FORGING

used where –

1) High $\frac{\text{strength}}{\text{weight}}$

2) High fatigue strength
3) High impact strength
4) Directional properties

Raw material starts from Ingot (cast product)

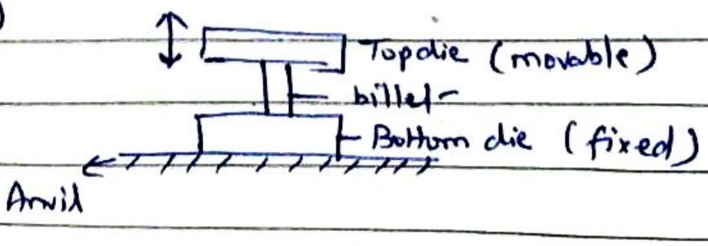
Either static ingot
or continuous cast billet

Ingot $\xrightarrow[\text{Rolling mill}]{\text{Reduced in}}$ bar (billet)

Classification of forging process –

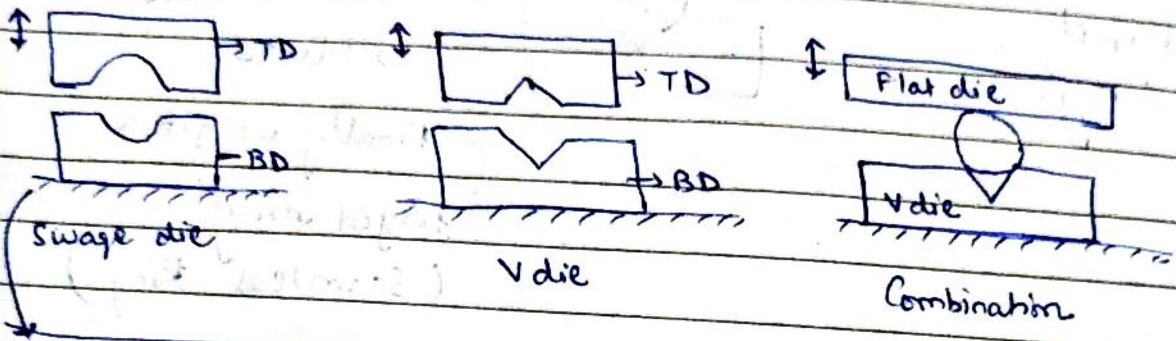
Based on
- → Shape of die set → Open die forging / → Closed die forging
- → Temperature (Hot, Cold) → Energy req. very high
  - Hot ↓ exp. contra exp. contrac. machining req. (dimension)
  - Cold ↓ better accuracy, precision forgings, surface finish
- → Equipment

Open die forging – ~~die shape~~ billet is deformed b/w flat shaped dies
(Flat die forging)
(Free forging)



Why free forging? — because there is no restriction ~~for~~ in metal movement

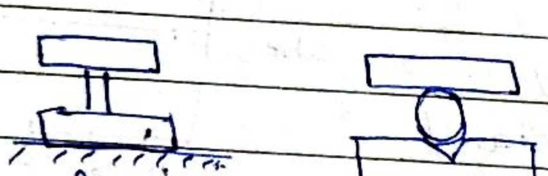
Application — for making large components.



~~On~~ for getting diff. dia. every time we need to change the shape of the dies.

Comes under Open die forging

Here, any diameter can be obtained.



for Plain Carbon steel

(Easy to deform)

(High skill is required)

(Time taking)

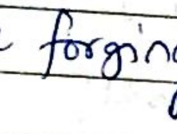
↓

No Alloy steel forging otherwise central part of material can fail

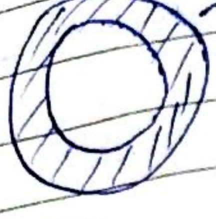
for Alloy steel (low forgibility)

↓

Yes Alloy steel forging

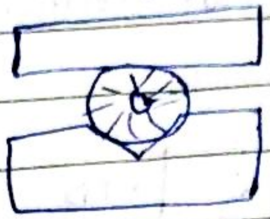


→ Manufacturing



~~Large Ring~~
Forged Ring

1) Upsetting of Ingot
2) Piercing
3)



→ Wall thickness will reduce.

