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Design and Finite Element Analysis of Guide Pillar for Compound Press Tool

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ABSTRACT

Sheet metal is one of the most important semi finished products used in the steel industry, and sheet metal forming technology is therefore an important engineering within that area of mechanical engineering. The development of new sheet metal forming processes, tooling and so on has up till now to a large extent been based on experience, trial-error experiments without or with only little use of scientifically based engineering methods. Identification of these uncertainties and quantifying them will facilitate a risk free manufacturing environment, which goes a long way to minimize the overall cost of production. This study recommends criterion for selection of Guide pillar. Further design is performed using suitable modelling software and Finite Element Analysis of the model is performed to reduce time and cost. Experimentation validation is carried out in SRES, Kopargaon Testing Lab. Necessary design changes and relevant test will be carried out to satisfy testing criterion of Guide pillar.

Keywords- *Press Tool, Failure Analysis, Guide Pillar, Compression Test, UTM*

I. INTRODUCTION

The compound die performs a series sheet metal working at one stage during the press running to produce a production part as the strip stock moving through the die surface. This work points towards failure analysis of Compound Press Tool used for Secondary Gasket. Further suitable changes are made to overcome the failure of tool with the help of FE analysis. Necessary testing has carried out to validate the FE results. [4] Sheet metal forming processes are used in making the parts of aircraft, automobile, ship. Deformation processes promise to be even more intricate to meet the need for high productivity, cheap price, and greater accuracy. Sheet metal stamping dies are used for both serial and mass production. Sagar Enterprises manufactures press tool as per specifications prescribed by the customer but after some day's period it fails due to wear or failure of some components encounters a big loss. Hence analysis of failure causes and recommend new alternatives to failed component is main objective of this work. Analysis is necessary step in between design and factory production. The compound press tool as shown in figure 1. [6]

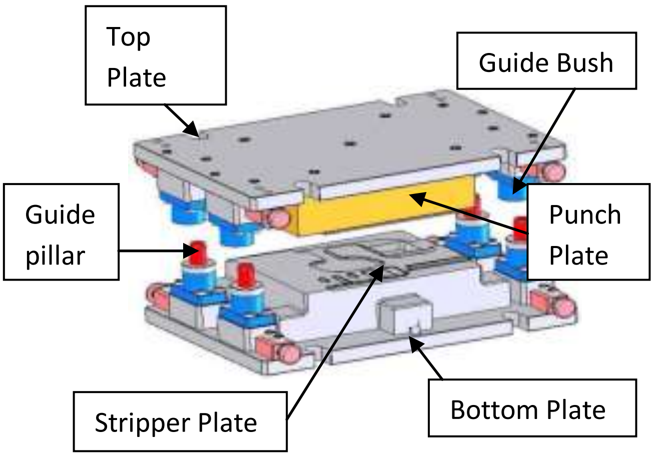

Figure 1. Compound Press Tool

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II. FAILURE ANALYSIS

2.1 General procedure of FEA [3]

- Pre processing
  - CAD model preparation
  - Meshing (Element descritization)
  - Set-up
    - Assigning material properties
    - Selection of proper element type
    - Assigning contacts
    - Applying boundary conditions
    - Applying loads
- Processing
  - Solution of mathematical models
- Post processing
  - Result viewing
  - Result analysis

2.2 Analytical calculations

Failure analysis of base model is important aspect of this work. For this analysis we must know the design parameters such as force applied, stress induced and deflection of assembly component. The theoretical calculations for component of compound press tool.

The forces are calculated from following relations-

Shear Force = $k \times L \times S \times t_{max}$ (1)

Also other forces that are cutting force, stripping force, press tonnage and all dimensional parameters of press tool are verified by analytical calculations. [1]

Further deflection, force applied on each part and stress is calculated by following relations.

