Compound Die Design: A Case Study

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Abstract: ***Various components/parts used in Mechanical industry are manufactured by sheet metal. They can be produced by different cold pressing processes. This paper presents a design of compound die by combining the blanking, piercing, drawing operation. Compound die design is applied to dies in which two or more cutting operations, typically piercing, blanking and drawing are performed in the same single station and completed during the single press cycle.***

Keywords: Compound die design, Drawing operation, Punching, Blanking, Force.

1. Introduction

The evolution of products, dictated by the necessity to survive in the market, requires changing in manufacturing processes. This requires an integrated approach of constructive aspects, technological, organizational and management of the development stages in order to reduce as much as possible time and cost of the new products. Design activity has an important role in developing a new product. Design time being very often decisive in terms of the marketing time of the product. Compound die design is applied to dies in which two or more cutting operation, typically piercing, blanking and drawing are performed in the same single station and completed during the single press cycle. 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.

2. Objective

Design of compound die for downlight housing by combining the blanking, piercing and drawing operation.

3. Case study -Die Design Calculations

The case study present here includes the design and development of the **"down light housing assembly"** that is used for popular LED Light mounting assembly. Three operations namely blanking, drawing and punching are required to produce the component. Detailed design procedure is given below. Figure 1 and 2 shows the view of downlight housing.

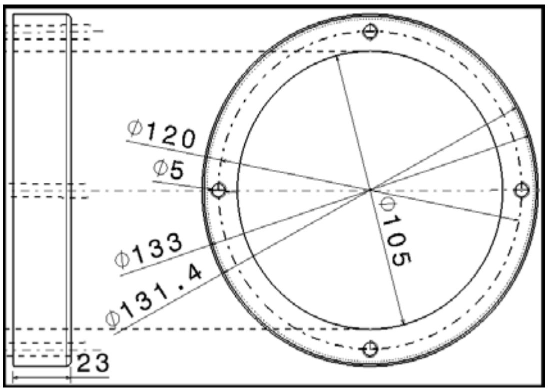

Figure 1: Housing 2D view

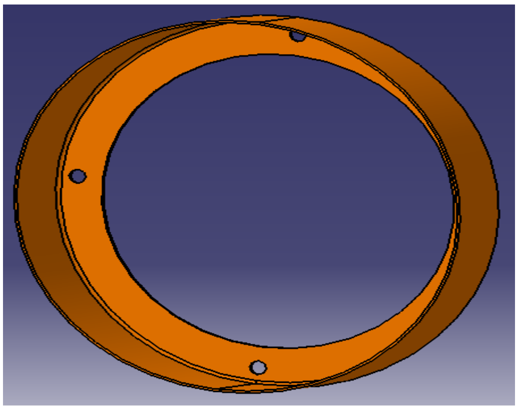

Figure 2: Housing 3D view

3.1 Design of die for blanking operation

Blanking is the operation of cutting a flat shape from the sheet metal. In the blanking operation required diameter are taken from the calculation of blank size in drawing operation. Blanking calculations are given below.

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

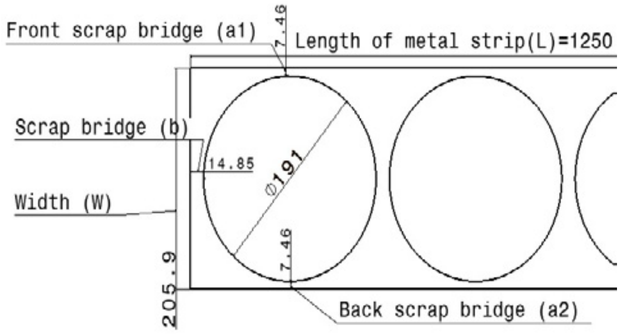

Figure 3: Housing 2D view

Economy factor = $\frac{area\ X\ no. of\ raw\ X\ 100}{width\ of\ stip\ X\ pitch}$ #

= 67.66 %

(ii) Clearance =10% x thickness = 0.08mm
(iii) Diameter of punch (dp1)=Blank dia + m =191.05mm
(iv) Where, m-Elastic recovery
(v) Diameter of die=dp1 +Clearance =191.13mm
(vi) Die Block Dimension
(vii) Perimeter (p1) = π x dia of die =600mm

T_1 =25.4 + $(p_1)^{0.015}$ =26.49mm
T = T_1 + grinding allowance = 27mm
h =10% x T=2.7mm
A=1.5 x T = 40.5mm

Where,
P1= Perimeter
T = Thickness of die block
h = Land of die block

Angular clearance α =2^0 or 3^0

(viii) Blanking force = π. D. t. τs =19ton

Where, D= blank diameter =191
h= cup height =23mm
d = punch diameter = 133mm
τs = shearing force =400 N/mm^2

(ix) Thickness of Plates

- **Die plate (TD)=**$\sqrt[3]{Fc}$=31.4 mm
- **Top plate** =1.5 X TD = 46.5 mm
- **Bottom plate** = 1.75 X TD =82mm
- **Punch holder plate** = 0.75 X TD=23.4 mm
- **Stripper plate** = 0.5 X TD = 15.5 mm
- **Thrust plate** = 8.5 mm

3.2 Design of die for drawing operation

Drawing is a process of forming a flat work piece into a hollow shape by means of punch which causes the blank to flow into a die cavity.