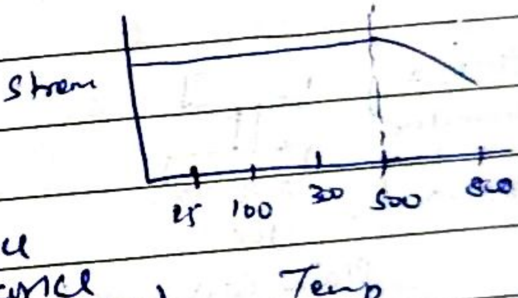
Finally we get a forged ring (Seamless Ring)

But forging die design is done by closed forging.

Die Material?

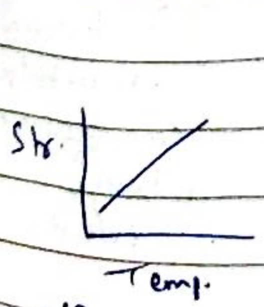
Properties of Die required ment:
- High T withstand
- Severe load withstand
- should have high creep resistance
- should have high wear resistance
- → " " high hardness (40-45 RC)

→ ~~Die steel~~ Hot work tool steel or die steel



Requirement of die material

HWTS
- H11, H12, H13 } Cr based die steel
- H19, H22 } Mo based, W based die steel



(Rare case)

Anamoly Behaviour

~~Ke~~

NiAl, Ni_3Al — Nickel Aluminides

FeAl, Fe_3Al

TiAl, Ti_3Al, $TiAl_3$

In general, Aluminides — High strength
→ No ductility

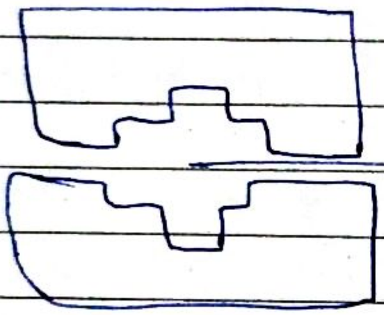
2 operations in ODF for making any component.

→ Upsetting / Drawing (Logging)

↓ Reduce in thickness, Inc. in cross sect area

↓ Length inc. cross se area dec.

Closed die forging → ~~Not~~ Metal is not free to move in all directions.
(Impression die forging)



→ Hot metal filled

Imp.	Flat	Imp.
flat	Imp.	Imp.

Machining req. very less

In ODF Machin required.

CDF

CDF with flash (Conventional forging)

CDF without flash ← (costly) (Ti alloy)
(Non conventional forging)
(Flashless forgin)
(Precision forging)

Fn. of flash
Flash helps in filling the die cavity completely.

otherwise
Defect – underfilling
(some part of
die cavity has not
been filled up)

Removal of flash — Trimming (Post forging operation)
↓
Impt
wastage

Above RT
below recryst temp. } Warm Forging.

Advantage of Hot forging.
1) Load req. is less
2) More & more chemical homogeneity (High diffusion rate)

Based on Equipment.
NO ← ① Hammer — apply sudden load
② Press — apply gradual load
↓
Variation in mechani. properties
↳ Response in better way in the heat treatm process

Mech | $\boxed{\text{Hyd.}}$ | Shaft
↓
deformation
is ~~homogeneous~~ uniform.

Press Better?

Thin Turbine blades — H / P

Press

~~Gk~~ Contact time more → More chilling ☹

Hammer → " " less → Less chilling ☺

So, Turbine blades are made by hammer

+

Uniform Mechan- properties

(because section is thin)

ASM Handbook Vol 14 forming and Forging

Cold and Hot Forging and its application by T. Altar.

ASM Handbook Vol 14 forming and Forging

Cold and Hot Forging and its application by T. Altan.

Forging Die Design

[Parting Line Selection Criteria] -

Parting Line or Flash Line - where the two die halves meet.

- Die filling easy
- Defect formation is reduced
- Wt. of forging, cost of forging is reduced
- Trimming is easy
- Extent of mismatch, tolerance is reduced.
- Favourable grain flow
- Die sinking becomes easy

If we choose correct parting line

Forging plane - normal to the direction of ram movement.

Types of parting line

Straight parting line

curved parting line

Irregular shape (Broken parting line)

In SPL — Parting line & forging plane coincide. 

