Design of Die for Industrial Part

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Abstract

An accurate design of the product and data required for manufacturing is must before converting raw materials to a finished product. If the design is not accurate then defects will occur in the manufactured product. This paper presents a design of die by combining the blanking and two piercing operations for industrial part in single die. Compound die generally consist of blanking and piercing operation which are performed in single press stroke. This design tool is manufactured by company and used in cargo load body. Required modelling is done with CATIA V5.

Keywords: Die design, blanking, piercing, industrial part,Catia V5.

I. INTRODUCTION

The blanking die design and modelling process for sheet metal operations is quite systematic and involves various activities such as checking of part design features from manufacturability point of view, choice of manufacturing operations, selection of the type of die, selection of the press machine and selection of the dimensions of the die components. Compound die generally consist of blanking and piercing operation which are performed in single press stroke. There are many ways to design a compound die, but since there is no place for the finished part to go during a compound die's operation, the part must be pushed back into the scrap web such that it can then be carried out of the tool and extracted in one or another fashion later in the die cutting operation. This necessity for a separate parts extraction process is one downside of the compound die system. Advantages of a compound die system, first and foremost being the high and unsurpassed mechanical accuracy of a single step process. A second advantage of a compound die set up is its throughput. Because all internal and perimeter features of the part are created in one cycle. That means that if a strip is designed to create 10 parts, these 10 parts will be created in 10 press strokes.

II. Selection of Tool Steel and Die Component Materials

The die components are constructing from Tool steels used in a variety of press working operations which is subject to wear. As If this tool steels are heat-treated develop high level of hardness and abrasion resistance. The important in all industrial manufacturing processes is that the production runs are trouble free during cutting operations of sheet metal parts. It is important to achieve good productivity and tooling economy, selecting appropriate tool steel is crucial.

As some standard items are involved, the whole system may not require high strength material. It could be made from less expensive materials; the researchers categorize the selection of materials under three groups. Tool steels are used to construct the die components subject to wear. They are used in a variety of press working operations. These steels are designed especially to develop high hardness levels and abrasion resistance when heat-treated. Selection of tool steel for a specific operation must be based on two major considerations:

i. for an application Predicting the performance of the steel and
ii. The limitations associated with the manufacturing of tools and dies analysing.

A high-carbon, high-chromium tool steel alloyed AISI D2 is with molybdenum and vanadium characterized by: high wear resistance, high compressive strength and high stability in hardening and good resistance to tempering back. In most worldwide AISI D2 material is the most widely used tool steel. It also fulfils the requirements of the manufacturing of piercing and bending punches and dies plate. The remaining parts can be manufactured by structural steel St-42 a less expensive material suite for structural parts.

III. Die Design Calculations

The design of compound die for industrial part which includes blanking and two piercing operation. After these operations further operations will be performed on part to get finished product. Here we are focusing on blanking and piercing operation. Detailed design procedure is given below. Figure 1 and 2 shows the view of part.

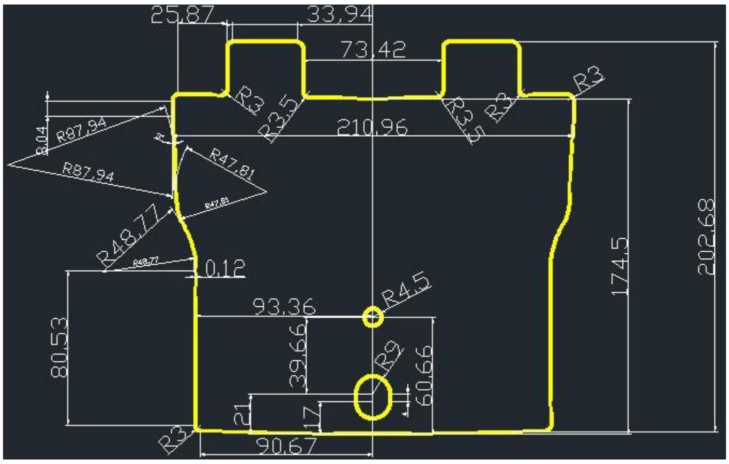

Fig:1 Developed blank Fig: 2 Finished blank

A. **Die Clearance and Tool life**

The standard clearance among the die and punch cutting edges depend upon the material properties. To avoid the drawon out of soft metal from gap, usually the die clearance for ductile material is less. Otherwise the for hard material large clearance is required. To reduce the burr die clearance need to be less. But the blunting of the cutting edges of dies and punches gets accelerates. The recommended Die clearance is 2.5% to 5.0% of thickness. That is:-0.04 mm and 0.08 mm is the Minimum and maximum die clearance is to be taken.
From this,
Size of Die hole = diameter of punch + 2*(per side clearance of die)
To increase the tool life the die clearance must be doubled from 2.5% to 5% (for sheet of mild steel) so that the tool life doubles.

