Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 06, June-2016

Design and Analysis of Press Tool to Produce Radiator Stay Bracket

M Subrahmanyam[1]
[1]Department of Mechanical Engineering
Malaviya National Institute of Technology
Jaipur, India

A Mokhalingam[2]
[2]Department of Mechanical Engineering
Malaviya National Institute of Technology
Jaipur, India

***Abstract*— Progressive press tool is a die in which two or more operations are performed on each stroke of the press. The following study mostly focuses on the designing of progressive press tool and bending press tool to be used in the production of the stay bracket, also modeling of all the components, and analyzing the stress and deflection on the components. The modeling of the components was carried out on AUTODESK INVENTOR PROFESSIONAL 2016, and the structural analysis of the components was carried out on ANSYS WORKBENCH (ver. 17.0). The design and analysis of components was done by following the standard die design and analysis methods. The selection of materials for various components was also made by following standard die design procedure. The manufacturing of all the above components was done by following the standard manufacturing principles on Lathe, Vertical milling, and Drilling machines according to the requirement.**

Keywords—Press Tool; Radiator stay bracket; Blanking; Manufacturing

I. INTRODUCTION

Various operations can be carried out by press tools. These can be classified majorly into two types cutting operations and forming operations. Cutting operations are achieved by applying sufficient force which causes the material to fail, in many cases this force will be a shear force. In cutting operation when a significant enough shear force is applied, the shear stress in the material will exceed the ultimate shear strength of the material and the material will fail and separate at the cut location. Forming operations are achieved by applying a force which produces stresses in the material to be below the ultimate strength of the particular material. As the stresses produced in the material are below the ultimate strength, there will be no cutting of the metal, but there will be a change of contour of the workpiece to obtain the desired product.

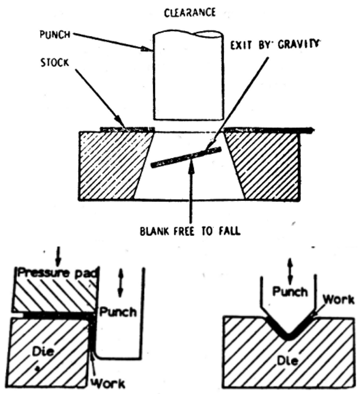

Fig 1. Cutting and forming processes

Fig1. Shows the cutting and forming operations namely, Blanking and bending respectively.

II. COMPONENT DESCRIPTION

Name of the component: Radiator Stay Bracket
Material: Cold rolled steel
Thickness: 1.2mm
Shear Strength: 260 MPa

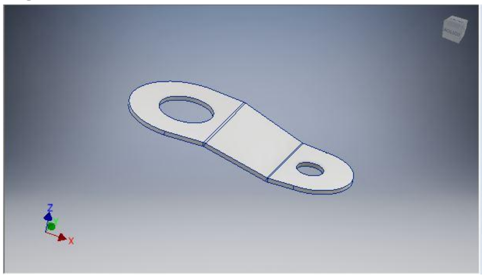

Fig 2. 3 D model of the component

Initially the component 2 D drawing is received from the customer and it has been developed to exact dimensions in Autodesk Inventor software.

III. PRESS TOOL DESIGN

Design of a press tool is a most skill full job. It is required a exact dimension and precision in the parts. Which takes a lot of time and experience to master in this.

Some basic things should keep in mind while designing a press tool are,

- All the parts that are designed to make press tool should capable of taking the applied load.
- Parts that are actually involved in cutting should have enough hardness to cut the component and to have a great life time.
- There should be enough room provided to move the sheet.

A. Selection of materials

Proper material selection is necessary for all the components for the performance of die set assembly, also for the ease of manufacturing them. In order to get a longer die life which in turn results in higher productivity, tool steels are selected widely as materials for die and punch because tool steels provide high hardness levels and resistant to abrasion when heat treated. The whole assembly may not require high strength material, as many parts involved are standard ones which can be manufactured with

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 06, June-2016

less expensive materials. The only materials involving direct abrasion wear are the die and the punch, so they need to be made of high strength materials.

Selection of proper tool steel for the particular operation is based on the below stated major considerations:

- Performance requirements of the tool steel for the particular application.
- Tool materials availability.
- Considering the restrictions related with the manufacturing of tool.

