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DESIGN AND ANALYSIS OF PROGRESSIVE TOOL FOR U-BRACKET OF POWER METER CABINET

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Abstract -*In the present situation, the production of U-brackets are made with a new raw material and in a two different tools, each tool requires press machines which leads to the usage of more resources and considerable financial loss thus the industry stopped the production of U-brackets and given out sources for the production. The present U-bracket components can be done using scrap material which is sufficiently available in industry and it has not all used for any other production. Considering all these criteria, the existing tools can be simplified with a single progressive tool so that usage of more resources can be simplified and can be done using scrap material and raw material cost will be saved. In this work a three stage progressive tool has been designed and analyzed the stresses and deformation for different parts of progressive tool like top plate, bottom plate, die plate, stripper plate and guide pillar. A progressive tool performs two or more operations at different stages in a single stroke of ram to produce the part as the strip moves through the die. Modeling is carried out in SOLID EDGE VERSION 20 and simulation is carried out in ANSYS WORKBENCH 18.1 and result obtained from analysis is validated with manual calculations. The designed tool will help the industry to manufacture the part rather than outsourcing and hence saves money. 30T available mechanical press can be used with newly designed tool as the press capacity is greater than the required.*

Key Words: Progressive tool, U-Bracket, Scrap material, Raw material, Press capacity

1. INTRODUCTION

In recent day's different kinds of sheet metal developing processes were using in sheet metal product manufacturing companies. These sheet metal developing processes have been using for manufacturing various sections of airplanes, vehicles and ships etc. by using the complicated devices discovered from modern innovations. With the ever growing knowledge of science and technology, the progressive tool design process has become more precise to satisfy the demand of more productivity, low price and better exactness. For a better improvement, the more delicate design development of today has not replaced the need for basic sheet forming of dies and process. The popularity of sheet metal stamping process is due to its high productivity, ease in manufacturing of intricate shapes and will be done at lower cost. The parts manufactured from the sheet metal have well good-looking qualities, better dimension accuracy, light weight and higher strength.

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2. COMPONENT DATA

Component Name: U-Bracket
Material: CRCA Steel
Thickness: 0.8mm
Shear strength: 36 Kg/mm^2
Tempered Grade: Cold Rolled

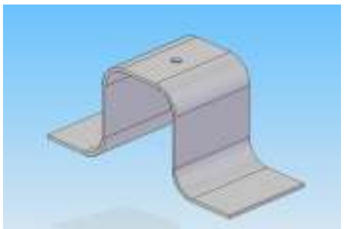

Fig -1: Solid model of component

U-bracket is a small component used in the meter cabinets to fix the domestic power meters. The 2D drawing is received from the industry.

3. PROBLEM STATEMENT

- Currently for window cutting operation of the top box, the material of dimension 100×90mm has been wasting as scrap material and decreasing the productivity.
- The industry used separate two separate press tools and machines for each sheet metal operations of U-bracket thus stopped production and outsourcing it.
- New stamping tools like progressive tools which produce well superior quality and consistent parts with enormous amount has not completely installed where ever its requirement meet.

- By analyzing the recorded problems it came to know that the problems became an obstacle to the production improvement.

3.1 Objectives of Work

- To know the source of causes of less productivity in Elite Insulators and propose the possible of improvement in present production line.
- Collecting geometrical details which describe size, shape and additional description of the component (U-bracket).
- Modification of tool to use the available scrap material.
- Suggesting the new tool as progressive tool.

