

PRODUCTIVITY IMPROVEMENT THROUGH MULTI CAVITY EXTRUSION DIE MANUFACTURING

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Abstract - Extrusion can be defined as the process of subjecting a material to compression so that it is forced to flow through an opening of a die and takes the shape of the profile(2). But normally Extrusion take place through single cavity. So we are doing our project on extrusion through multi section for improved production rate. Multi-section extrusion is the process of extruding the products through a die having more than one section. Multi-section extrusion increases the production rate and reduces the cost of production.

In this project we are going to produce four section at a time. We are selected die material as H 13 steel which are suitable for our project because we are going to use aluminum as billet material so our working temperature range will 400 to 500 C.

Key Words: Productivity¹, Cost of Production², Die Design³, Manufacturing⁴

1. INTRODUCTION

Now day's extrusion manufacturing become a major production process in mechanical industries but due to increase in population, the customers' demands and requirements also increased. So to fulfill the customer demands we need to improve production rate within short period so our project is on improve production rate of extrusion process.

Extrusion dies can be made to form a virtually limitless array of shapes and sizes. The die itself is a steel disk (normally H13) with an opening, the size and shape of the intended cross-section of the final extruded product, cut through it.

Dies are broadly grouped as solid (or flat) dies, which produce solid shapes, and hollow dies, which produce hollow or semi hollow shapes. Combinations of solid, semi hollow, and/or hollow shapes may be incorporated into a single die. Solid die may have one or more orifices or apertures through which the softened alloy is forced (extruded). Multiple apertures in a single die produce multiple extrusions with each stroke of the press. (1)

A semi hollow die extrudes a shape that is nearly hollow, partially enclosing a void; the area of which (the area of the die tongues) is large in comparison with the gap where the tongue is connected to the main body of the die. Hollow dies take a variety of forms. Bridge, porthole, and spider dies, for example, include a fixed stub mandrel as an integral part of the die. Each type of hollow extrusion die serves certain

functions and carries its own advantages and disadvantages. The manufacturing methods and costs vary widely (1).

The ram force in a single-hole extrusion process is more than in a multi-hole extrusion process (3).

Multi-cavity name itself shows that more than one number of holes is there in a die. When a multi-hole die will be used in extrusion process then this is known as multi-cavity extrusion process. As the number of cavity on the die, the same number of products will extrude at a time during extrusion... The process has great importance for producing micron-size parts. In order to increase the productivity, the multi-hole extrusion process is also considered by the practicing engineers to design an efficient extrusion tooling (2). The choice of design, and even manufacturing methods, will depend on the profile, press and container size, and production requirements. And we are manufacturing the solid die for aluminum extrusion process.

2. PROBLEM DEFINITION

How to increase the production rate?

The main motive of our project is to increase the production rate by using the multi section die. In extrusion industries now days they are using only one cavity section die. So it require more machine to achieve the target, then making the multi section die we can increase the production rate and minimize the time of production. It reduces the human effort.

How to reduce production cost?

If one machine achieves three machines target so comparatively it reduces the cost of production. Machine installation cost to machine maintenance cost will reduces because machines are less used.

How to satisfy the customer?

By using multi section die it achieve the target of production and fulfill the requirement of customer within less period of time.

3. DIE DESIGN

In extrusion process, geometry of the die constitutes an important aspect of die design. The die geometry determines the extent of redundant work done during the deformation (4).

Die design and die making are the most important and demanding aspects of the entire extrusion process. Die design is influenced by many factors including press procedure and maintenance, understanding of the section or profile and its tolerances, and alloy characteristics (1). Three basic goals apply to all extruding operations. They are providing for relative ease of metal flow, dimensional stability, and desirable surface finish (1). Deformation of the die under pressure and its expansion under high temperatures also must be considered in the die design (1).

Following six factors are considered in the design and construction of a die (4).

1. The flow pattern.
2. Maximum specific pressure.
3. Geometrical shape of the section.
4. Wall thickness and tongue sizes.
5. Shape of the bearing surfaces (die lands).
6. The tolerances of the section.

To start with the design of a die, the designer needs fundamental information regarding the geometry of the shape, alloy to be extruded, size of the press, billet size, runout required by the customer, support tooling like backer or bolster to be used, the weight of extrusion per unit length, and so on.

After looking through the customer profile drawing, the die designer decides the type of die needed, that is, solid, hollow, or semi hollow.

3.1 Dimensions of Extrusion Section:

The size of extrusion section depends upon customer requirement so designer design extrusion section according to customer's demands. So we are going to manufacture below size section (cavity).

Size= 25mm.*25mm.*1 mm.