For this particular process, AISI D2 is selected as the material for die and punches used in a progressive die. As AISI D2 is high carbon, high chromium tool steel which is alloyed with vanadium and molybdenum and it has high wear resistance, high compressive strength and excellent resistance to tempering back. It is also easy to machine after heat treated it hardness will be increased up to 60-62 HRC. All the remaining parts in the assembly can be manufactured by structural steel St-42, which is less expensive and serves the purpose.

TABLE 1 Chemical composition of D2 Steel

C	Si	Cr	Mo	V
1.50%	0.30%	12%	0.80%	0.90%

TABLE 2 D2 steel Mechanical Properties

Properties	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 strength	2150	N/mm^2
Yield strength	1532	N/mm^2
Thermal expansion coefficient	1.04×10^{-5}	/K
Thermal conductivity	20	W/(m-K)
Specific heat	460	J/(Kg-K)

IV. PROGRESSIVE TOOL

A progressive die is typically multiple-station die, in which a number of sheet metal operations are completed at two or more stations in each stroke of the punch. The unwanted portions of the sheet strip are cut out as it moves forward through the die, as sheet itself carries the partially completed product to forward at least one or more tabs are left connected to the sheet.

The required shear force calculation will be done as followed based on the formula.

Shear force required for Blanking,

$$F_b = P \times t \times \tau_s$$

Where,

F_b – Force required for blanking
P – Perimeter of blank to be cut
τ_s – Shear stress of the strip
t – Thickness of the sheet

$F_b = 218.726 \times 1.2 \times 260$
$= 68242.512$ N

Shear force required for Punching,
For 10mm diameter punch
$F_{p1} = 31.415 \times 1.2 \times 260$
$= 9801.48$ N
For 20mm diameter punch
$F_{p2} = 62.831 \times 1.2 \times 260$
$= 19603.272$ N

Total Punching force, $F_p = F_{p1} + F_{p2}$
$= 9801.48 + 19603.272$
$= 29404.752$ N

Total shear force required will be the sum of blanking force and the punching force.

i.e., $F_s = 68242.512 + 29404.752$
$= 97647.264$ N
$= 10$Tons

Stripping force = 20% of total shear force
$= \frac{20}{100} \times 97647.264 = 19529.45$ N

A. *Die block Design*

Die block is made of AISI D2 tool steel, It is the female part of the assembly in which it has the blank and piercing shapes are grooved. The die block is modeled in the INVENTOR software. Die block thickness is calculated based on the total shear force required for the cutting operations performed on that die block. The expression can be given as,

$$T_d = \sqrt[3]{F_s}$$

Where,

T_d – Die block thickness in mm
F_s – Shear force in ton

As above calculated the shear force in cutting operations, $F_s = 9.95$ ton

Therefore,

$$T_d = \sqrt[3]{9.95} = 2.15 \text{ cm}$$
$= 21.5$ mm

Thickness of die block = 22 mm

B. *Design of stripper plate*

For this particular operation fixed stripper is chosen, because there is no need of blank holding pressure in the progressive tool as it is required in combination tool. Stripper plate is made of structural steel St – 42. The dimensions of the stripper are same as the die block as it is fixed on the die block except for thickness.

Thickness of the stripper plate, $T_s = 0.5 \times T_d = 0.5 \times 22 = 11$ mm

C. *Design of Bottom plate*

The bottom plate provides required damping effect to the die, and it provides enough space to securely clamp the die set to the press bed or the bolster. All the components of the assembly are mounted on this. There may be a provision provided in the bottom plate to fall of the blank from the die block. The material used for manufacturing of bottom plate is structural steel St-42.

Thickness of bottom plate, $T_b = 1.5 \times T_d = 1.5 \times 22 = 33$ mm

The die block assembly is shown in Fig 3.

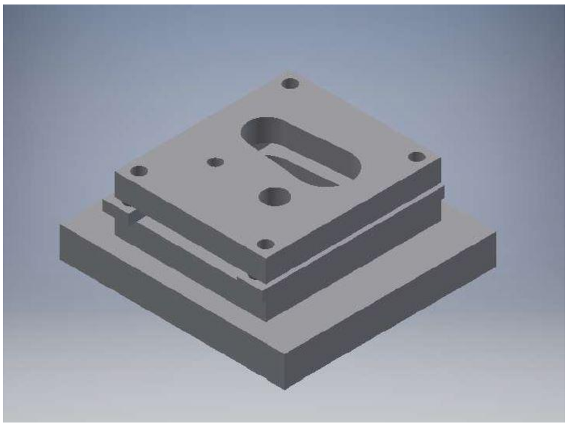

Fig 3 Die block assembly

D. *Design of top plate*

The top plate is the upper member of the tool. The punch assembly, i.e., punch holder and back up plate are attached to the top plate. The tool shank, which is used for fixing the whole assembly in the press ram is screwed into the top plate. The material utilized for the manufacturing of top plate is St-42.

