NEUTRAL SURFACE

During forging , the metal is stationary at the centre line of the plate which defines the neutral surface.

The flow of metal is always outwards, away from this neutral surface.

It is difficult to establish the neutral surface in a forging with a complex geometry.

FACTORS AFFECTING FRICTION HILL

1. **Nature of friction at the die/ work interface**

   a. Sliding Friction : exponential variation
   b. Sticking Friction : linear (more severe conditions of friction)
   c. Mixed Friction : linear at the middle where sticking friction exists and exponential at the edge where sliding friction exists

2. **Lubrication :**(lubricants used : graphite powder, liquid glass)
   - If lubricant film is maintained, it gives sliding friction
   - Possible in cold forging
   - Under condition of high forging pressure and high temperature the lubricant is squeezed out or burnt
   - Leads to stitching friction and normally in hot forging

3. **Finish on die surface**: roughness on die adds to friction.
   - Proper selection of die material to retain finish is necessary.

4. **Working temperature**

   Hot Forging : lubrication difficult, easy flow of metal

   Cold " : lubrication easy, less plastic flow

5. **Nature of work surface:**
   - Smooth/clean surface – less friction
   - Scales/dirt/rough surface – more friction

FORGING PRESSURE / LOAD IN CLOSED DIE FORGING (CFD)

The deformation in closed die forging is highly complex and hence designing dies and intermediate steps is very critical and requires high skill.

The main objectives are: – complete die fill and closed dimensional tolerance. Important factors to be considered in CDF are:

1. Flash design : flash controls die fill and creates high forging loads
2. Proper understanding of the flow stress of the material: ensures successful forging operation
3. Frictional conditions
4. Optimal geometry of the die: Result of proper understanding of flow stress, friction conditions and flow of the metal in the die
5. To prevent rapid cooling of the work piece by cold die's :
   - die's are preheated for many difficult aerospace applications- called isothermal heating
   - Results in lower flow stress and forging loads
   - Gives complete die fill and close dimensional tolerances

The design of a workpiece (part) made by CDF involves the prediction of the following :

1. Vol. and wt. of the workpiece
2. No. of pre-forming or intermediate steps and their configuration
3. Flash dimension in finishing die
4. Load & en-requirement for each operation

Forging load in CDF:

Prediction of forging load in CDF is quite difficult because of complexity involved
Usual prediction methods are:

1. **Past Experience**:
   To estimate forging load of a new part/geometry: using information available from previous forging s of similar materials and shapes is used.

2. **Using empirical relations**:

   One of the widely used equations is:

$P = \sigma . A_t C_1$

Where σ = effective true stress

A_t = cross sectional area of the forging at the parting line, including the flash

Where C_1 = a constant, depends on the complexity of the forging

C_1 = 1.2 to 2.5 for upsetting a cylinder between flat dies

= 3 to 8 for simple closed die forging

= 8 to 12 for more complex shapes

3. **Slab Analysis**- with suitable modifications for situations in CDF

   Basic approach:

   - The forging required is divided into simple geometric shapes, which are separately treated by slab analysis
   - The addition of all the loads of parts gives the total forging load

Source : http://elearningatria.files.wordpress.com/2013/10/mp3_unit3_forging_final.pdf