DESIGN AND OPTIMIZATION OF EXTRUSION DIE ANGLE

V.Jayaseelan[1], P.Jayaraman[2], N.Dilli Babu[3], B.Himaya Sri[4], V.Ajith Kumar[5]
Professor[1, 2], UG student [3,4,5]
Department of mechanical engineering
Prathyusha Engineering College, Thiruvallur, India.
jayaseelan.mech@prathyusha.edu.in[1]

Abstract: *In extrusion the metal is pushed through a die of desired cross-sectional area where the metal experiences compressive and shear stresses. During the compression of metal, it encounters frictional force between the billet and the die. This is due to the action of the die angle and extrusion area. As a result of this, large amount of force is required for the metal extrusion. In addition to the force requirement it is known that the dies suffer many problems due to high force application. Many attempts have been made to rectify these problems and improve the die design. In this project it has been attempted to reduce the force applied for the metal extrusion by proposing an alternative method of die designing using depierre equation. Various parameters such as area reduction, friction between die-billet interfaces, inlet and outlet diameter, extrusion die angle and extrusion ratio has been studied for process optimization. The theoretical calculations for all those parameters have been done. After complete calculation it has been observed that the dies designed by the above mentioned equation requires less force for metal extrusion. By using the depierre equation for die designing the load difference has been calculated and the die angle has been optimized.*

Key Words: *Extrusion, Compressive stress, Frictional force, Extrusion die.*

1. INTRODUCTION:

Extrusion is a process where the metal is pushed through a die of desired cross-section. The extrusion methods have been used in industries for high quality and increased productivity. It also can be used for working brittle materials. In present industries, extrusion is the majorly used production method for the production of uniform shaped sections. In extrusion method the critical criteria is the die designing which is being done by experience. By designing dies in this method the force requirement has not been taken into account. Other than the force applied the friction between billet and die affects the surface finis of the metal which has an impact over the quality and cost of production. In order to avoid these metal distortions, the frictional force has to be reduced. This frictional force depends upon the extrusion area, extrusion angle and the metal flow rate. In this paper attempts have been made to reduce the force and the friction by analysing the die angle. Some of the analytical methods for die designing have been proposed by some research workers that enable to design the extrusion die using an alternative method of applying depierre equation for optimizing the die angle.

The depierre equation has the following objectives:

- Time taken for die designing has been reduced.
- The frictional force is reduced for a great extent.
- Area reduction has been done.
- High surface finish is obtained.

The depierre equation is given by,

$$F_t = \pi DL\tau + \sigma\,(1+\beta/\beta)\,(R^{\beta}-1)(\pi(D+D_i)y_i/2)$$

Where,

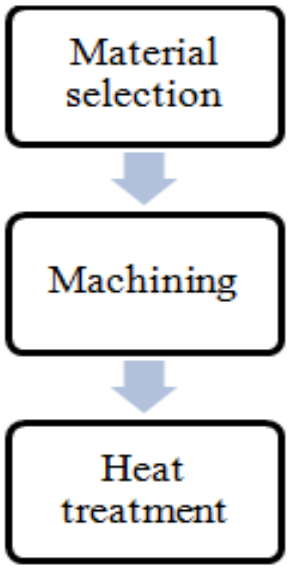
F_t – Total extrusion load in kN
D – Inlet diameter of billet in mm
L – Billet length of container in mm
σ – Billet shear stress in kN

τ – Material flow stress in kN
β – Semi die angle in degree
D_i – Instantaneous diameter in mm
y_i – Instantaneous height in mm
R – Extrusion ratio
Extrusion ratio = Inlet area/Outlet area

2. LITERATURE REVIEW:

R. Ponalugusamy et.al. [1] has explained the problems suffered by the conventional dies due to stress. He has proposed the use of Bezier curve for designing the extrusion die. He has given the theoretical calculation on the total extrusion pressure. Then it is compared with polynomial based dies which showed the lower extrusion pressure for Bezier curve based dies. M. Kiuchi et.al.[2] has given the problems faced during designing the non symmetrical extrusion die and proposed a better and efficient method for drawing and designing the non symmetric extrution die. V.Jayaseelan et.al.[3] has said that when the metal is forced to go through a sudden change in cross section it experiences some practical problems such as non uniformity in metal flow and more redundant work. To overcome these problems he has modified the extrusion dies to steamlined extrusion die to ensure smooth metal flow. R. Narayanasamy et.al.[4] has given the problems such as dead metal zone, more redundant work and breaking of whiskers faced by the conventional dies. He has also said that the major issue is the die designing which is based on the experience. In order to solve the die design problem he has approached Stroke's theorem for designing square cross sectional dies.