Thickness of the top plate, $T_t = 1.25 \times T_d = 1.25 \times 22 = 27.5$ mm

E. *Design of punch palte*

The punches are usually fitted in the punch plate with a light press fit. It contains all cutting and guiding elements to ensure proper alignment in between punch and die. It is also made of St-42.

Thickness of the punch plate, $T_p = 0.5 \times T_d = 0.5 \times 22 = 11$ mm

The punch assembly is shown in the Fig 4.

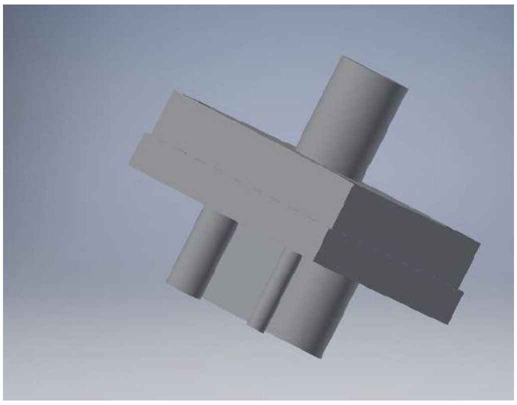

Fig 4 Punch assembly

V. Bending Tool

Bending is the second operation that is carried out. Total force required to bend the sheet metal is calculated using the formula. The type of bending is Z bending which is similar to V bending. Spring back is considered and necessary excess bend angle is provided which is called as over bending technique.

Bending Force = $\frac{C \times \tau \times W \times t^2}{L}$

$= \frac{0.1 \times 250 \times 74 \times 1.2^2}{88}$

=30 Tons

VI ANALYSIS OF PRESS TOOL

A. *Theoritical Stress and Deflection analysis*

1. Die block

The die block was assumed to be a fixed beam, with a uniformly distributed load. The deflection recommended should be less than 0.025 mm.

Deflection, $\delta = \frac{FL^3}{384EI}$

$$I = \frac{bh^3}{12}$$

Where,

F = 80% of the total shearing force

E – Modulus of elasticity

E = $2.1 \times 10^5\ N/mm^2$

I – Moment of inertia of die block

F = 0.8 × 97647.264 N

= 78117.811 N

L is distance between two screws = 108 mm

b = 154 mm and h = 22 mm (the width and thickness of die block)

Therefore,

$$I = \frac{154 \times 22^3}{12} = 136649.33\ mm^4$$

$$\delta = \frac{78117.811 \times 108^3}{384 \times 2.1 \times 10^5 \times 136649.33}$$

= 0.009 mm

Stress-induced in die block is given by, $\sigma = \frac{F}{A}$

Where, A = b × h = 154 × 22 = 3388 mm^2

$$\sigma = \frac{78117.811}{3388}$$

= 23.05 N/mm^2

2. Stripper Plate

Stripper plate was also assumed to be a fixed beam, with a uniformly distributed load. The maximum force acting on the stripper is 20% of the total cutting force.

Deflection, $\delta = \frac{F L^3}{384\ E\ I}$

$$I = \frac{b\ d^3}{12}$$

Here, b = 154 mm and d = 11 mm

Length is distance between two screws, L = 108

$$I = \frac{154 \times 11^3}{12} = 17081.166$$

F = 20 % total shearing force

Therefore,

F= 0.2 × 97647.264 N

= 19529.45 N

So, $\delta = \frac{19529.45 \times 108^3}{384 \times 2.1 \times 10^5 \times 17081.166}$

= 0.017 mm

Stress induced in the stripper plate, $\sigma = \frac{F}{A}$

A = b × h = 154 × 11 = 1694mm^2

$$\sigma = \frac{19529.45}{1694}$$

= 11.52 N/mm^2

3. Bottom Plate

The bottom plate was manufactured by using the structural steel St-42 material. The whole assembly is placed on this plate. The bottom plate was supported by two parallels. Hence, we may consider the support to be simply supported. Force acting on this block may be considered as 30% of the cutting force.