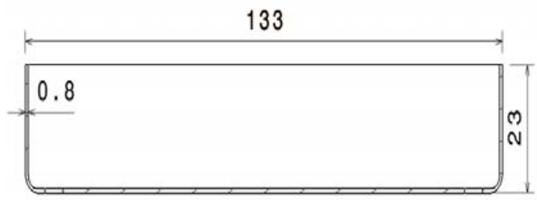

Figure 5: Cup

(i) Blank Diameter(D)=$\sqrt{d^2 + 4dh}$ =191 mm.

(ii) Draw Force – Draw Force can be calculated by empirical relation,
P = π.d. t. s. ((D/d) – C) =12 ton
Where, P = Draw Force in Tons
S =Yield strength of Metal in
=427N/mm^2 C= Constant (Take 0.65 to 0.7)

(iii) Die clearance-
Die clearance =1.1x t =1.1 x 2= 2.2 (For single side clearance)
Punch diameter (d_p) = (d) – 2x t =131.4mm
Die diameter d_d =d_p+ 2 x (1.1 t)=133.16mm

(iv) Draw Ratio – At this component, the Draw = H/d = 23/133 = 0.2 < 0.7 which indicates the draw is simple & may require only one stage for completion.

(iv) Draw & Punch radius – The Draw radius usually ranges from 4 to 10 times the Blank thickness, therefore, Radius of Draw Die = Rd =4.5x0.8=3.6mm The Punch radius usually ranges from 3 to 4 times the Blank thickness, Therefore, Radius of Punch = Rp =3 x 0.8 = 2.4 mm

(v) Blank Holding Force=1/3 x Drawing Force = 4ton

(i) Punch design

Checking the punch for crushing,

$$\text{Cutting force} = \frac{\pi}{4} X\ d^2 X\ \sigma_c$$

$$133706.18 = \frac{\pi}{4} X\ 133^2 X\ \sigma_c$$

σ_c = 9.62N/mm^2 << 750 N/mm^2
Safe in crushing.
Maximum length in punch .

$$L_{max} = \frac{\pi d}{8} X \left(\frac{E\ X\ d}{t\ \ X \tau s}\right)^{1/2}$$
#

L_{max}= 21.29 mm

Where, E=200 X10^3 N/m^2

Taking the length of punch, L=25 mm

3.3 Design of die for punching operation

3.3.1 Punching operation -A (105 mm)

Punching is a cutting operation by which 105mm hole are made in the sheet.
(i) Clearance=10% x thickness =0.08mm
(ii) Diameter of punch =105.05mm
(iii) Diameter of die =105.1 mm
(iv) Cutting force required
F_c= π x dia of punch x t x τs =11ton

(v) Die Block Dimension

Perimeter (p_1) = π x dia of die =330mm
T_1 =25.4 + $(p_1)^{0.015}$ =26.49mm
T = T_1 + grinding allowance = 27mm
h =10% x T=2.7mm
A=1.5 x T = 40.5mm

Where,
P1= Perimeter
T = Thickness of die block
h = Land of die block

Angular clearance $\alpha = 2^0$ or 3^0
Material for Die block should be use HCHCr
Hardness – Die Block should be harden upto 60 to 62 HRC

(vi) Punch design

Checking the punch for crushing ,

$$\text{Cutting force} = \frac{\pi}{4} X\, d^2 X\, \sigma_c$$

105557.5 = π/4 x 105^2 x σ_c

σ_c = 12.19 N/mm^2 << 750 N/mm^2

Safe in crushing .

Maximum length in punch .

$$L_{max} = \frac{\pi d}{8} X \left(\frac{E\ X\ d}{t\ \ X\tau s}\right)^{1/2}$$

L_{max}= 10.56 mm
Taking the length of punch, L=25 mm

3.3.2 Punching operation –B (5mm)
It is cuttings operation by which four hole of 5mm are made in the sheet.

(i) Diameter of punch = 5+0.05=5.05 mm
(ii) Diameter of die =5.1mm
(iii) Cutting force required
F_{c2} = π x dia of punch x t x τs =0.5ton
Total cutting force for 4 holes = 0.5 x 4
= 2 ton

(iv) Die Block Dimension
Perimeter (p_1) = π x dia of die =330mm
T_1 =25.4 + $(p_1)^{0.015}$ =26.49mm
T = T_1 + grinding allowance = 27mm
h =10% x T=2.7mm
A=1.5 x T = 40.5mm

(iv) Punch design

Checking the punch for crushing

$$\text{Cutting force} = \frac{\pi}{4} X\, d^2 X\, \sigma_c$$

5026.55 = π/4 x 5^2 x σ_c

σ_c = 256 N/mm^2 << 750 N/mm^2

Safe in crushing

Maximum length in punch.

