Optimizations of extrusion semidie angle and fabrication of extrusion die

Conference Paper *in* AIP Conference Proceedings · October 2020

DOI: 10.1063/5.0025152

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Cite as: AIP Conference Proceedings **2283**, 020063 (2020); https://doi.org/10.1063/5.0025152
Published Online: 29 October 2020

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Optimizations of Extrusion SemiDie Angle and Fabrication of Extrusion Die

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Abstract. Extrusion is the important manufacturing process and many components have been manufactured. Extrusion load play the major role for that the selection of die angle. A pilot study has been conducted for selecting a suitable die design for the present work. The selection of the semidie angle has been determined for the die of inlet diameter 12 mm and outlet diameter 8 mm. Hot die steel (H-13) is used as the die material for this study.

INTRODUCTION

Castle and Sheppard (1976) investigated the hot working characteristics of six aluminum alloys and the constants in the relevant equation. Venkata Reddy et al (1996) studied the combined upper-bound method and finite-element method (FEM) for the optimal design of axisymmetric die. The billet material during plastic deformation process is modelled as visco-plastic rate-sensitive material. The extrusion power required is lowest for the stream-lined die with cosine die. The hyperbolic die is; however, better than the conical die at lower reduction ratios, whilst the conical die is superior at greater reduction ratios.Chung and Hwang (1997) developed the genetic algorithm for the optimal design of the die shape extrusion. The optimal die shape predicted by the proposed genetic algorithm was compared with the theoretical die shape. They found the minimum punch load for the given dimensions. Narayanasamy et al (2003) studied the stream lined extrusion die. The authors concluded that the dead metal zone is avoided, so that the work required and the extrusion pressures are minimum. Pongalagusamy et al (2005) developed a Bezier curve model for streamlined extrusion dies. Stream lined extrusion dies are designed by various methods such as the polynomial equation based die, area and line mapping technique and analytical method.

Proceedings of International Conference on Recent Trends in Mechanical and Materials Engineering
AIP Conf. Proc. 2283, 020063-1–020063-8; https://doi.org/10.1063/5.0025152
Published by AIP Publishing. 978-0-7354-4013-5/$30.00

MATERIALS AND METHOD

Chemical Composition of Hot Die Steel (H-13)

The chemical composition of hot die steel is shown in Table 1

Table 1. Chemical composition of hot die steel (H-13)

C	Mn	Si	Cr	V	Mo	Fe
0.38%	0.4%	1%	5%	1%	1.3%	Balance

Properties of Hot Die steel (H-13)

Hot Die Steel (H-13) is used in hot working tools requiring the greatest possible toughness and high wear resistance (Rajiv Shivpuri and SaileshBabu 2005).

PILOT STUDY

To select the die design, a pilot study is conducted. Considering the material cost, mild steel is used as the die material in the pilot study. The following types of dies were fabricated as Channel type, Rectangular type, three components circular die set and two components circular die set.

Channel Die

The channel die is fabricated with one C shaped channel, two split die and two clamping plates. The split dies are placed in the open side of the C channel. One of the clamping plates is fitted in front of the die with four nuts and bolts as shown in Figure 1. Another clamping plate is fitted at the bottom of the die for supporting purposes. The billet is placed inside the die and pressed. The extruded billets of the Channel die are shown in Figure 2 and used by V.Jayaseelan and K . Kalaichelvan (2013)

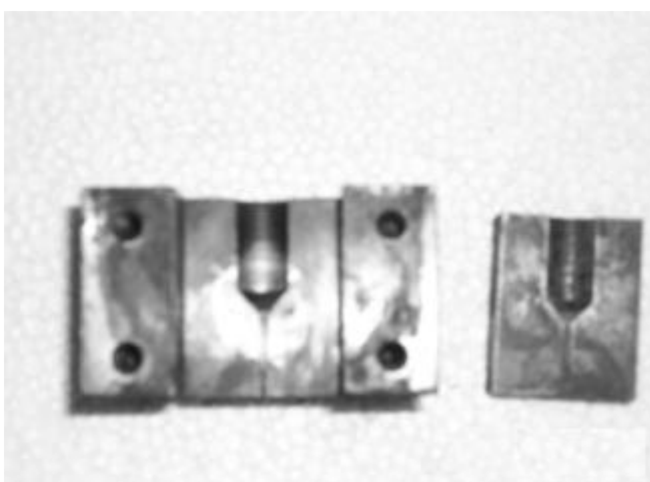

FIGURE 1. Channel Die

FIGURE 2. Extruded Billet by Channel Die

Rectangular Type

The rectangular type die is fabricated by clamping two rectangular blocks placed side by side with the help of nuts and bolts. The billet is placed inside the die and pressed. The image of the rectangular type die is shown in Figure 3, and the extruded billets are shown in Figure 4.

