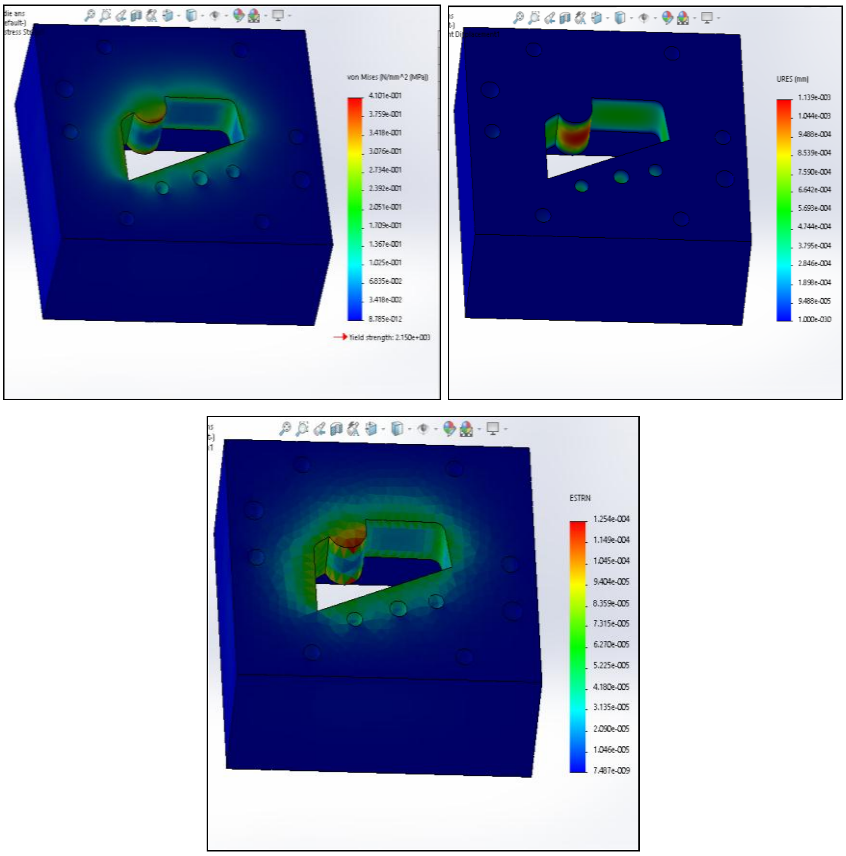


Fig 8: Von-Mises stress, Static displacement and Static strain of Forming Die.

Static Analysis Results of forming Die

Type	Von-Mises Stress, N/mm^2	Static Displacement, mm	Static Strain
Maximum	41.01	0.0013	$1.254x10^{-4}$
Minimum	$8.785x10^{-12}$	0.001	$7.487x10^{-9}$

Table 8: Static Analysis Results of Piercing Die.

6. CONCLUSION

In this project work some significant aspects of press tool design for chain guide mounting bottom brocket is discussed and also detail study and analysis were carried out. Punch and Die analysis of the tool were carried out and the design was found to be safe. Both in punch and die maximum stress developed was very less when compared to the calculated value. Through static analysis it confirms that the material selected for both punch and die are safe. Punch and die designed is made detachable so that only the damaged part is replaced. By incorporating finite element method overall production rate is optimized. The results reveal that by integrating CAD/CAE will be highly beneficial. By the implementation of computer in design, accuracy of design is improved and design process time is reduced drastically than by traditional method. Many design problems which are complicated to eliminate by traditional methods are eliminated by using CAD system.

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