4. METHODOLOGY

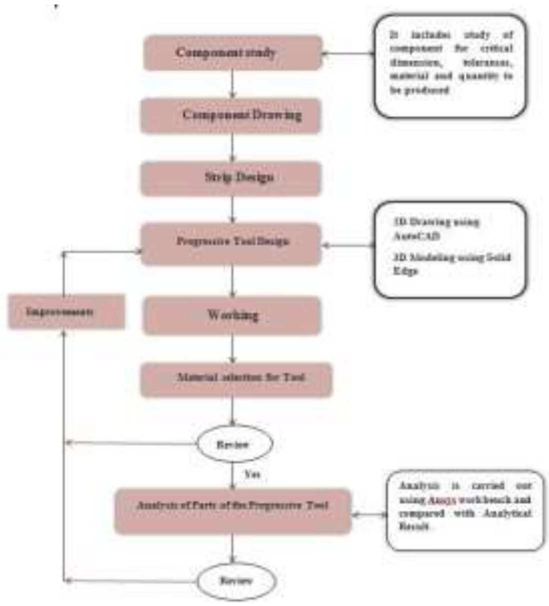

Fig -2: Methodology Adopted

5. MODELING AND MATERIAL SELECTION

5.1 3D Model of Progressive Tool

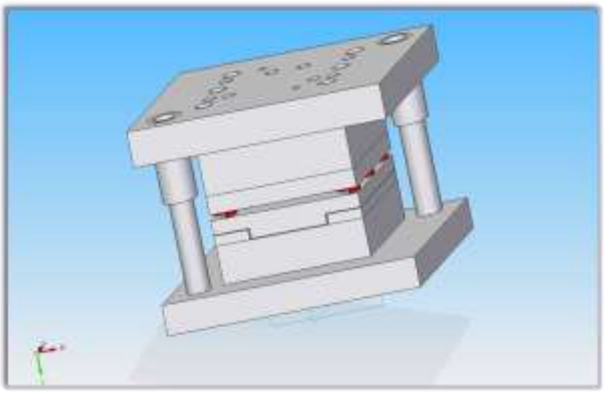

Fig -3: Progressive Tool Assembly

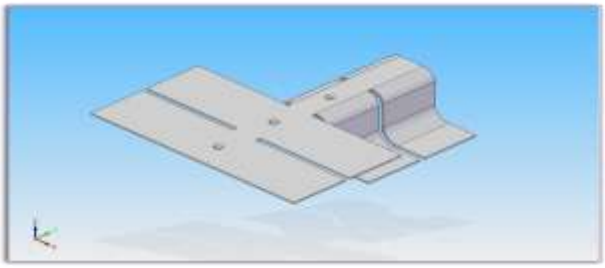

Fig -4: Strip Layout

5.2 2D Drawings of Progressive tool and component

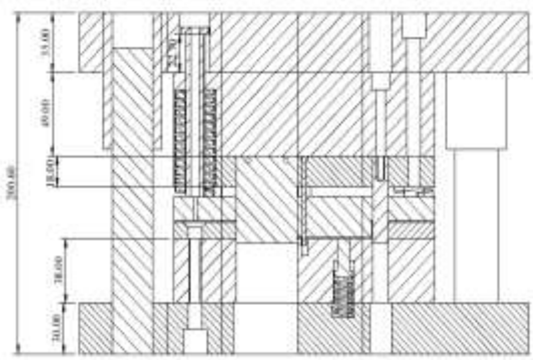

Fig -5: Section view of progressive tool

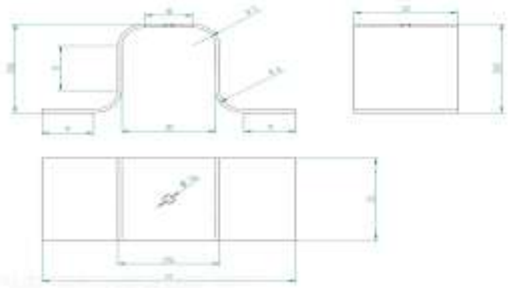

Fig -6: Component Drawing

5.3 Mechanical Properties of Tool Materials

Table -1: Mechanical properties

Property	Mild steel (st-42)	HCHC steel (D_2 steel)	EN-31 Steel
Mass Density (Kg/m^3)	7850	7700	7700
Yield strength (Mpa)	250	1532	450
Ultimate Tensile Strength (mpa)	460	1320	750
Possion's ratio	0.303	0.3	0.3
Shear modulus(Gpa)	78	79	86
Young's Modulus(Mpa)	210000	210000	215000

