Design and Development of a Press-Tool Assembly

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Abstract— The report consists of Press tool operations and explains principle of tooling. The project is an industrial project for 'Mungi Brothers'. The company has provided a component which is the bracket used in chassis mounting for which the press tool is to be manufactured. The project details with material selection for every component required in press tool. It includes the design of the blank required for the component. All the components required in the press tool are designed followed by selection of press of required tonnage. The part models are also included in this report. The inspection and testing procedures are explained.

Keywords: Press-Tool, Blank, Tonnage, Bracket, Operation

I. Introduction

The project consists of sheet metal working with operations performed as forming and piercing in press tool. The component produced is connector whose assembly is used in smoke detector. The major considerations are tool life, replaceable die inserts and stripping force. We have a progressive die which is a multiple station die in which strip moves from one station to another to produce a part. The selection of multiple operation die is justified by principle that number of operations achieved simultaneously is more economical than single series operation dies. The advance of strip in each stroke is pitch and, in each stroke, we get some metal removal. The required profile is cut by applying appropriate stripping force. As component requirement is high, the progressive die results in greater saving in handling cost. For high shocks and continuous trial runs, the progressive die is heavily constructed.

The various other factors include obtaining the exact size of strip provision of crop punch is accommodated as the width of strip will not always be available as required. Proper cutting clearance is critical for life of tool and quality of pierced part. Dropping of the component without stacking or scratching edges is very important for which provision of proper angular clearance and stripping plate is made. Ball cage bearing is provided for smoother guide motion between guide pillar and guide bush.

II. Objectives of the Project

1) The main objective of this project is to have high tool life with good productivity.
2) Assisting in tool design, catering for factors and reducing material waste by proper and effective utilization of material and strip layout.
3) Increase die life using proper material for punch and die, proper tolerances for various mating components and various heat treatment processes on die plate for absorbing continuous shocks and loads.
4) The inspection of component is to be carried out so as to ensure complete dimensional data to which the component should conform.
5) Testing of tool is to be carried out on production and continuous basis so as to ensure that tool performance is consistent.
6) The next and final objective is the cost estimation which is carried out to determine the various costs incurred in the manufacture of press tool.

III. Design Procedure of Press-Tools

1) The Determination of force (press tonnage) required for operation
2) Selection of press for requisite force, work piece size and shape
3) Determination of shut height of the tool
4) Computing die thickness, and margins (minimum cross section)
5) Drawing strip layouts and comparing material utilization
6) Design of locating elements
7) Selection of hardware
8) Drawing Die plan and selection of pillar die set
9) Deciding punch length and mounting
10) Finding center of pressure and checking scrap disposal
11) Drawing details

A. *Materials used for tool Elements*

1) Mild Steel: Guide Pillars and bushes

Most of these parts to not require hardening and can be made using cost effective material. These parts only require hard skin for high wear resistance. Mild steel parts are case hardened to provide a tough exterior therefore guide pillars and bushes are manufactured using MS.

2) High carbon steel (0.85% Carbon) 61 RC hardness: Punches

These require grinding after heat treatment as there is distortion due to heat and can be cured by grinding only. They are hard elements which require to have high hardness number as they are responsible for piercing operation in the tool

3) C40 Steel (0.4% Carbon): Fasteners (Allen screws, nut bolts)

As these elements are subjected to high amount of tensile stresses, the quality fasteners are made out of C40 Steel.

4) High Carbon, High Chromium (HCHC) Non-shrinking tool steel: Dies, upper plate, Lower plate

This steel gets a little distorted in heat treatment. It is nearly impossible to finish small closed profiles of blanking dies. Such dies must be made from non-shrinking tool steel.

B. *Blank Design:*

Component thickness, t =4mm

A component is usually blanked before bending. Consequently, it is necessary to calculate the length before bending or the developed length of the workpiece before blanking is to be designed.

The formula for developed length,

Given that, $R < 2t$

We have R=6 mm and t=4mm

L= $\frac{\pi}{180} * A * (R + 0.33t)$
A= Angle of bend in degrees
R= Radius of bend in degrees
t= thickness of the sheet
L= Developed length
Therefore,
L= $\frac{\pi}{180} * 90 * (6 + 0.33 * 4)$
L= 11.492 mm
Therefore, the total length,
L_t =2*L1 + L2+ 2*L
=2*132+ 55+ 2*11.4
=341.8 mm
This is the total length of the required blank.

