Modelling and Analysis of a Progressive Cam Tool for Blade Fuse Holder: A Case Study

Asif Afzal, Mohammed Sirajuddin, Abdul Razak R.K, Chethan K.M, Avinash
P. A. College of Engineering (Affiliated to Visvesvaraya Technological University, Belagavi), Mangaluru, India

E-mail: asif.afzal86@gmail.com

Abstract. Sheet metal segments delivered from press working find wide applications in the territories going from telephonic gadgets to space stations. To design a progressive tool for sheet metal components according to the given details is a testing assignment. This article covers design and modelling of a progressive cam press tool for the component blade fuse holder, which is used in the Printed circuit boards of cars. Few very essential basics of press tools are briefly mentioned. The design and modelling process begins with the careful examination of the component geometry and material specifications. The tool development and modelling of the tool carried out by modelling software Solid Works are provided in detail. Points of interest and detriments of progressive tools over stage tools are additionally spotlighted.

1. Introduction
Sheet metal is a metal formed into flat and thin pieces. It is one of the fundamental forms used in metalworking and can be cut and bent into a numerous different shapes. Countless day to day objects are constructed from the sheet metals [1]. Thicknesses can vary significantly, even though extremely thin thicknesses are well thought-out for foil or leaf, and sheet metal components that are thicker than 0.25 inches (6 mm) are usually considered for plates. Sheet metal is accessible as flat pieces or as a coiled strip. The coils are produced by running a continuous sheet of metal through a roll slitter. The thickness of the sheet metal components is known as its gauge. The sheet metal gauge typically varies from 8 gauges to about 30 gauges. The higher the sheet metal gauge, the thinner the metal will be. There are several different metals that can be prepared into sheet metal, such as brass, aluminium, copper, nickel, steel, titanium and tin. For decorative uses, important sheet metals include platinum, gold, and silver [2].

Sheet metal has applications in car bodies, airplane wings, and roofs for building, medical tables, and several other things. The sheet metal of iron and of materials having high magnetic permeability, which is also known as laminated steel cores, has many applications in electric machines and transformers [3]. Historically, a vital use of sheet metal was in plate armor worn by horse cavalry, and further sheet metal continues to have various decorative uses, together with, in horse tack [4], [5]. The prime objective of this work was to design a progressive cam tool to produce the component that exceeds the expectations of the consumer in aspects like cost, quality and on time delivery. It holds out the strong probability of achieving, reduced overall cost of manufacturing a product by producing acceptable parts at the lower cost, raise the production speed by designing tools that will generate parts
and rapidly possible and uphold quality by designing tools, which will, over and over again produce parts with the obligatory precision [6-14].

The rest of the paper is composed as follows: Section II presents the component study and its drawing. Section III gives the 3D modeling details of tool and analysis details of the component. Section VI presents the manufacturing of the component. In section V we conclude with a brief report on challenges and hereafter work in progressive tools.

2. Progressive tool
The major parts of standard press tool die and progressive tool are mentioned in this section. Important press cutting operations generally employed are also mentioned.

2.1. Press Tool Elements
In general press tool consists of the following two half’s:

- Top half, which consists mainly of: Punches, Punch plate, Punch back plate, Top plate/ top bolster, Shank, Guide bush. All these parts are shown in Figure 1 and 2.
- Bottom half, which consists of: Stripper plate, Guide plate, Die plate, Bottom plate/ bottom bolster, Guide pillar. All these parts are clearly shown in Figure 2 and 3.

![Figure 1. Press tool elements](image_url)
2.2. General Press Tool Operations
General operations done carried out using press tools are mainly:
- Cutting operations: Piercing, Notching, Trimming, Cut off and Part off.
- Non cutting operations: Bending, Forming, Drawing, Curling and Dimpling.

3. Design of progressive cam tool
3.1. Component: Blade Fuse Holder

The study of the component is the most important and the first step for the designer. The component drawing is studied to know the important features like its geometry, special and important features of the component. The component drawings are carefully scrutinized to extract the maximum possible amount of information as shown in Figure 4. The solid models of the component are as shown in Figure 1-3. By using these models the entire tool is built. Table 1 gives the details of the component.