6. DESIGN CALCULATIONS

6.1 Strip layout Development

Scrap Bridge (B) = (1 to 1.25)t
B=1mm
Margin (M) = (1.25 to 1.5).t
M=1.5mm
Area of Blank (component) = 22×87 =1914mm

No. of Rows = 1
Pitch=Advance of die = L+B, where L = Length of blank
=24mm
Economy Factor = (blank size area × No. of rows)/ (Strip breadth × Pitch) ×100

Economy Factor = 92.46%

% of strip used = $\frac{\text{Area of the component}}{\text{Area of the strip}}\times 100$

=88.61%

% of scrap = 100-88.61 = 11.31%

6.2 Die clearance and Tool Life

Die clearance = thickness of work piece× suggested %
For steel, Die clearance = (2.5 - 5%) t, where t=thickness of sheet
Min. Die clearance = 0.02mm
Max. Die clearance = 0.04mm
Max clearance can cause burr and min clearance cause repeated reshaping of die and tool life decreases.

For better tool life, the die clearance has an optimum average value. Optimum value can be calculated by averaging the min and max die clearances.

Optimum clearance = 0.02+0.04/2 = 0.03mm

6.3 Force calculations

Shearing force
$F_{sh} = L\times t\times f_s$
Where F_{sh} = shear force or cutting force in tons
f_s = shear strength in Kg/mm^2
L = cutting length in mm
t= thickness of sheet = 0.8mm

At stage 1, pitch punch
Cutting length L_1 = 54mm
At stage 2, parting with embossing
Cutting length L_2 = 171mm
At stage 3, small cut-off
Cutting Lengt L_3 = 20mm
Total cutting length L = $L_1+L_2+L_3$ =245mm

F_{sh} = 7056Kgf

F_{sh} = 7056×0.6 (for safety purpose 60% additional force is added)
F_{sh} = 4233.3Kgf
F_{sh1} = 7056+4233.3 = 11529.6 Kgf
Again 20% of force is added to make the tool theoretically strong
F_{sh2} = 11529.6×0.2 = 2305.92 Kgf
Total shearing force = $F_{sh1}+F_{sh2}$ = 13835.52 =14000 Kgf
= 14T

Stripping Force
Stripping force = 15% of shear force
= 0.15×14 = 2.1T
Total Force (F) = stripping Force+ Shearing Force
` = 14+2.1+2.1 = 16.1T

6.4 Press Capacity

The total press capacity is 125% more than the total force calculated therefore
P_c = total tonnage×1.25
= 20.125T

6.5 Stress and deflection calculation for different elements of Progressive tool

a) Die Plate

Die plate is considered as a fixed beam. The shoe deflection is computed from strength of material concept for fixed beam. Equation for deflection is given by

$$\delta = \frac{FL^3}{192EI}$$

Where,
F=80% of shearing force = 109834.4N
E - Young's modulus = 2.1×10^{5}N/mm^2
I- Moment of inertia of plate in mm^4
L- Least distance b/w successive fasteners=45.6mm
Width, B = 167mm and thickness, H = 38mm

F = 109834.4 N
$I = \frac{BH^3}{12}$
I = 763635.33 mm^4
δ= 0.0003382mm

Stress generated in the die plate is given by, $\sigma = \frac{F}{A}$
Where A = B×H = 167×38 = 6346mm^2
σ =17.304 N/mm^2

b) Bottom Plate

Bottom plate is supported by number of parallel blocks hence we consider it as a simply supported beam. Using strength of materials, the deflection for simply supported beam with concentrated load, deflection equation is given below
$\delta = \frac{FL^3}{48EI}$, F = 80% shearing force =109834.4N

B = 287mm and H = 30mm
L = 62mm
I = 645750 mm^4
δ = 0.0040215mm
$\sigma = \frac{F}{A} = 6.172\ N/mm^2$

C) Top Plate
For analysis top plate is considered as a simply supported beam with concentrated load acting on it. The equation is given by
$\delta = \frac{FL^3}{48EI}$, where F=80%shearing force = 109834.4N