#

$$L_{max} = \frac{\pi d}{8} X \left(\frac{E\ X\ d}{t\ \ X\tau s}\right)^{1/2}$$

L_{max}= 10.56 mm

Taking the length of punch, L=25 mm

Press capacity –Press Tonnage can be calculated by using following formula,
Press Tonnage = Draw Force + Blanking force+ Punching force (A & B)+ Blank Holding Force
= 12+19+11+2+4 = 48.78ton
Therefore, Press Capacity of 50 Ton shall be suitable.

3.4 Working of compound die

Figure 6 depicts the die as it appears during various stages of its cycle. The pressure plate-II is shown with metal strip nested in position on the die block i.e. pressure plate-II hold that strip over die block. The press ram is descending. The drawing and cutting punch just contacted with metal strip. Cutting action is take place. The press ram continues to descend drawing action is initiated and proceeds as shown. Further descent will cause the outer edge of the draw around the draw die radius. The pressure plate-I just hold the cup. This pressure plate-I act as a guide for cutting punches-II. The drawing operation is complete. Punching of 105mm start as soon as the drawing operation is completed. During the upstroke, the ejector plate will ejected the draw piece from the die.

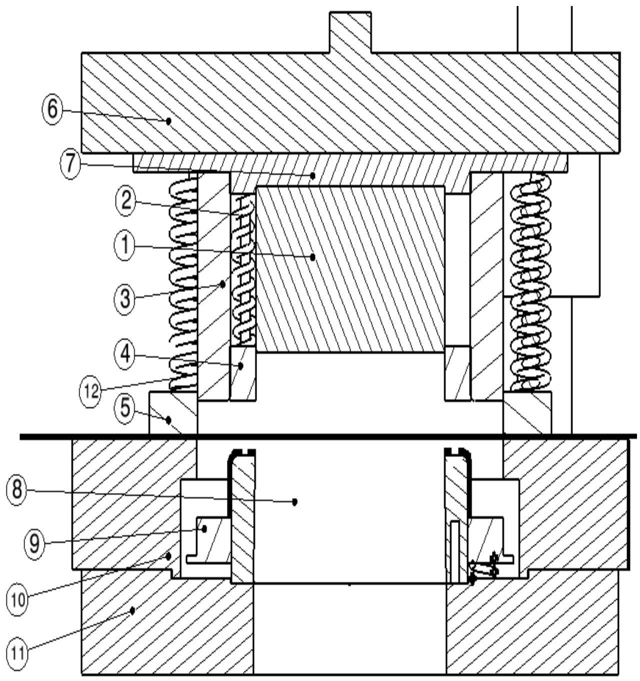

Figure 6: 2D view of compound die
Cutting punch-I (1) ,Cutting punch-II(2), Drawing punch(3),Pressure plate-I(4), Pressure plate-II(5),Punch plate(6),Thrust plate(7), Die(8),Ejector plate(9),Die block(10),Die palate (11),Spring(12),pillar(13)

4. Conclusion

- Successfully Design a compound dies by combing blanking, drawing and punching operation.

- It is possible to get product in single die
- The developed cad design conforms the possibilities of compound die
- The simulation also confirms the die design

References

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

[2] S. Badrinarayanan "Perform and die design problems in metal Forming" Cornell University (1997).

[3] Nicholas zabaras And akkaram srikanthm "An object-oriented programming approach to the lagrangian fem analysis of large inelastic deformations and metal-forming processes international journal for numerical methods in engineering". 45,399– 445, (1999).

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

[5] Vamshikrishna reddy chada , "Computer aided design of sheet metal die assembly utilispro / engineer and mechanica" B.tech. Jawaharlal nehru Technological University, India, (2007).

[6] Wilson Burton, Jon Carlson, Brad Cobb, Amber Monceaux ,Tyler Ray ,Ron York"Manually operated punch press Design report draft 3"(2008).

[7] Mohammad Haider, K. K. Pathak, Geeta Agnihotri "Perform design for near net shape close die gear forging using simulation technique", Archives of Applied Science Research, 2 (6):317-324, (2010).

[8] Iulian stanasel, florin blaga and ioan radu "Research on parametric design of die punch". Academic journal of manufacturing engineering, vol. 10, issue 1, (2012).

[9] Milash Kumar Lahadotiya, Abhay Dinkar Kakirde and Asutosh Kumar Pandey "Mini Review on Designing of Press Tools for Sheet Metal Parts" JECET Vol.2.No.3, 650-660, (2013).

[10] Mr. Amit D. Madake, Dr. Vinayak R. Naik, Mr. Swapnil S. Kulkarni "Development of a Sheet-Metal Component with a Forming Die Using CAE Software Tools (Hyper form) For Design Validation and Improvement" International Journal of Modern Engineering Research, Vol. 3, Issue. 3, Pp-1787-1791, (2013).

[11] P.H.Joshi, "Press Tool Design and Construction" *S.chand publication,* First edition, ISBN 81-219-2938-5(1989).

[12] Cyrll Donaldson, George H.LeCain, V.CGoold, "Tool design", *Tata Mcgraw-hill publication,* third edition ISBN 0-07-099274(1943).

[13] K. Mahadevan, K.Balaveera Reddy, "Design data hand book", *Satish kumar jain for CBS publisher and distributors,*Third edition ,ISBN 81-239-0162-3(1987).

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