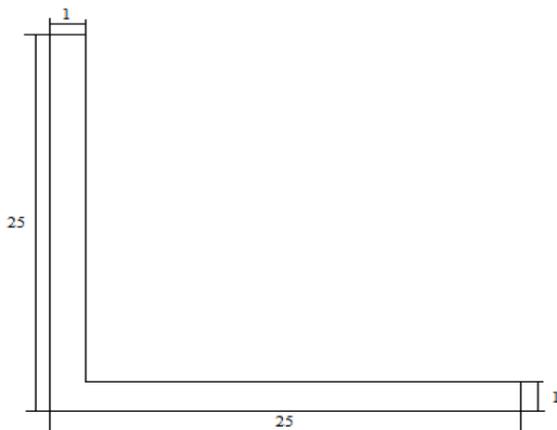


Fig 1: Line sketch for die L-section

1. Area - 49mm²
2. Perimeter = 100mm
3. Weight/M - 0.130 Kg.
4. Billet Material - Aluminium

3.2 Die Dimensions:

We are going to design die for hydraulic press having capacity of 600 ton. So according to standard size of die stack of 600 metric ton hydraulic extrusion press, **dimension of die will be-**

1. Diameter= 169 mm.
2. CCD= 94 mm.
3. Thickness= 35 mm.

Note- CCD depend upon diameter of billet

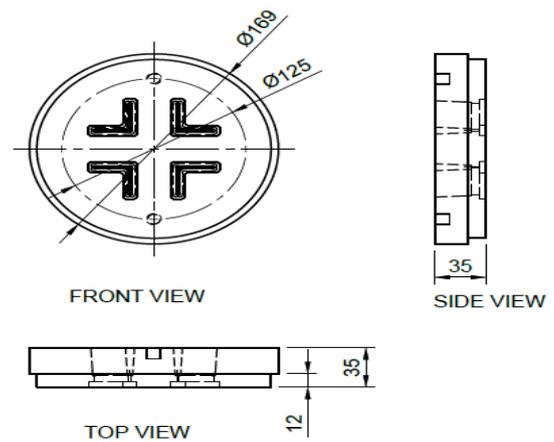


Fig 2: different view of die

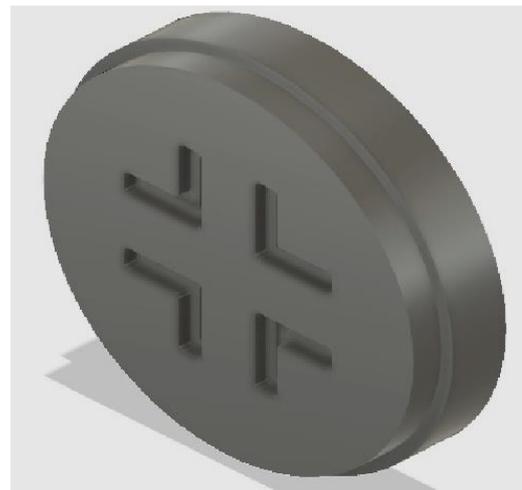


Fig 3: 3d model

3.3 Design Calculation:

1. PRESS SPECIFICATION-

- a) Press Capacity= 600t
- b) Die Ring Size= Dia.169x80mm

c) Bolster Size= Dia.182x55mm $=7850 \times 400 \times L_n (7850/2 \times 145.3)$

d) Container Bore= Dia.110x400mm $=10.35 \times 10^6 \text{ mm}^2$

A) MAIN CYLINDER DETAILS-

a) Cylinder Bore = 585mm

b) Ram Diameter= 580mm

c) Stroke= 1150mm

d) Working Pressure=210kg.F/Cm²

e) Main Cylinder Area=2.65x10⁶

B) SIDE CYLINDER-

a) Cylinder Bore = 115mm

b) Ram Diameter= 70mm

c) Stroke= 1200mm

d) Working Pressure=210kg.F/Cm²

e) Side Cylinder Area=0.454x10⁶mm²

2. SECTION DETAILS-

a) L- Section 4 Cavity

b) Section Area= 49 Mm²

c) Section Perimeter= 100 Mm

d) Alloy=6063

3. FORCE APPLIED BY THE PRESS

$$F_p = P \cdot A_1 + 2 \cdot P \cdot A_2$$

Where,

a) A₁=Area of Main Cylinder

b) A₂=Area of Side Cylinder

c) P=Hydraulic Pressure

$$F_p = 210 \times 2.65 \times 10^6 + 210 \times 2 \times 0.454 \times 10^6$$

$$= 747.18 \times 10^6 \text{ N}$$

4. EXTRUSION FORCE

$$F = A_c \cdot K \cdot L_n (A_c/A_e)$$

Where,

a) A_c= Area of Container

b) K= Strength Coefficient

c) A_e= Extruded Profile Area Mm²

5. EXTRUSION RATIO

$$R = A_b / N \cdot A_e$$

Where,

a) A_b = Billet Area Mm²

b) A_e =Area of Extruded Rod

c) N =No Of Cavities

$$R = 7850 / 4 \times 145.31$$

$$R = 13.50$$

4. STRAIN RATE €

$$E = 4 \cdot L_n \cdot \sqrt{R}$$

$$E = 4 \cdot L_n \cdot \sqrt{13.50}$$

$$E = 6.89$$

6. FLOW STRESS

$$\Delta = K \cdot E^M$$

Where,

a) K=Strength Coefficient

b) E=Strain Rate

c) M=Friction Factor

$$= 200 \times (6.89)^{0.11}$$

$$= 247.30 \text{ N/mm}^2$$

7. Extrusion Pressure

$$P_{ext.} = K (A + B \cdot L_n(R))$$

$$= 200 \cdot (0.5 + 1.2 \cdot L_n(13.50))$$

$$= 724.64 \text{ N/mm}^2$$

8. Extrusion Force (F)

$$F (N) = P \times A_c$$

$$= 891.00 \times 157000$$

$$= 139.88 \times 10^6 \text{ N}$$

Where,

a) P=Extrusion Pressure N/mm²

b) A_c=Area of Container Mm²

9. Extrusion Speed

= Ram Speed x Extrusion Ratio

= 3x13.50

= 40.5mm/Sec.