B = 287mm and H = 35mm
L = 60mm
$I = \frac{BH^3}{12} = 1025427.083mm^4$
δ =0.0022952mm
$\sigma = \frac{F}{A} = 10.93N/mm^2$

D) Stripper Plate
Assuming stripper plate to be a fixed beam, the deflection and stress calculation is done by adopting SOM concept as

F = 20% shearing force = 27458.6 N
B = 167mm and H = 24mm
L = 60mm
F = 20% shearing force = 27458.6 N
$I = \frac{BH^3}{12} = 192384mm^4$

$\delta = \frac{FL^3}{192EI} = 0.0007468mm$

$\sigma = \frac{F}{A} = 6.850N/mm^2$

E) Guide Pillar
Considering guide pillar as a cantilever beam with load acting vertically on it and guide pillar is considered as one side fixed and another side for free column construction. From strength of material, for column construction of one side is fixed and another side is free type.

Load acting on guide pillar = 80% shearing force = 109834.4N
Load per pillar $P = \frac{109834.4}{2} = 54917N$
Crippling load $P_c = \frac{\pi^2 EI}{4l^2}$

Where, E = 2.15×10^5 N/mm^2
Diameter of pillar = d = 28mm
Pillar length = l = 150mm

$I = \frac{\pi d^4}{64} = 30175.768\ mm^4$

P_c = 482708.54 N < 54917N
Since applied load is less than the crippling load therefore applied load is harmless for design.

$A = \frac{\pi}{4} d^2 = 615.83mm^2$
$\delta = \frac{pl}{AE} = = 0.0636969\ mm$

$\sigma = \frac{P}{A} = 89.9N/mm^2$

7. FINITE ELEMENT ANALYSIS

Finite element analysis was carried out in Ansys workbench 18.1. For analysis of tool, the five major elements of tool were chosen based on the maximum loading conditions. This helps to predict real condition of tool components in the operation. This helps to eliminate traditional way of validating the results by making prototype model and also saves time and money.

Meshing Condition

Table-2: Meshing Conditions

Parameters	Chosen
Physical preference	Mechanical
Element used	Solid 185
Element shape	Tetra hadron(Default)
Element size	Default
Mesh type	Medium size mesh

Analysis is done on die plate, bottom plate, top plate, and stripper plate and guide pillar. The results obtained from analysis is given below