For Guide pillar,

Deflection=Fl/(AE) (2)

$F = (\pi^2 EI)/4l^2$ (3)

Stress (s) =F/A (4)

Similarly, the theoretical calculations for other components of compound press tool are verified. [1]

2.3 Analytical calculation results

Table 1. Analytical results

Sr. No.	Part Name	Force N	Max. Shear Stress N/mm^2	Deformation mm
1	Top Plate	45115	3.68	0.02
2	Bottom Plate	45115	4.27	$0.8e^{-2}$
3	Stripper Plate	11278	6.26	$6.0e^{-3}$
4	Die Plate	45115	11.86	$6.8e^{-3}$
5	Dia.10 Piercing Punch	3166	50.42	$3.5e^{-3}$
6	Dia.23 Piercing Punch	7283	21.92	$8.0e^{-3}$
7	Guide Pillar	403649	1062	1.26
8	Blanking Punch	30076	21.35	$4.7e^{-3}$

From the above table we can come to know that Maximum shear stress of Guide Pillar exceed the value of Shear strength of EN31. FE analysis simulation gives the material behaviour and thus these analytical results are validated and we can provide a better alternative to overcome the cause of failure.

2.4 Image of failed guide pillar

Figure 2. The failed guide pillar

III. DESIGN AND ANALYSIS OF NEW MODEL

Therefore unsafe value of equivalent stress is the main cause of failure of the Guide Pillar. Thus to overcome this failure cause we have to take some corrective actions.

3.1 Corrective action against failure cause

Following table gives alternative to Guide pillar design in terms of dimensional changes and material.

Table 2. Design Alternatives to new model of Guide pillar

Sr No	Dia. Mm	E N/mm^2	Stress N/mm^2	Remark
1	22	210000	776.54	Reference
2	22	210000	1060.6	Base model
3	22	190000	959.67	Reducing E
4	22	215000	1085.9	Increasing E
5	32	210000	4747.8	Increasing Dia.
6	22	210000	695.92	Increasing length reduces stress induced
7	22	210000	541.80	
8	22	210000	433.74	
9	22	210000	391.45	
10	32	210000	778.77	Not feasible

Thus from the above tabulated results it is clear that by increasing length of guide pillar serves purpose of reducing stress induced. Also it will not affect dimensional changes in the mating parts.

3.2 Alternative model of guide pillar.

From the above table, alternative 8 is selected for further analysis. Dimension of new model is as follows;

- Diameter: 22mm
- Length: 190mm

An analytical result of new model is verified by using finite element analysis.
General procedure for FE analysis is

a. CAD model

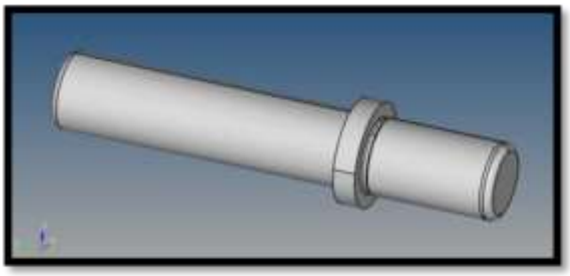


Figure 3. CAD model of guide pillar

b. Meshed model with boundary conditions

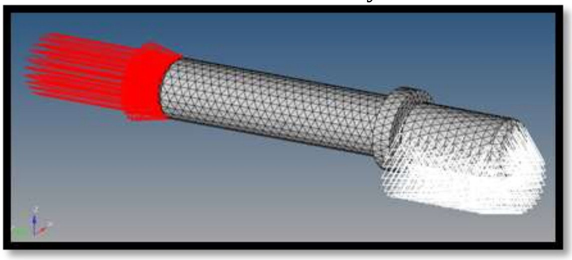
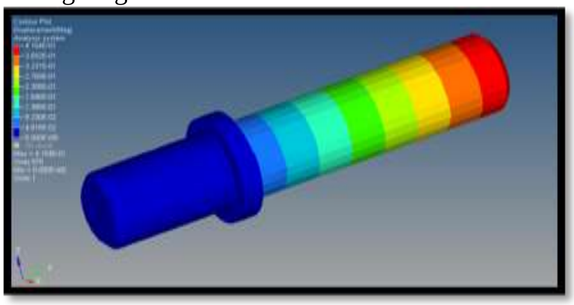