4. MATERIAL SELECTION

The properties to be considered for the selection of the die material are the ability to harden uniformly, high wear resistance, resistance to plastic deformation, toughness, resistance to thermal fatigue and resistance to mechanical fatigue. Based on these properties Hot Die Steel (H13) has been selected.

In the process of manufacturing an aluminum extrusion, the selection of a die material and its specific properties are critical factors. Since the aluminum extrusion process is a hot working process in the average range of 1050 °F, the most frequently used die material worldwide is the well-established hot die steel AISI H13 (5). The performance of the extrusion die is normally limited by typical material related failure mechanisms. In aluminum extrusion, the most common die failure mechanisms are hot wear, plastic deformation, and cracking.

In order to offer good resistance against these failure mechanisms, the die material should have the following properties (1):

- High hot hardness (hot yield strength)
- High tempering resistance
- Good wear resistance (response to nitrating and thin hard coatings)
- Good toughness

4.1 Chemical Composition-

C	MN	SI	CR	MO	V
0.40	0.40	1.00	5.25	1.35	1.00

4.2 Physical Properties-

- a) Density- 7750kg/M³
- b) Machinability- 70% Of 1% Carbon Steel

4.3 Mechanical Properties-

- a) Modulus of Elasticity- 215 GPA
- b) Ultimate Tensile Strenght-1590 MPA
- c) Yield Strenght-1380 MPA
- d) Hardness- 55 HRC

4.4 Thermal Properties-

- a) Melting Point – 1427c

5. METHODOLOGY

Die making involves many steps and processes starting with receipt of a profile drawing from the customer to the shipment of a die. The steps and processes are shown in the flow diagram (Fig.4).

Two distinct areas require consideration in die making. In the first area, the die must be manufactured based on economic and extrusion productivity. In the second area to be considered, die manufacture must provide for maintaining the highest quality and reliability. Modern technology allows the die manufacturer to reduce the number of steps gradually (1).

Once manufactured, the die is sent to the press for testing and production, or for testing only, depending on the critical features of the extrusion.

Despite the introduction of CAD/CAM and CNC in the design and manufacture of aluminum extrusion dies, the shape and finish of the product may not be accurately predictable. If the produced shape is successful in the first trial, production continues with proper checks and measures. If the extrusion does not succeed, the die needs to be corrected based on the report of the test run along with the front piece of the extrusion (1).



Fig 4: multi cavity extrusion die

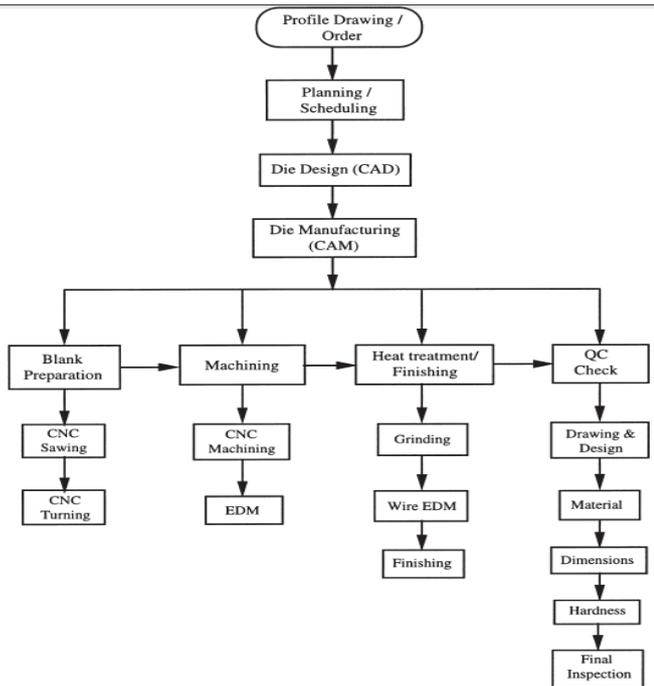


Fig 5: methodology

6. CONCLUSIONS

- i. In multi section extrusion system less extrusion force require as compare to single section extrusion system.
- ii. In multi section extrusion system production rate increased as compared to single section extrusion system.
- iii. Multi section extrusion system reduce cost of production and save time of installation and time for inspection of die.
- iv. The shape and size of all extrusion section required exactly same to avoid unbalance of flow

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