As we know from strength of materials, the deflection of beam which is simply supported with uniform load is,

Deflection, $\delta = \frac{5F\,L^3}{384\,E\,I}$

$$I = \frac{b\,d^3}{12}$$

Here, b = 181 mm and d = 26 mm

Length is distance between two screws, L = 108

$$I = \frac{181 \times 26^3}{12}$$

= 265104.666

F = 80 % total shearing force

Therefore,

F= 0.8 × 97647.264 N

= 78117.811 N

So, $\delta = \frac{5 \times 78117.811 \times 108^3}{384 \times 2.1 \times 10^5 \times 265104.666}$

= 0.023 mm

Stress induced in the bottom plate, $\sigma = \frac{F}{A}$

A = b × h = 181 × 26 = 4706mm^2

$$\sigma = \frac{78117.811}{4706}$$

= 16.59 N/mm^2

4. Top Plate

The top plate was manufactured by using the structural steel St-42 material. This supports the punch plate and on the top of it has a shank screwed in it, which holds the whole punch assembly in ram of the press which is a moving member to perform cutting.

For analysis, this block is considered as a fixed beam with a uniformly distributed load on it. For which stress and deflection equations are known. The load taken by this will be considered as 80% of cutting force.

Deflection, $\delta = \frac{F\,L^3}{384\,E\,I}$

$$I = \frac{b\,d^3}{12}$$

Here, b = 127 mm and d = 26 mm

Length is distance between two screws, L = 104

$$I = \frac{127 \times 26^3}{12} =$$

186012.66

F = 80 % total shearing force

Therefore,

F= 0.8 × 97647.264 N

= 78117.8 N

So, $\delta = \frac{78117.8 \times 104^3}{384 \times 2.1 \times 10^5 \times 186012.66}$

= 0.0058 mm

Stress induced in the plate, $\sigma = \frac{F}{A}$

A = b × h = 127 × 26 = 3302mm^2

$$\sigma = \frac{78117.8}{3302}$$

= 23.65 N/mm^2

5. Blanking Punch

The punch was manufactured by AISI D2 tool steel, to provide sufficient hardness for cutting the punch was heat treated. This can be considered as one end fixed and the compressive force is acting on the other end of the member with a force on the other end. The deflection and stress can be calculated as follow. Force is 80% of cutting force.

Deflection,

$$\delta = \frac{Fl}{AE}$$

F= 0.8 × 97647.264 N

= 78117.8 N

A = 9328.378

Therefore,

$$\delta = \frac{78117.8 \times 54}{9328.378 \times 2.1 \times 10^5}$$

= 0.02153 mm

Stress,

$\sigma = \frac{F}{A} = \frac{78117.8}{9328.378}$ = 83.73 N/mm^2

6. 20mm diameter Punch

This punch was also manufactured by AISI D2 tool steel, to provide sufficient hardness for cutting the punch was heat treated. This can be considered as one end fixed and the compressive force is acting on the other end of the member with a force on the other end. The deflection and stress can be calculated as follow. Force is 80% of cutting force.

Deflection,

$$\delta = \frac{Fl}{AE}$$

F= 0.8 × 97647.264 N

= 78117.8 N

A = $\frac{\pi\,d^2}{4} = \frac{\pi \times 20^2}{4}$ = 314.15 mm^2

Therefore,

$$\delta = \frac{78117.8 \times 54}{314.15 \times 2.1 \times 10^5}$$

= 0.06394 mm

Stress,

$\sigma = \frac{F}{A} = \frac{78117.8}{314.15}$ = 248.66 N/mm^2

7. 10mm diameter Punch

This punch was also manufactured by AISI D2 tool steel, to provide sufficient hardness for cutting the punch was heat treated. This can be considered as one end fixed and the compressive force is acting on the other end of the member with a force on the other end. The deflection and stress can be calculated as follow. Force is 80% of cutting force.