C. Press tool Design

For calculating the forces required for forming and piercing operations,

Bending force depends on width W, worksheet thickness t, and tensile strength ft, as well as length to be bent to form the required shape.

Forming Force= $V_f = \frac{2.66LT^2ft}{W}$
L= Transverse length of the bend
T= Thickness of the blank
ft= Tensile Strength of the blank
W= Width of the formed blank
$V_f = \frac{2.66*115*4^2*355}{63}$
= 27.579 tonnes ~ 28 tonnes
Minimum die clearance
For Mild Steel minimum die clearance is given as 2.5-5% of sheet thickness
Therefore, considering 3.5% of 4mm we get,
die clearance = 0.14mm

D. Selection of Press

Generally, the press is selected such that the press should be capable of delivering at least 33% more force than required for the operation.

Therefore, minimum capacity of the selected press should be 133/100*28 = 37.24 tonnes ~ 38 tonnes
Die insert
Thickness= $(Fmax)^{1/3}+(0.4Fb)^{1/3}$
= $(38*1000*9.81)^{1/3}+(0.4*28*1000*9.81)^{1/2}$
= 74mm
Width = L- bend allowance
=155-11.4
=143.6mm
Pad
Width = straight length of formed bottom portion of blank + 2xt = 67+2*4 = 75 mm
The selected dimensions of the components according to company standards,
Lower Plate
Standard plate of fixed dimensions as per required L*W*T
Length= 600mm
Width= 450mm
Thickness= 48mm
Upper Plate
Standard plate of fixed dimensions as per required L*W*T
Length = 600mm
Width= 450mm
Thickness= 48mm
Riser Plate
Length = {2(top of the lower steel housing= length of lower steel) + [(2* sheet thickness) +pad width+ C)]}
=2(18.42+116)] +[(2x2) +195+1]
=450mm
Shut Height= 350mm
Bottoming Block
Length = Distance between vertical forces of lower steel housing – 2xC
= 42-(2x1)
=40 mm
Length = Diameter= 40mm
Width= [width of riser – diameter of spring – 2xC]
= [184-120-(2x2)]
= 60mm
Tool Shut height
For the Press Shut height of 350mm and Ram adjustment of 80mm and 70mm stroke
Maximum tool shut height= 350-10= 340mm
Screw adjustment – regrind allowance= 80 mm - 20mm=60mm
Minimum tool shut height= 340-60mm=280mm
Optimum tool shut height= minimum tool shut height+ regrind allowance = 280+20= 300mm

1) Strip layout and feasibility:

In the design of die set, the 1st step is to prepare various configurations of strip layout possible. Strip layout is the position of the component in the metal strip and their orientation with respect to each other. After strip layouts are prepared, we select the most feasible layout for the given application.
The factors which influence the strip layout are:

1) Economy of the material
2) Direction of material grain or fibre
3) Strip or coiled stock
4) Direction of burr
5) Press Used
6) Production required
7) Die cost

The most appropriate strip layout is also based on the scrap produced. There are two types of scrap:

1) Design scrap: This scrap is produced due to functional requirement of the component. This scrap cannot be eliminated.
2) Tool scrap: This scrap is produced due to the arrangement of components in strip layout. This must be kept as minimum as possible.

E. Selection of fasteners

Any misalignment of die plates may cause severe damage. Therefore, these plates are fastened with the help of fasteners. Along with screws, dowel pins are also used for alignment purposes.
They are selected on the basis of the following:

1) Socket Headed Cap Screw:

a) Stripping Force (F_s):
The force required to strip the blank from the strip is called as stripping force.
F_s = 20 % of C_f … (17)

Where,
C_f = Forming force
= 20 % of 28000
= 15.6 kN
Stripping force is used in selecting the number of screws required.

b) Selection of Screws

Stripping Force		M6	M8	M10	M12
TONS	kN				
1.25	12.455	8	4	3	2
1.6	15.942	-	5	3	2
2.5	24.910	-	8	5	4
4	39.856	-	-	8	6

Table 1: Number of screws based on stripping force

Size – Nominal Diameter in mm	Pitch in mm
M 6.00	1.00
M 8.00	1.25
M 10.00	1.50

Table 2: Reference Table for ISO terminology of Size and Pitch

Since the calculated stripping force is 22.59 kN, the number of M8 screws selected is 8. Also, for metric threads of diameter 8 mm, the standard pitch is equal to 1.25 mm. The data related to this is shown in table 2.