![Component drawing and its application](image_url)

Figure 4. Component drawing and its application
Table 1. Details of the component

| Name of the component | Blade fuse holder (Clip for PTF200) |
|-----------------------|-------------------------------------|
| Material              | CuSn5 (Phosphor bronze), Typical cold |
| Mass of the component | 0.48 gms(approx)                    |
| Weight of the component | 4.7 N                             |
| Thickness of the component | 0.4±0.05mm                          |
| Density of the component | 8.85 gm/cm³                       |
| Length of component   | 11.0±0.2                           |
| Width of component    | 7±0.1 mm (approx)                  |
| Number of components required | 1,75,000/ week                     |
| Maximum height        | 3.2 mm                             |
| Minimum height        | 2.8 mm                             |
| Volume of component   | 54.08 mm³                          |
| Surface area of component | 135.2 mm².                      |

3.2. Calculation

Figure 5. Wide Row Strip Layout

- Strip Width = 14.5 mm
- Pitch = 18.2 mm
- No. of Stages = 9

Figure 5 shows the strip layout designed for the progressive tool having nine stages wide strip layout. The following shows the values of different parts of the tool calculated using suitable appropriate formulas mentioned in Table 2.

Table 2. Details of the parts of tool

| Part of the tool         | Formula                                      | Values approximated |
|--------------------------|----------------------------------------------|---------------------|
| Scrap for the Strip      | A = 1.0 x t (For Single row)                 | 1.0mm               |
| % Area of Utilization    | Area of Blank x No. of Rows x Strip Width x Pitch | 51.23 %            |
| Press tonnage for press selection | total shear force required 70 - 80 % | 25T press          |
| Cutting Clearance        | C = 0.005 x t x √fs                         | 0.015 mm per side  |
| Punch plate              | Thickness= 0.75 x Td                        | 19mm                |
Punch back plate  Thickness= 0.5 x Td  9mm
Stripper plate  Thickness= 0.75 x Td  19mm

3.3. 3D modelling of tool and analysis of the component
The finite element method (FEM), which is sometimes mentioned as finite element analysis (FEA), is a technique which performs computations to produce approximate solutions of boundary value problems in almost all the fields of engineering. Depending on the nature of physical problem being analysed, the field variables may include temperature, fluid velocity, physical displacement, heat flux and to name only a few. This section gives the complete 3D model on the progressive cam tool in different views. This tool was modelled using Solid Works modelling software package. Analysis carried out using the same software is also presented for the Blade Fuse Holder. Number of nodes created for FEA analysis are 2396 with number of elements = 1461. Force applied on the top curl of the holder is equal to 1 KN/ m2. Tetrahedral element mesh was created applying fixed i.e. no deformation at the bottom of the holder as it is in contact with the fuse extension part as shown in Figure 6. Displacement and stress concentration analysis of the component was carried out for the applied force.

4. Results and Discussions
4.1. 3D Model of Tool
The 3D model of the tool designed according to values obtained in Table 2 is modelled accordingly as shown in Figure 8. The designed and modelled tool in its closed form, top half, bottom half and explode view showing the entire parts of the tools are provided below.

![Figure 7. Top half and bottom half of the tool](image1)

![Figure 8. Assembled half of the tool and exploded view of the tool](image2)

4.2. Analysis for the progressive component

The finite element analysis of the blade fuse holder component using Solid Works software is shown in Figure 9-10. From Figure 9 it can be seen that the maximum deformation is occurring at the end of the curled component. This occurrence is due to expansion of the component during its assembly with the actual blade fuse. The component is considered to be fixed at its flat end, hence there is nil deformation. However a closer look reveals that the stress concentration is highest at the junction of curled component and the U shaped part as shown in Figure 10. It is worth emphasizing that there has to be a further deeper investigation using coupled thermal, mechanical, and electrical consideration as during the operation electric current continuously flows through the component leading several structural changes. From the above analysis it is clear that the component does not have any effect on the physical behaviour. As load applied and deformation is very less leading to very less stress concentration, this component is safe to be used in electrical parts. Force applied to the part is almost nil hence it does not affect the material.
Figure 9: Displacement to the component

Figure 10. Deformed part of the component during assembly and stress concentration

5. Conclusion
In this work, modelling, study and analysis of the progressive tool for blade fuse holder was carried out successfully. The drawing of the component was studied carefully using Auto Cad, as it was more critical to do its development. The three dimensional modelling of the progressive tool using cams employing solid works is carried out successfully. Also, the analysis of blade fuse holder component was performed using the same software. While modelling the tool it was found that the component needs cam for its curling operation hence increasing the complexity of modelling and number of press operations. Employing cams further can be avoided for designing of progressive tools as it leads to increased manufacturing time and cost. Stage tools to be preferred for complex press operations. Progressive tools anyway reduce labour cost and provide increased production. Analysis, carried out using Solid Works suggests, having no effect of force and displacement on the component.
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