3. METHODOLOGY:



The extrusion die is manufactured in three stages namely material selection, machining and heat treatment. The material selected for die should have high strength and rigidity. It must withstand high temperature. Corrosion resistance is a major requirement. After material selection machining is to be started. 2-D diagram is made for the die with specified dimensions assigned for that die. The 2-D drawing is uploaded in the numeric control machines like CNC to obtain accurate and precise die dimensions. It also provides good surface finish. Heat treatment s done to improve the strength of the die to withstand the stresses formed during extrusion process. Heat treatment temperature is maintained between 525°to 600°C for about 24 to 36 hours in a furnace. Die specification is shown in table 1.

Table 1. Die specifications

Die material	Cast Iron
Die angle	27 degree
Inlet diameter	12 mm
Outlet diameter	8 mm
Throat length	5 mm

Table 2. Design calculation

S.No	Inlet diameter (mm)	Outlet diameter (mm)	Billet length (mm)	Die angle (Degree)	Load difference (KN)
1	12	8	5	75	-
2	12	8	5	70	63.98
3	12	8	5	65	65.08
4	12	8	5	60	59.25
5	12	8	5	55	53.67
6	12	8	5	50	49.59
7	12	8	5	45	38.12
8	12	8	5	40	33.34
9	12	8	5	35	27.98
10	12	8	5	30	23.34
11	12	8	5	27	10.23
12	12	8	5	25	13.14
13	12	8	5	23	19.72
14	12	8	5	20	26.44
15	12	8	5	15	38.21
16	12	8	5	10	43.87

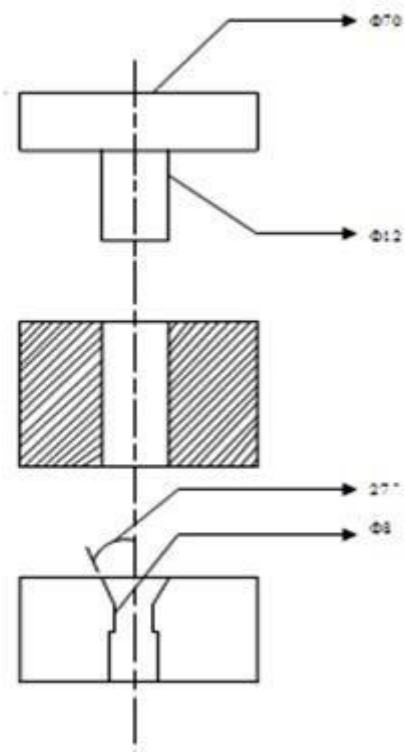


Figure 1. 2-D diagram

4. RESULT AND DISCUSSION:

The design and development of die has become easy using depierre equation. The complete load analysis gives an effective die angle, inlet and outlet diameter and the billet length. The reduction in the die angle gives smooth surface finish with low load requirement. The designing time for the die has been reduced and thus the lead time is also reduced. The designing of the conventional extrusion die is based on the experience which takes much time for designing the dies. Though designing after experience it is found to have some problems such as dead work zone and

redundant work during the extrusion process. When using depierre equation to design the extrusion dies it does not produce redundant work and gives better surface finish. This technique of die design when compared with Bezier curve based die design and fifth order polynomial die design, depierre equation has comparatively less theoretical calculation.

5. CONCLUSION:

In this paper we have discussed the problems caused in conventional extrusion dies due to stress and factors. A detailed analysis has been done it is verified that we can use depierre equation for extrusion die designing which eliminates various obstacles faced during the die designing. It also reduces the time taken and cost for die designing.

REFERENCES:

1. R.Narayanasamy, R.Venkatesan, P.Srinivasan, Computer aided design and manufacture of steamlined extrusion dies, Journal of Materials Processing Technology 138 (2003) pp 262–264.
2. R. Ponalagusamy a, R. Narayanasamy b, P. Srinivasan, Design and development of streamlined extrusion dies a Bezier curve approach, Journal of Materials Processing Technology 161 (2005) pp 375–380.
3. V.Jayaseelan and K .Kalaichelvan Influence of Friction Factor on Extrusion Process, Advanced Materials Research 622-623 (2013) pp 457-460.
4. R. Ponalagusamy , R. Narayanasamy , R. Venkatesan , S. Senthilkumar, Computer-aided metal flow investigation in streamlined extrusion dies, Materials and Design 29 (2008) 1228–1239.