Deflection,

$$\delta = \frac{Fl}{AE}$$

F= 0.8 × 97647.264 N

= 78117.8 N

$$A = \frac{\pi d^2}{4} = \frac{\pi \times 10^2}{4} = 78.53 \text{ mm}^2$$

Therefore,

$$\delta = \frac{78117.8 \times 54}{78.53 \times 2.1 \times 10^5}$$

= 0.1957 mm

Stress,

$$\sigma = \frac{F}{A} = \frac{78117.8}{78.53} = 597.375 \text{ N/mm}^2$$

B. FEM Analysis of Components

Material considered for Die block, and the punches is AISI D2 tool steel, which has a yield strength of 2200 N/mm^2. All the remaining components were made by structural steel St-42 which has a yield strength of 250 N/mm^2

The force applied on each component for stress and deflection analysis by using CAE software ANSYS WORKBENCH (Ver 17.0) is given below. The force applied on various components is given according to the percentage of maximum shear force acting on the assembly. The amount of forces applied are calculated and tabulated in the Table 3.

All the plates are considered to be fixed at one end and a uniformly distributed load acting on the other end. While the punches are considered as strut members i.e., one end of the punch is fixed and the other end is loaded with a compressive load with an amount given below.

Table 3 Force applied on components

Component	Force applied	Amount of force (N)
Die block	80% of cutting force	78117.8
Stripper	20% of cutting force	19529.45
Bottom plate	80% of cutting force	78117.8
Top plate	80% of cutting force	78117.8
Blanking punch	80% of cutting force	78117.8
20mm Diameter punch	80% of cutting force	78117.8
10mm diameter punch	80% of cutting force	78117.8

VII RESULTS AND DISCUSSION

The material for die block is selected as D2 (HCHCr) tool steel; the optimum die clearance for the die block is considered as 0.046mm, for the blanking operation. The die block is provided with an Angular clearance of 2^0 with 2mm land. The dimensions of the die block calculated analytically as 130 × 154mm with a thickness of