c) Root Area of Cap Screw

Root area of cap screw = 0.7954 [D – (1.227 x P)]^2… (18)
Where,
D = Diameter of nut (mm)
P = Pitch of nut (mm)
Root area of cap screw = 0.7954 [8 – (1.227 x 1.25)]^2
= 33.25 mm^2

d) Load Capacity

Load Capacity = Root Area x Design Stress … (19)
= 33.25 x 120
= 3.990 kN
The number of screws used is 8.
Total Load Capacity = 3.99 x 8
= 31.92 kN
For safety purposes, the load capacity i.e the load which the screws can sustain, must be greater than the stripping force. If it is less than the stripping force, the press tool will fail.
Since Load Capacity is greater than Stripping Force i.e. 31.92 kN > 22.59 kN, selection of screws is appropriate.

e) Dowel pins

For the simplicity the diameter of dowel pins is selected same as that of the cap screws. The selection of dowel pins is as follows.
Consider the number of dowel pins n_{dp} = 4

$$F=\frac{\pi d_c^2 n\sigma}{4} \quad \ldots (20)$$

Where,
d_c = Diameter of dowel.
n = Number of dowels.
σ= Design stress = 90 N/mm^2

$$F = \frac{\pi(8)^2(4)(90)}{4}$$

= 18.095 kN
Since, 18.095 kN< 22.59 kN
The system will fail.
Now, consider the number of dowel pins n_{dp} = 6

$$F = \frac{\pi(8)^2(6)(90)}{4}$$

F = 27.143 kN.
Since, 27.143 > 22.59 kN i.e. stripping force, the design is safe. others.

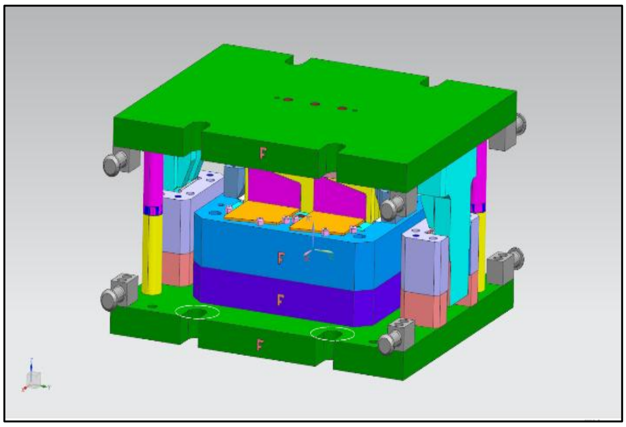

Fig. 1: Complete Press CAD Model.

IV. Testing

The dimensions of the component, its surface finish and geometry are dependent on inherent quality of press tool and their accuracy. Also, for mass production, various products must be of such accuracy that they may be assembled on a non-selective basis. A press tool operated on a power press is subjected to continuous reciprocating motion which causes compressive and tensile forces on the tool. For this, the alignment and force carrying capacity must be proper. For checking these parameters; it is necessary that the press tool should be tested to give the required productivity.
Types of tool testing trials:

A. Tool Trial Run (TTR)

After assembly, the tool is then mounted on the power press to take out the first component for which the tool has been designed. During this trial, correct raw material is used to ensure proper functioning of the tool. About 10-15 parts are tried out and its inspection is done as per the drawings and specifications given by customer.
These components are then inspected on profile projector and the detailed report is prepared.

B. Production Trial Run (PTR)

After the first component inspection report is prepared, the pilot lot of 3000 component is produced. During this trial, a component is inspected from each hour lot, to check the uniformity of dimensions of component throughout the Production Trial Run (PTR). Also, the tool is tested for continuous production to check parameters like wear and tear, misalignment and heating of tool. After the pilot lot of 3000 components, no wear and tear of the tool was observed because of the material used. D2 – High Carbon High Chromium steel material used ensures no wear and tear of the components. Subsequently, the life of tool increases.

V. CONCLUSION

While performing the project, the design, manufacturing, inspection and testing was done on the press tool. Special attention to the design, material selection and inspection of the component was given. The result of the project is determined based on the proper functioning of the tool for long period and the dimensional correctness of the component. After modelling the component has been analyzed using analysis software, ANSYS. The analysis is complete and conforms the company measures the press tool. On completion of manufacturing the machine, proper inspection and quality check were carried out where the accuracy and precision of the tool were measured. Using progressive tool, the time required for performing operations was reduced by 1 second per component. Hence the total cost of the tool was reduced. As the tool life is the major criteria of our project, the increase in tool life was achieved by using suitable methods.

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