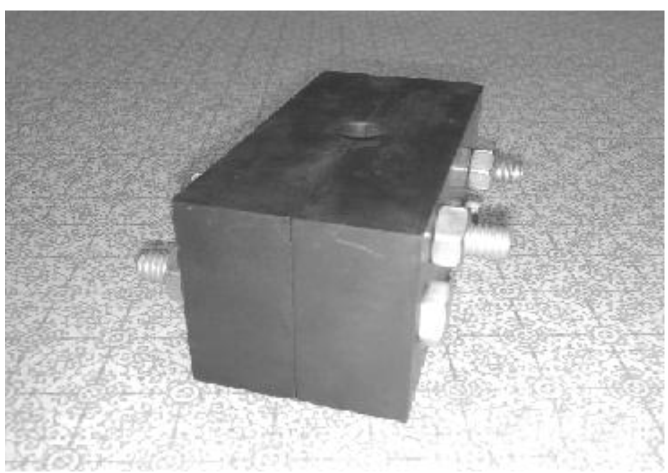

FIGURE 3. Rectangular die

FIGURE 4. Extruded billet by rectangular die

Three Components Circular Die Set

The circular die is fabricated, by stacking three circular discs one above another. The drawback of clamping is tackled by the male and female configuration of the circular disc. The billet is placed inside the die and pressed. The setup image of the three components circular die set is shown in Figure 5 and the extruded billets are shown in Figure 6.

FIGURE 5. Three Components Circular Die Set

FIGURE 6. Extruded Billet by Three Components Circular Die Set

Two Components Circular Die Set

The circular die with two parts is fabricated by stacking two circular discs one above another. The clamping is provided along the direction of the load to avoid rotation of the discs. This avoids the flashing of the billet in the horizontal direction. A tiny slot is provided to remove the work piece easily. Two additional holes are provided in the die for forcible removal of the component without causing any damage in case an over load is applied. The image of the two components circular die set is shown in Figure 7, and the extruded billets are shown in Figure 8. Venkata Reddy (1996) found that conical die is superior at greater reduction ratio; the same was followed for die design.

FIGURE 7. Two Components Circular Die Set

FIGURE 8. Extruded billet by two components circular die set

The experimental observations are implying that the two components circular die set is a suitable die for the present work, due to the following advantages.

- No clamping problem
- Easy removal of the work piece
- Less time consuming
- No flashes observed in components

SELECTION OF DIE ANGLE

The extrusion load may depend upon factors like the extrusion ratio, temperature and semidie angle. Among these, the semidie angle is the biggest influencing factor. If the semidie angle is too small, the length of contact between the billet and die is high, which will maximize the extrusion load. On the other hand, if the semi cone die angle is too large, distortion will occur. In order to minimize the extrusion load, proper semidie angle to be selected. The extrusion load determined by the Depierre (1970) approach and the equation 1 can be written as

$$F_t = \pi D L m \frac{\sigma}{\sqrt{3}} + \sigma \left(\frac{1+\beta}{\beta}\right)\left(R^{\beta}-1\right)\left(\frac{\pi (D+d)}{2} l\right) \quad (1)$$

where

Ft	-	Total extrusion load (N),
D	-	Initial billet diameter (mm),
L	-	Billet length in the container (mm),
α	-	Semidie angle (degree),
β	-	Semidie angle constant,
σ	-	Material flow stress (N/mm2),
R	-	Extrusion ratio,
d	-	Extruded billet diameter (mm),
l	-	Length of die (mm),
m	-	Friction factor.

The extrusion load required for the various semidie angles has been determined from Equation 1 from the determined values at a semidie angle of 5°, the extrusion load is the maximum 675.76 kN, and at the maximum semidie angle of 85°, the extrusion load is the minimum26 kN. It is inferred that, as semidie angle increases, the extrusion load decreases. Therefore, the range of selecting the semidie angle is around 25°. For ease of manufacturing the die, the die length is considered as 4 mm with a semidie angle of 26.5° for the 12:8 die used by Jayaseelan et al (2014).