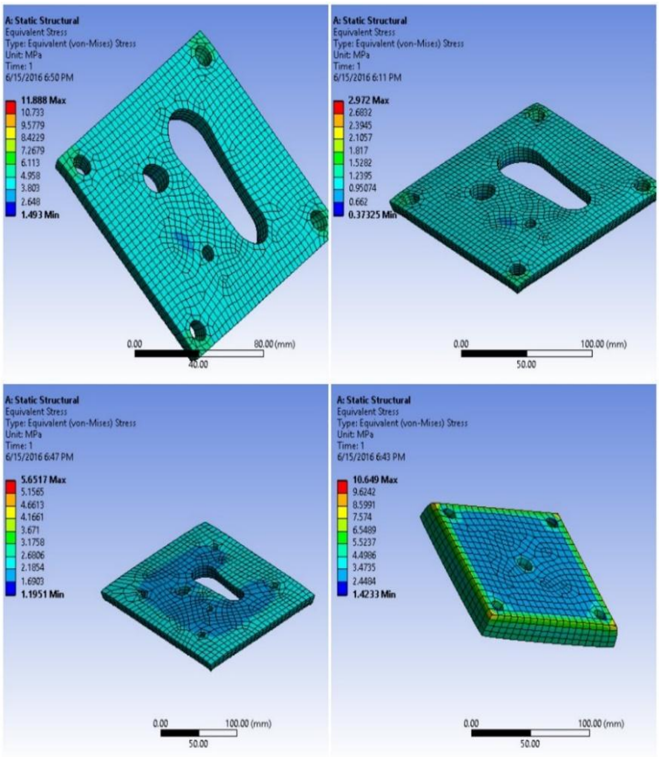

Fig 5. Stress analysis of blocks

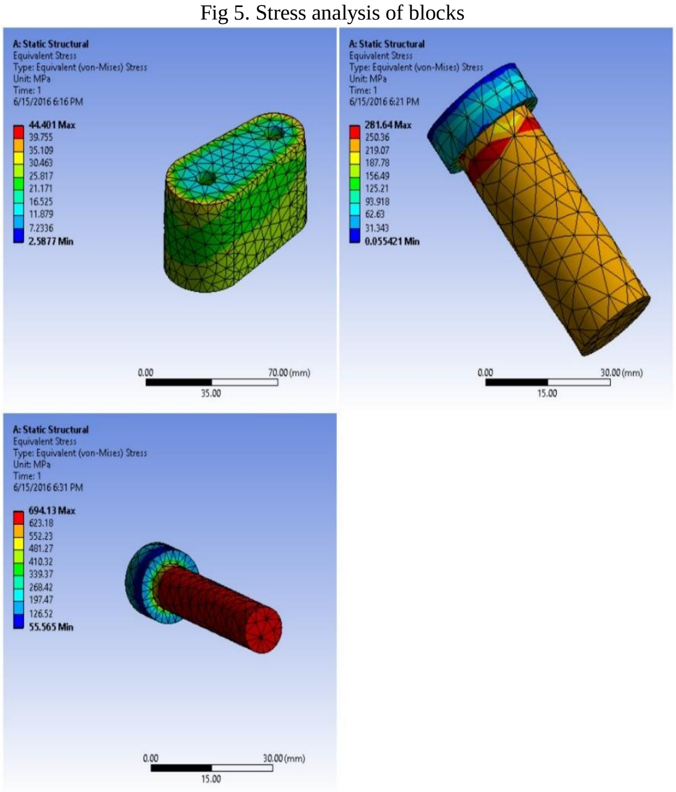

Fig 6. Stress analysis of punches

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 06, June-2016

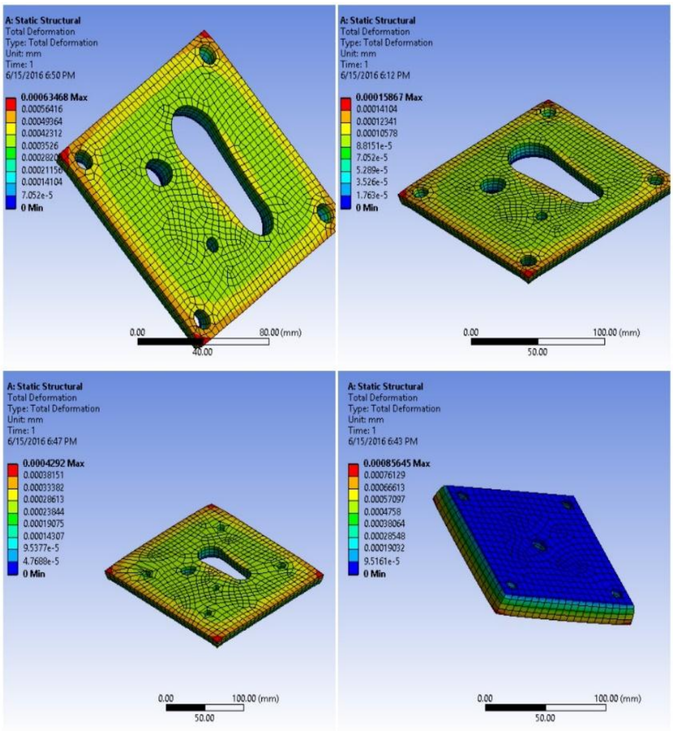

Fig 7. Deflection of Plates

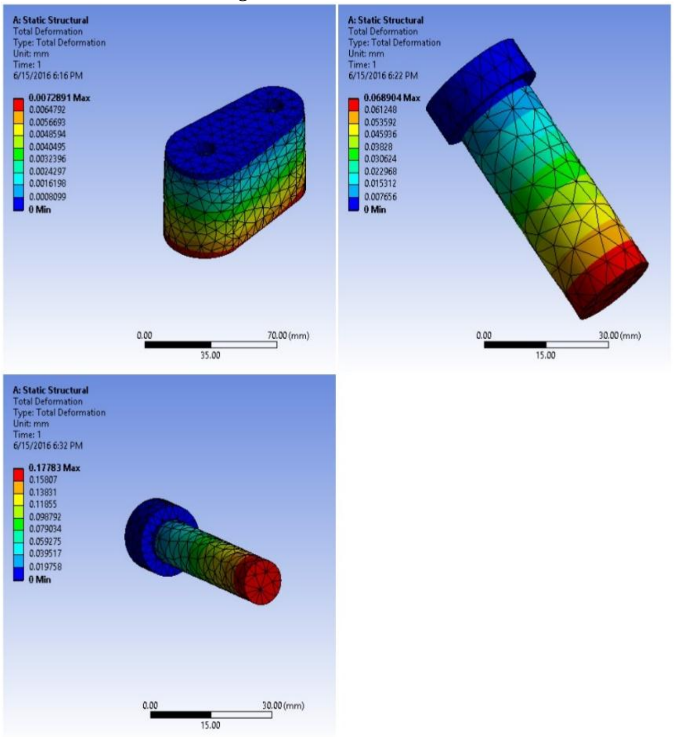

Fig 8. Deflection of Punches

22mm. The stress on the die block is computed as 23.05 which is within the allowable limit.