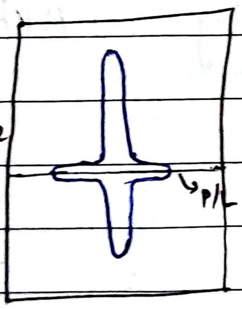
In CPL — side thrust will not develop 

In IS/BPL – always a tendency of side thrust (mismatch is caused) 

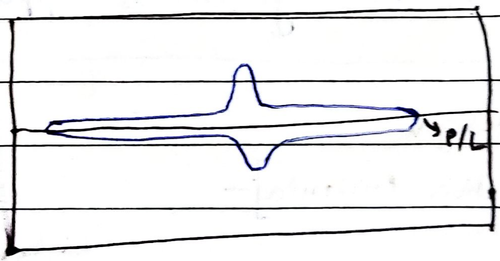
Criteria for selection of Parting Line

1. Avoidance of deep impressions.
2. Avoidance of side thrust
3. Favourable grain flow

1. Avoidance of deep impressions

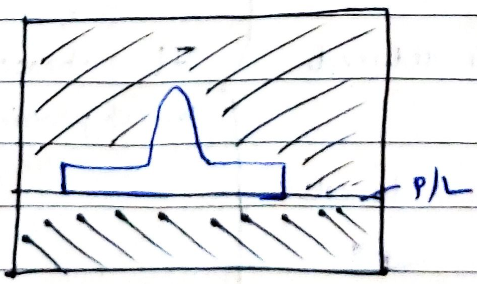


X

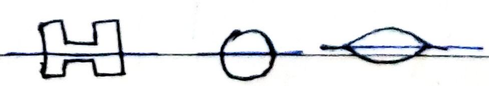


✓

In general, where there is largest cross sectional area, that plane should be considered as parting plane.



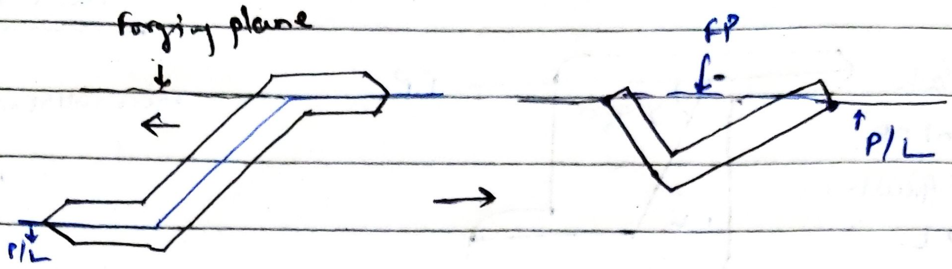
No chance of ~~side thrust~~ mismatch



centre of the height is considered as P/L

For shallow, simple shapes.