FABRICATION OF THE DIE

The Hot die steel rod is cut into three pieces. Machining processes such as Turning, Drilling, Threading, Taper turning, Slotting and Polishing are performed as per the die design. The processed parts are assembled to check for proper fitting. The heat treatment is carried out on the dies, and the required hardness of 55 HRC is obtained. The surface roughness of the die is maintained around 5 µm. Hot Die Steel (H-13) is hardened by the air treatment method. The furnace is heated to 1024°C, and then the hot die steel is placed inside it, near the thermocouple. The two dimensional view of 12:8, extrusion ratios fabricated, are shown in Figure 9.

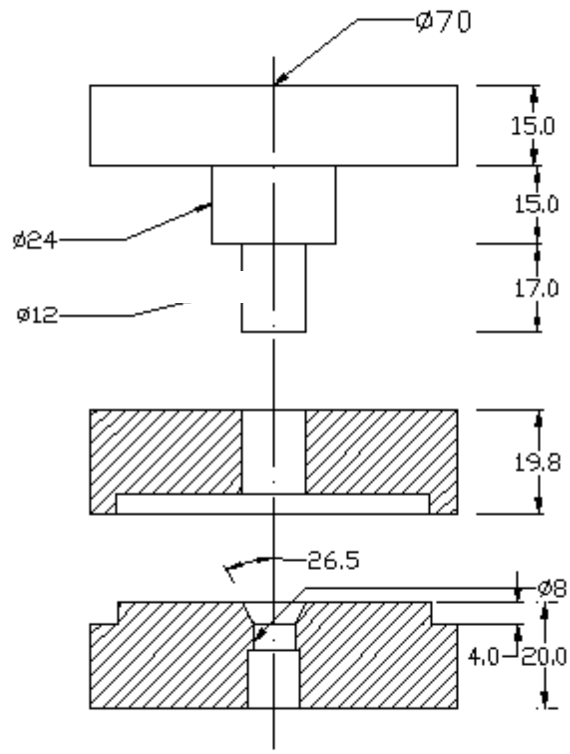

FIGURE 9. TWO-DIMENSIONAL view of the 12:8 die

CONCLUSION

The characteristics of the Hot die steel (H-13), the chemical composition, properties and applications were studied. A pilot study had been made to select a suitable die design for the present work. The semidie angle for 12:8 is 26.5°. The experiment reveals that, when the area reduction is minimum, the semidie angle becomes smaller, and an increase in the area reduction causes the semidie angle to increase. Hence, the semi die angle is not constant for all area reductions.

REFERENCE

1. Castle, A.F and Sheppard, T, 1976, 'Hot working theory applied to extrusion of some aluminum alloys', Journal of Materials Processing Technology, Vol. 3, pp. 10-14
2. Wifi, A.S, Abduljabbar, Z.S and Sakr, M.T, 1990, 'A combined ubet/fem investigation of metal flow and stress analysis of dies in extrusion processes', Journal of Materials Processing Technology, Vol. 24, pp. 431-440.
3. Venkata Reddy, N, Sethuraman, R. and Lal, G.K, 1996, 'Upper-bound and finite-element analysis of axisymmetric hot extrusion', Journal of Materials Processing Technology, Vol. 57, pp. 14-22.
4. Chung, J.S and Hwang, S.M, 1997, 'Application of a genetic algorithm to the optimal design of the die shape in extrusion', Journal of Materials Processing Technology, Vol. 72, pp. 69-77.
5. V.Jayaseelan and K . Kalaichelvan, 2013, 'Influence of Friction Factor on Extrusion Process', Advanced Materials Research, Vol. 622, pp. 457-460.
6. Pongalagusamy, R, Narayanasamy, R, Venkatesan, R and Senthilkumar, S 2008, 'Computer-aided metal flow investigation in streamlined extrusion dies', Journal of Materials and Design, Vol. 29, pp. 1228-1239.
7. Jayaseelan.V, Kalaichelvan.K and Vijay ananth.S, 2014, Lubrication effect on friction factor of AA6063 in forward extrusion process, Procedia Engineering, Vol. 97, pp. 166–171.
8. Arunkumar, M., V. Dhinakaran, and N. Siva Shanmugam, 2019 'Numerical prediction of temperature distribution and residual stresses on plasma arc welded thin titanium sheets' International Journal of Modelling and Simulation, Vol. 4, pp. 1-17.