EXTRUSION VARIABLES

They affect the extrusion process considerably. They are:

1) Type of extrusion (direct or indirect)

In direct extrusion process, metal begins to flow through the die at the maximum value of the pressure called “break through pressure”.

As billet extrudes, the pressure required progressively decreases with decreasing length of the billet in the container (because, the friction between the billet and container decreases).

- In indirect extrusion, there is no relative motion between billet and wall. Therefore extrusion pressure is almost constant with increase in ram travel.
- It represents the stress required to deform the metal through the die.
- Limited in application by the need of hollow ram, which limits the size of extrusion & pressure.
- Hence most of the hot extrusion is done by direct extrusion.
- At the end of the ram stroke, there is a rapid pressure build up & therefore a small “ discard ’’ is left behind in the container, without extruding it.

2. Extrusion Ratio : (R)

R= Initial cross area of the billet / final cross section area after extrusion

R = Ao / Af

Up to = 40 : 1 for hot extrusion of steel

Up to = 400 : 1 for Aluminium

- ❖ A small change in the fractional reduction results in large increase in extrusion ratio

Velocity of extruded product = ram velocity x R

Therefore high sliding velocities exist along the die land.

Extrusion Pr. = P = K Ao ln (Ao / Af)

K = extrusion constant, which accounts for flow stress, friction ,and inhomogeneous deformation.

3. Temperature :

Hot extrusion decreases flow stress of metal, but increases oxidation of billet & extrusion tools. Other features are:

- Softens die & tools
- Difficult to provide lubrication
- Therefore it is advantageous to use the min. temp. which provides required plasticity to metal.

- The upper hot working temp. of metal is the temp. at which " Hot shortness " occurs.
- Higher plastic deformations involved also lead to internal heating of the metal.
- Therefore max. working temp. must be safely below the melting point.
- Typical Values steel billets heated to 1100^0 C to 1200^0 C
- Toolings : preheated to 350^0 C.

4. **Extrusion pressures** – range : 800 MPa to 1200 MPa

5. Lubrication : (Glass)

- To be maintained at high temperature & under high pressure.
- Low strength alloy (Al) does not require lubrication.
- Metal deformation is non – uniform and therefore wide variation in heat treatment response is observed
- Effect of temperature, pressure & strain rate on the allowable working range or interdependence of extrusion speed & temperature:
- For a given working pressure & temperature there will be a maximum amount of deformation possible on the work piece.
- As pre heat temperature of billet increases, the flow stress falls & therefore amount of possible deformation increases

- As strain rate of deformation increases, more heat is retained in the work & therefore work temperature will have to be reduced so that final temperature is below hot shortness temperature.

6. Ram speed :

Increase in ram speed increases the extrusion pressure.

Whereas, low ram speeds leads to cooling of the billet and because of billet cooling, flow stress is increased.

- The higher the temperature of billet, the greater the effect of low extrusion speed on the cooling of the billet.
- Therefore high extrusion speeds are required with high strength alloys which need high extrusion temperatures.
- At the same time at high extrusion speeds, temperature rise due to deformation is greater.
- The selection of proper extrusion speed & temperature is best determined by trial & error for each alloy and billet size.
- For a given extrusion pressure the extrusion ratio which can be obtained increases with increasing temperature.
- For a given temperature a large extrusion ratio can be obtained with high pressure.
- Maximum billet temperature is determined by the temperature at which melting is about to occur.
- The temperature rise of extrusion is determined by the speed of extrusion & extrusion ratio.

Source : http://elearningatria.files.wordpress.com/2013/10/mp3_unit6_extrusion_final.pdf