B. **Design of Optimum Strip Layout**

Strip layout as shown in the fig 3. Economy Factor is depending upon the strip layout.

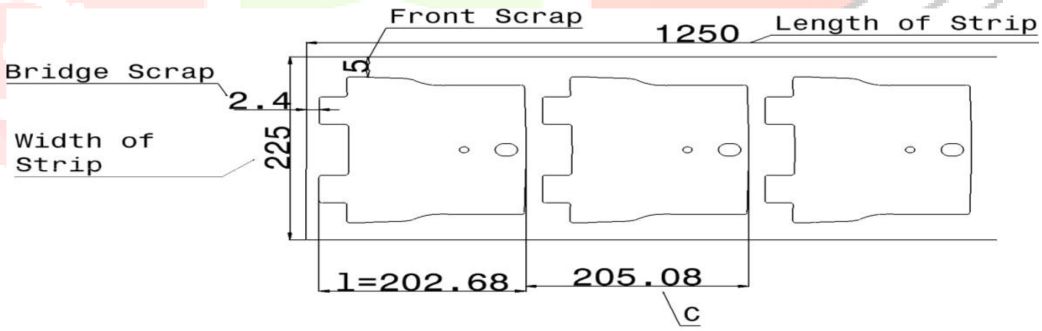

Fig: 3 Optimum strip layout

Bridge Thickness (B):- B = 1.5t =2.4mm
Distance between two consecutive point on 2 parts (C):- C = l + B= 205.08 mm
Front scrap (A):- A = t + 0.015 H=5mm
Width of strip (W):- W = H + 2A =225mm
No. of parts per strip (N):- N = L/C =6 parts
Length of part (l) =202.68, width of part (H)=210.96

Economy factor $= \frac{part\ area\ x\ no.of\ parts\ per\ sheet}{sheet\ area} x\ 100$

$= 91.22\%$

C. **Calculation of Force required**

1. Shearing Force**:-**to pierce a hole in part the shear force given as:

Fs = perimeter of part * t *τ
t- Thickness of part

τ –part material Shear strength
here, as two holes of different size are to be pierced So the shear force for piercing these two holes is given by;
Fs_1 = Perimeter of punch 1* t * τ
Here;
Perimeter of punch 1= 28.27 mm
Therefore, Fs_1 = 17.75 KN
Fs_2 = Perimeter of punch 2* t * τ
Fs_2 =45.54 KN
The shear force required for blanking operation is given as:
Fs_3 = Perimeter of Blank * t * τ
Here; Perimeter of Blank = 849.52 mm
Fs_3 = 533.2 KN

2. Total Shear force is given as;

T.S.F. = Fs_1 + Fs_2 + Fs_3
= 17.75+45.54+ 533.2
T.S.F. = 596.5 KN

3. Stripping Force:

Stripping force is required to remove the strip from the punch after the cutting operation. It is given as 10% of Total shear force.
Stripping Force = 10% of total shear force
= 0.1 x 596.5 = 59.65 KN

4. Total Required Force:-

Total force require for cutting is given as;
T.F. = T.S.F. + Stripping Force
= 656.15 KN
From the die design book, 20% of factor of safety is taken.
Requirement of press capacity is = 120% of Total Force
= 787.38 KN= 81 Tone
But the existing 100 tone of press machine capacity is suitable for the above requirement.

D. **Thickness of various plates -:**

Die plate (T_D)= $\sqrt[3]{\text{F1 in kg}}$ = $\sqrt[3]{533.20}$ =38 mm
Bottom plate = 1.5 T_D = 57 mm
Stripper plate = 0.5 T_D = 19mm
Punch holder plate = 0.75 T_D = 29 mm

E. **Design of punch for piercing operation**

Press tool material is selected for Punch. For the purpose of cutting operation punch material must be harder than part.So for the punch manufacturing d2(type of steel) material of 52-56 HRC hardness is used. The punch travel is given by the following formula,
Travel = Entry in Strip + Entry in die + Part Thickness.
= 5 +5+ 1.6 = 11.6 mm
Thickness of punch is depending on the punch alignment with stripper plate, compressed length of spring, and with punch travel. So here we take 45 mm as punch thickness. In blanking operation the clearance is given on punch.
For the length of piercing punch is larger than its diameter. So the overall performance get's affected by length of punch. By Euler's formula the critical force acting on punch is given as;

$$F_{cri} = \frac{2\pi^2 EI}{l^2}$$

Where;
E – Elasticity of material (For D2 steel material it is 2.1 x 10^5 N/m^2)
I – punch Minimum moment of inertia for

5. DESIGN OF PIERCED PUNCH 1

Shear force required = t * perimeter of punch 1 * τ
=40.51 KN/mm^2

=5 tone

The maximum length of punch is

$$l_{max} = \sqrt{\frac{2\pi^2 EI_{\min}}{p}}$$

Where; load acting on a punch 1is P - (40.51KN)

$I_{min} = \frac{\pi D^4}{64} + \frac{bd^3}{12}$

$I_{min} = 7097\ mm^4$

∴ lmax = 852.18mm

To work safely this is the maximum length.