i) Die Plate: for Die Plate D_2 steel is chosen

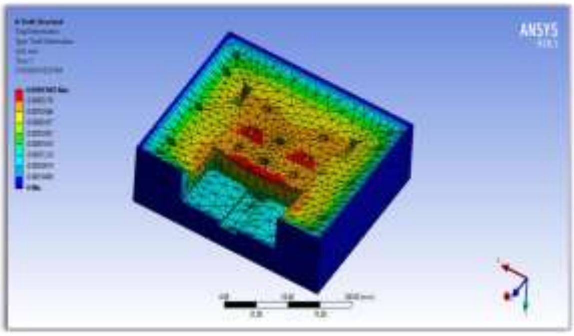

Fig-7: Total deformation of Die Plate

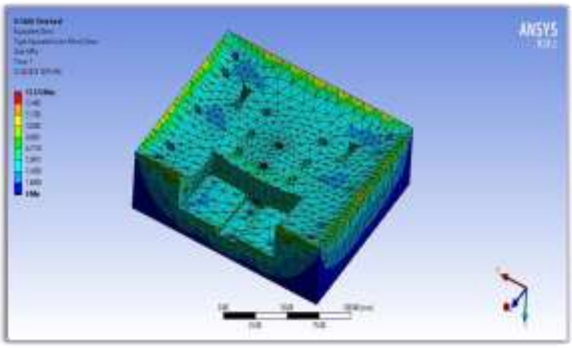

Fig-8: Equivalent stresses on Die Plate

ii) Bottom Plate: For bottom plate Mild steel is used

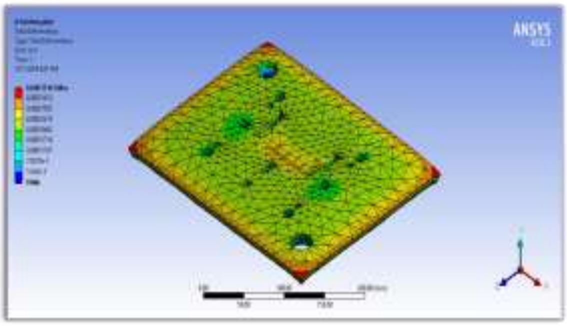

Fig-9: Total deformation of bottom Plate

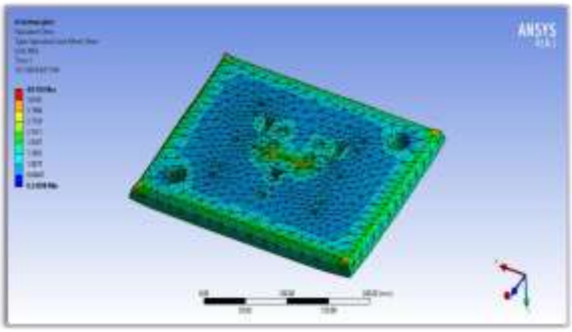

Fig-10: Equivalent stresses on bottom Plate

iii) Top Plate

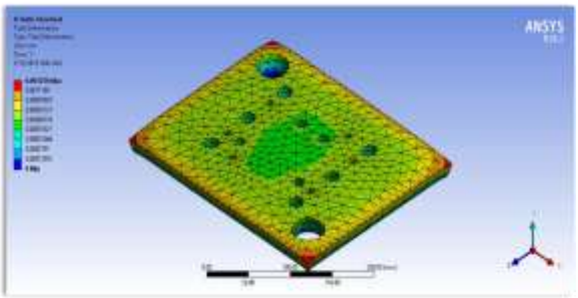

Fig-11: Total deformation of Top Plate

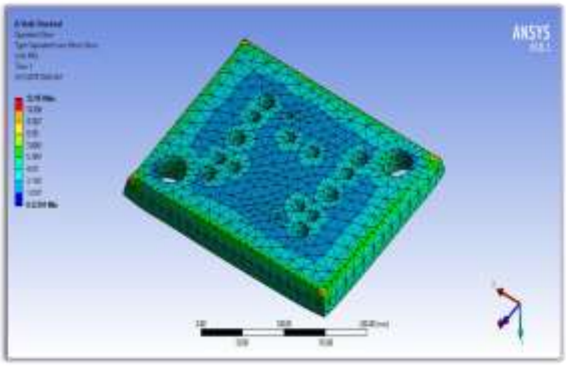

Fig-12: Equivalent stresses on Top Plate

iv) Stripper Plate: For Stripper plate EN-31 steel is used for Analysis

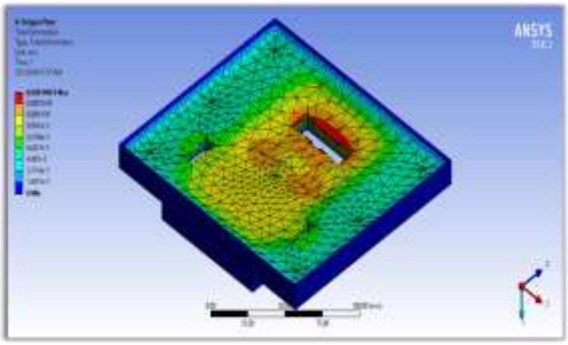

Fig-13: Total deformation of Stripper Plate

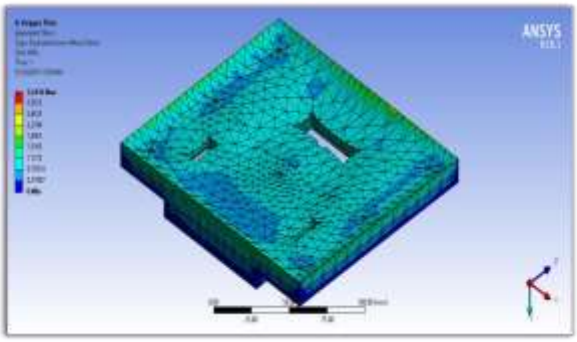

Fig-14: Equivalent stresses on die Plate

v) Guide Pillar

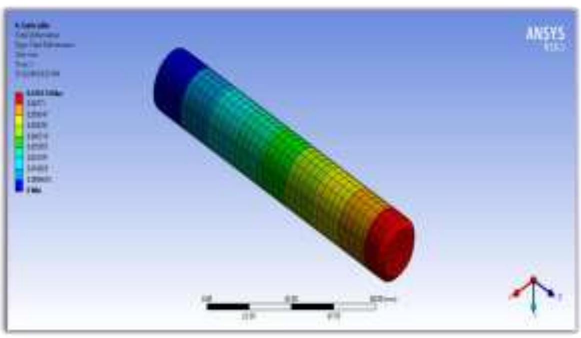

Fig-15: Total Deformation of Guide Pillar

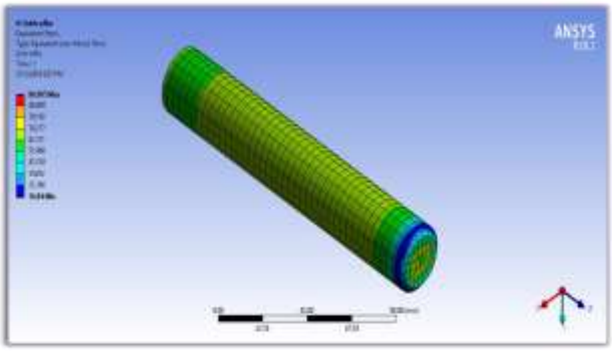

Fig-16: Equivalent stresses on Guide Pillar

8. RESULT AND DISCUSSION

The following Table- 3 shows the results of the cost analysis done for the raw materials and scrap materials which has been wasting and not using for any other purposes.

Table-3: Cost Analysis of Material for U-Bracket

Raw Material waste	Cost in Rs	Scrap Waste	Cost in Rs
Raw material per Kg	57	Scrap material per Kg	25
130Kg Raw material per day	7410	130 scrap per day	3250
Raw material per month (26 days)	192660	Scrap per month	84500
Total direct Loss per month			108162

Table- 4 shows the U-bracket component cost analysis and savings done by use of new designed tool

Table-4: Cost analysis of component

Description	Cost
Present cost of component	Rs.2