Here the stripper used was a fixed stripper. The thickness of the selected stripper plate is 11mm and the material used for manufacturing of the stripper plate is structural steel (St-42). The stripper is fixed to the die block with M8×1.5 bolts.

The material for die block is selected as D2 (HCHCr) tool steel. The length of the punch is found to be 54mm. The stress on the punch is calculated as 83.73 which is within the allowable limit.

An open die set is designed for progressive press tool, because of its easy operation and easy manufacturability of the press tool. The dimensions of various blocks are calculated in the design steps. For the bottom plate, the thickness was calculated as 33mm; the top plate thickness was found to be 27.5mm, and the punch plate thickness was 11mm.

All the components designed were checked analytically and by FEM simulation for stress and deflection and found to be within the allowable limits.

The results acquired from the FEM analysis were briefed and compared with the results obtained from the analytical calculation are shown in Table 6.1. By observing the results, it can be stated that the design is safe as all the values obtained are within the allowable limits only.

TABLE 4 FEM simulated and Analytical results

S.NO	Description	FEM simulated results		Analytical results	
		Stress (Mpa)	Deflection (mm)	Stress (Mpa)	Deflection (mm)
1	Die block	11.88	0.00063	23.05	0.009
2	Stripper	2.972	0.0001586	11.52	0.017
3	Bottom plate	5.657	0.00042	16.59	0.023
4	Top plate	10.649	0.000856	23.65	0.0068
5	Blanking punch	44.401	0.007289	83.73	0.0215
6	20mm dia punch	281.64	0.068	248.66	0.0639
7	10mm dia punch	694.13	0.1778	597.375	0.1957

VIII CONCLUSION

Design of Progressive press tool for stay bracket component, which was produced by sheet metal has been developed by following primary die design principles. All the components in the press tool assembly were initially designed in AUTODESK INVENTOR 2016. Later structural analysis of all the components was done both theoretically and by simulation. Both the results were compared and they look sound and are in acceptable range. The simulation was done in ANSYS WORKBENCH (Ver 17.0).

REFERENCES

[1] Biruke, F., Yonas, T. & Degu, M., 2014. Design of Combined Press Tool for the Manufacturing of Rice Thresher Blade (Case Study at Amhara Agricultural Mechanization and Food Science Research Center-Ethiopia). , pp.90–106.

[2] Desie, G. & Degu, Y.M., 2014. Progressive Die Design for Self Explosive Reactive Armor Holder (Case Study at Bishoftu Motorization Industry-Ethiopia). , pp.75–85.

[3] Kumar, V.D., 2015. International Journal of Applied Theoretical Science and Technology Design and stress analysis of washer tool ISSN : 2454-8065. , 1(8), pp.194–200.

[4] Mastanamma, C., Rao, K.P. & Rao, M.V., 2012. Design and Analysis of Progressive Tool. , 1(6), pp.1–10.

[5] Pawar, S.S. & Dalu, R.S., 2014. Compound Die Design : A Case Study. , 3(5), pp.2012–2015.

[6] Ramegowda, D., 2015. Design of Blanking Punch and Die for Cam Head Washer Component using Finite Element Analysis. , 4(07), pp.410–414.

[7] Ramesha, N., 2015. Design and Analysis of Blanking and Bending Press Tool to Produce Anchor Bracket Component. , 4(04), pp.1035–1039.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 06, June-2016

[8] Shankar, P.H., 2013. Progressive Tool Design and Analysis for 49 Lever 5 Stage Tools. , 4(7), pp.2197–2206.

[9] Bh, V., Ch, S.R. and Vinay, P.V., 2014. Effect of machining parameters on tool wear in hard turning of AISI D3 steel. Procedia Engineering, 97, pp.338-345.

[10] Rao, P.N., 2013. Manufacturing technology (Vol. 1). Tata McGraw-Hill Education.

[11] Khanna, O.P. and Lal, M., 1987. A Textbook of Production Technology. Vol II, Dhanpat Rai & Sons.

[12] Pandey, P.C. and Singh, C.K., 2001. Production Engineering and Science. Standard Publishers Distributors.