Here as per the size of die take the length of punch as l = 90 mm.

Area of punch is;

$A = \frac{\pi D^2}{4} + (L \times D)$

Where, L=4 mm, D =18 mm

$A = 326.47\ mm^2$

6. Design of pierced punch 2

Shear force required = t *perimeter of punch 2 * τ

=17.75 KN/mm^2

= 2 tone

$I_{min} = \frac{\pi D^4}{64} = 322.06\ mm^4$

The critical maximum length of punch is

$$l_{max} = \sqrt{\frac{2\pi^2 EI_{\min}}{p}}$$

Where; P - load acting on a punch 2 (17.75KN)

$l_{max} = 274.25mm$

To work safely this is the maximum length. Here as per the size of die take the length of punch as l = 90 mm.

Area of punch is; $A = \frac{\pi D^2}{4}$

Where, D =18 mm, $A = 63.62\ mm^2$.

IV. WORKING OF COMPOUND DIE

As per design calculations the modelling of compound die is done in CATIA V5, and manufactured by company. Once die is attached to press, during down stroke the operations blanking and punching is done at time produce the part. Once the operations are complete during upstroke of press ejector pin will eject part from the die.

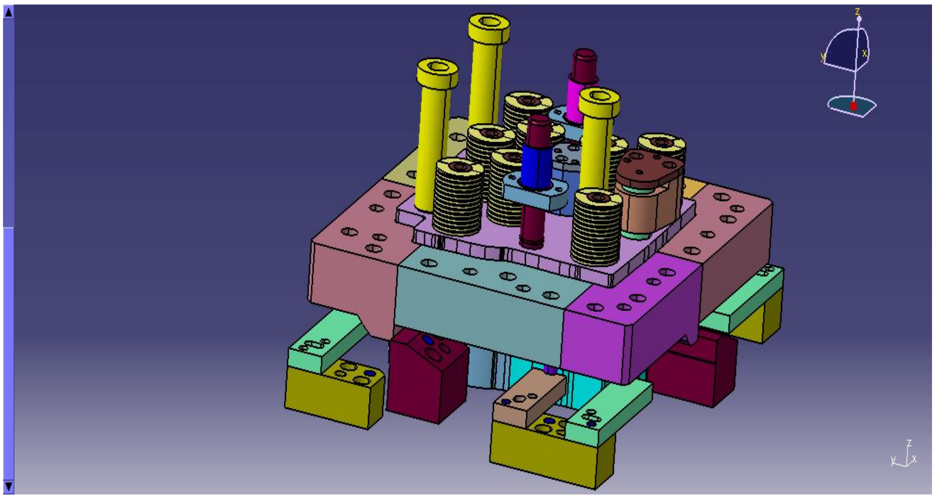

Fig.4: 3D Model of compound die

V. Conclusion

Pierced parts produced form compound die are very accurate and identical because all operations are carried out in a single station. Combining one blanking and two punching operations in single die, results decrease in size of die as compared to progressive die. Cost of manufacturing a compound tool is normally lesser than that of a progressive tool or casting for the same component.

REFERENCES

[1]Ch.Mastanamma, K.Ch.Mastanamma, K. Prasad Rao, Dr. M. Venkateshwara rao, "Design and Analysis of Progressive die" IJERA 2016,

[2] Shcy Ivana, Handbook of Die Design, 2nd edition McGrawth-Hill, 2006.

[3] J.A.W.Hijink, T.H.Elndhoven, A.C.H. Van Der WolF, "On the design of die-set" annals of the CIRP, 1975, vol 24.

[4] Bhaskar Jyothi, G Sathya Prakash, "Die design and analysis of progressive tool for can lid lever" IJREAT, Volume 1, 2013.

[5]Nicholas zabaras and akkaram srikanthm, "An objectoriented programming approach to the lagrangian fem analysis of large inelastic deformations and metal forming processes international journal for numerical methods in engineering". 1999,vol 45,399– 445.

[6] P. C. Sharma, "Production engineering" S.chand publication,1st edition, 1982,

[7] P. H. Joshi, "Press Tool Design and Construction" S.chand publication,First edition, 1989,

[8] Sneha S. Pawar1, R. S. Dalu2, 2014, "Compound Die Design: A Case Study", IJSR Volume 3.

[9] Vivek Barhate, Sachin Mahakalkar, Dr. A.Kale,"Design and Development of dies for an industrial part – A Case Study," (ICEMEM), 2015.