New component raw material cost per piece	0.32 paise
Processing cost for new component	0.50 paise
Savings per component	Rs.1.18

Table 5 and table 6 show the results obtained by ANSYS and theoretical calculations are made for different components of the progressive tool and results are compared with the Ansys Result

Table- 4: Deformation Result

Components	Ansys Result	Theoretical Result
	Deformation in mm	Deformation in mm
Die plate	0.00093685	0.0003382
Top Plate	0.00035361	0.0040215
Bottom Plate	0.001256	0.0022952
Stripper Plate	0.00014901	0.0007468
Guide Pillar	0.076174	0.0636969

Table-4: Stress Result

Components	Yield strength (Mpa)	Ansys Result	Theoretical Result
		Stress in Mpa	Stress in Mpa
Die Plate	1532	15.52	17.304
Top Plate	250	4.0376	6.172
Bottom Plate	250	12.19	10.93
Stripper Plate	450	3.4116	6.850
Guide Pillar	450	96.9	89.5

9. CONCLUSION

Progressive die is a cost-effective method to produce sheet metal parts with different characteristics which include strength, toughness and abrasion resistance, by the use of newly designed progressive tool it is possible to overcome the financial losses facing by the industry and Rs. 1, 08, 162 can be saved per month and also with this tool the cost of the component per piece is saved by Rs. 1.18. FEA analysis done for different parts and it is seen that results are in acceptable range and stress values obtained are less then yield strength of material and Deformations obtained from manual calculations closely match with Ansys results and were small in the range of recommended deformation. Bed size of mechanical press is 558×358 and tool dimension is 287×228mm therefore designed progressive tool perfectly fits onto the bed of mechanical press.

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