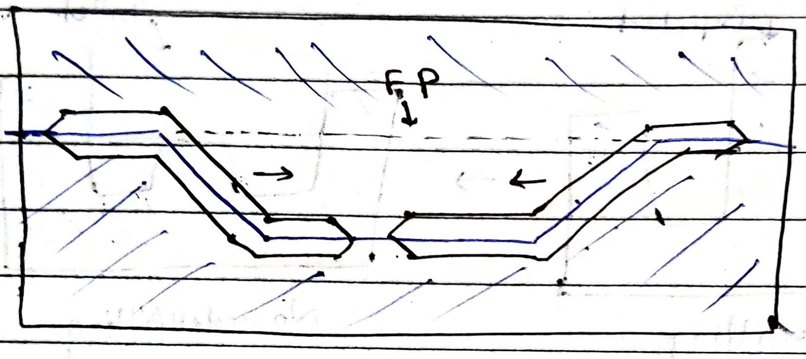
② Avoidance of ~~side thrust~~



Yes side thrust

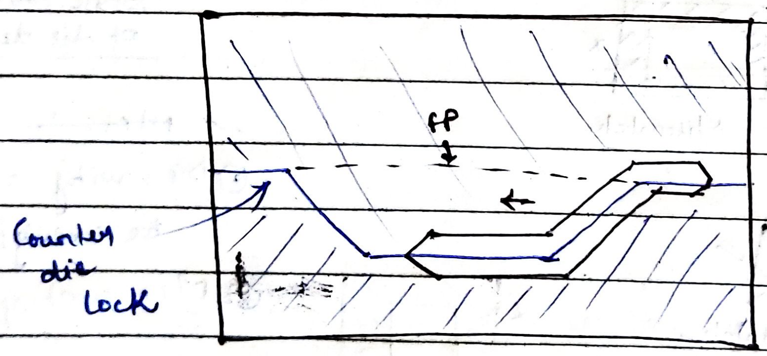
No side thrust

Moreover



- Avoiding side thrust
- Making 2 forgings simultaneously

Use of counter die

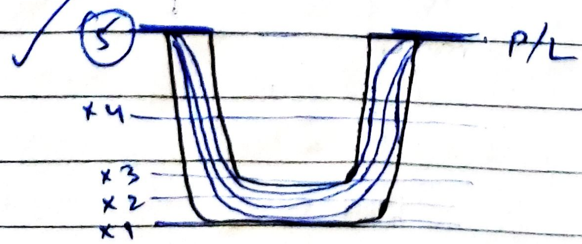


Avoiding side thrust

Demerit -

- Lot of die material is wasted.
- Costly process

③ Favourable grain flow :-

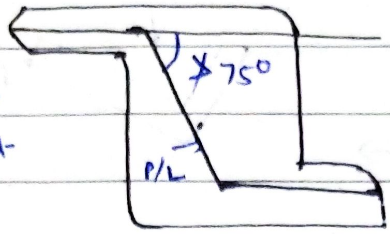


FVG
- No intersection of grain flow
- No overlap of grain flow
- No reversal of grain flow

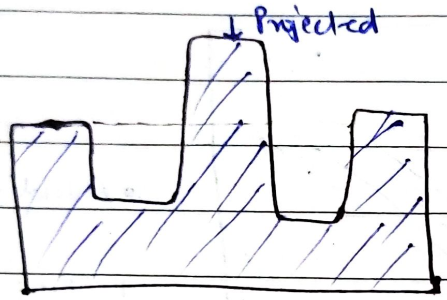
CDF – mass prod.
Then trimming

Otherwise
there will be more & more difficulty to trim the flash.

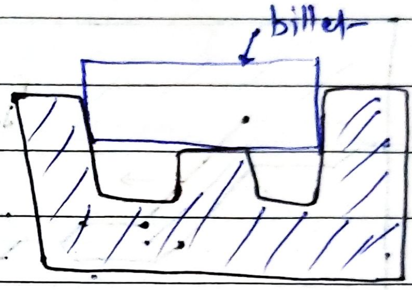
Trimming the flash along horizontal P.L is easy and difficult along vertical P.L. that's why



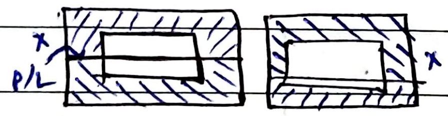
Angle b/w FP & P/L should not be more than 75°.



Underfilling



No underfilling

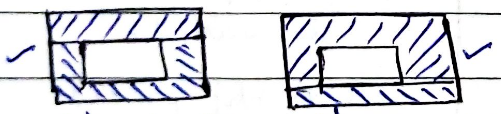


Mismatch Mismatch

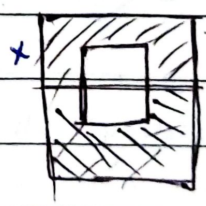
Basic principle of die design

~~Max. l~~

1. Die cavity should be completely filled
2. Min amt. of load
3. No defect formation



No mismatch No mismatch



Max. impressions in bottom die

Max. impressions in top die

Load req. is more

Mechanical press suitable — Hammer suitable

$\underbrace{\hspace{6em}}_{\text{Forging equipment}}$

Forging material – 1. Low alloy steel

Die Material – 2. Hot work Tool steel (Al alloy 7075)

Req. max. load b'coz flow stress is high.

3. Mild steel

Page No :
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Note - More alloying element-
More low m.p.

Flow stress of M.S. is very very less so, lod req. is less.

$\sigma = f(\theta, \epsilon, \bar{\epsilon}, M_{st})$

Flow stress, Temp., Strain, Strain rate, microstructure

$\sigma = f(\bar{\epsilon})$ for Hot forging/HT (High Temperature) $\sigma = C\bar{\epsilon}^m$

$\sigma = f(\epsilon)$ for cold forging/RT (Room Temperature) $\sigma = K\epsilon^n$

Servo Hydraulic Press
Cam Plastometer
} Flow stress determination machines.

$$\text{Yield stress} = \frac{\text{Load (Yield)}}{A_0}$$

$$\text{Flow stress} = \frac{\text{Load}}{A_i}$$