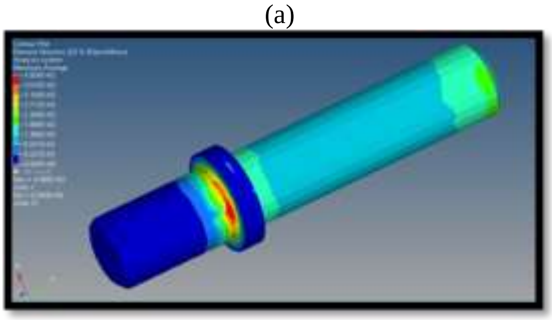
Figure 4. New meshed model with boundary conditions

c. FEA results.

Using radios as a solver and applying load as mentioned in table we have got following results for new model with increasing length.



(a)



(b)

Figure 5. Displacement and equivalent stress of guide pillar new model

From the analysis results we got displacement and equivalent stress as 0.415 mm and 406.8 MPa.

Table 3. FEA results of new model

	FEA	FEA
Part Name	Max. Stress N/mm^2	Deformation Mm
Guide Pillar (New Model)	406	0.4015

FEA results are matching well with analytical results. Also obtained equivalent stress < yield stress of EN 31 (i.e 450 MPa). Therefore new model of guide pillar is safe in design.

IV. GUIDE PILLAR COMPRESSION TEST

The test was performed on Universal testing machine SRES-C-1000 at Sanjivani College of Engineering, Kopargaon. The load 160 kN was applied on specimen for that load the deformation was obtained. After completion of test, specimen was dismantled from setup and kept for observation.
The experimental setup is as shown in figure 6.

Figure 6. Compression Test Setup

Before and after completion of Compression test the results shown in the figure 7 had observed respectively.

Figure 7. Guide Pillar

In compression test gradual load is apply on guide pillar, so we observe that there are no any variations in dimensions of the Guide pillar.

4.1 Compression test results

Table 4: Compression test results

	Experimental	Experimental
Part Name	Max. Stress N/mm^2	Deformation mm
Guide Pillar (new model)	450	0.45

Load vs Cross Head Travel

Figure 8. Graph of Load vs CHT

4.2 Comparison of FEA and testing results

For the sake of simplicity comparison of analytical solution with aid of FEA results and testing results are tabulated in subsequent section.

Table 5. Overall comparison sheet for stress

	Analytical	FEA	Exp.
Part Name	Equivalent Stress N/mm^2	Max. Stress N/mm^2	Max. Stress N/mm^2
Guide Pillar (New Model)	433	406	450

Table 6. Overall Comparison Sheet for Deformation

	Analytical	FEA	Exp.
Part Name	Deformation mm	Deformation Mm	Deformation mm
Guide Pillar (New Model)	0.39	0.40	0.45

From above summary sheet Experimental results are matching well with Analytical and FEA results. Also obtained deformation at 160 kN load is nearer same as obtained in analytical and FEA results. Therefore new model of guide pillar is safe in design.

V. CONCLUSIONS

- The results obtained through theoretical calculations and analysis are approximately nearer to the experimental values. This demonstrates that the experiment carried out was correct.
- It is observed that by increasing length of guide pillar serves purpose of reducing stress induced. Also it will not affect dimensional changes in the mating parts.
- In compression test gradual load is apply on guide pillar, so we observe that there are no any variations in dimensions of the guide pillar.
- In compression test of the guide pillar the obtained stress value was less than the allowable stress of the material and also obtained deformation at 160 kN load was nearer same as obtained in analytical and FEA results. Therefore new model of guide pillar is safe in design.

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