— Clyde M.

Motor & MEP NOTES

for

MEO Class 4 COC

Special Thanks To Samant Sir for his phenomenal efforts and expertise of the marine field.

Also Thanks to Joel Pinto for your efforts in teaching us and making us understand the concepts well.

Motor

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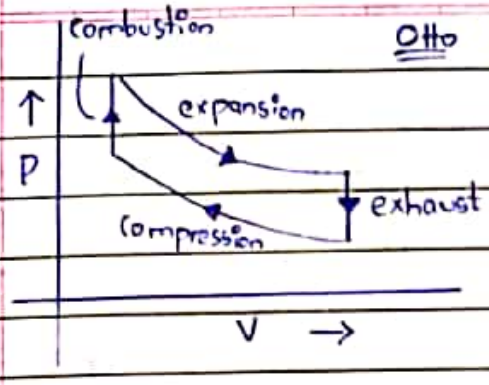
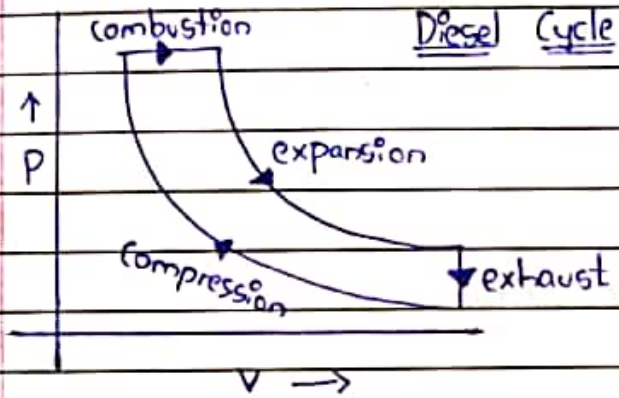
Otto Cycle



Petrol engines work on OTTO CYCLE

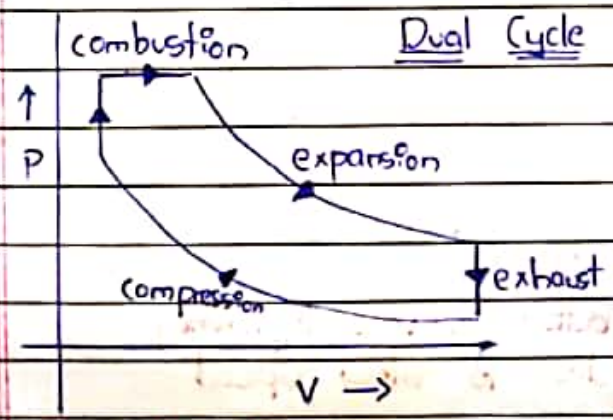
Comb & exh takes place at const vol.

Diesel Cycle



* Comb takes place at const pr
* Exhaust takes place at const vol

Dual Cycle



*Here comb. takes place at const pr & const vol

Our diesel engines works on dual Cycle

What is Adiabatic Cycle

- when we carry out compression, we want to retain this heat in order to self ignite fuel.

- Diesel engines works on Adiabatic Comp

What is Scavenging Efficiency?

- Scavenging is a process a pushing out exhaust gases by drawing in the fresh air inside the cylinder.

- The amt of fresh air inside the cylinder at beginning of compression is called Scavenging Efficiency

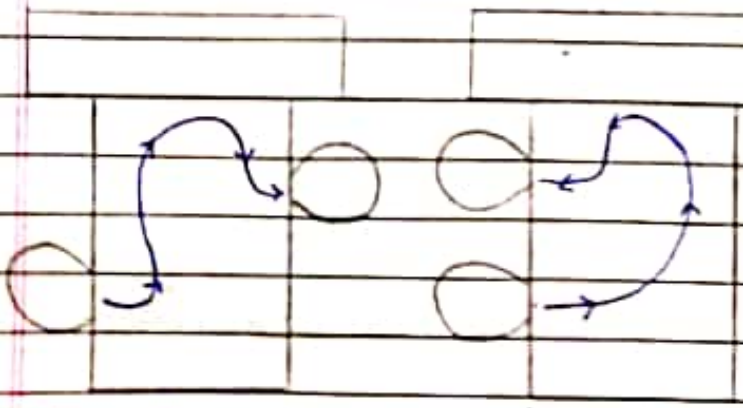
* In 4 stroke,
when piston after BDC
exh vlv open
so uniflow scavenging takes place

when piston comes before TDC
air inlet vlv also opens
now loop scavenging takes place

* In 2 stroke — Better Scaverge Efficiency due to slow speed

Uniflow scavenging takes place

Types Of Scavenging



Cross Scavenging
Ports are on opp side

Loop Scavenging
Ports are on same side

* In cross & loop scavenging, scavenging eff is very poor as some amt of exh gas will remain at top.

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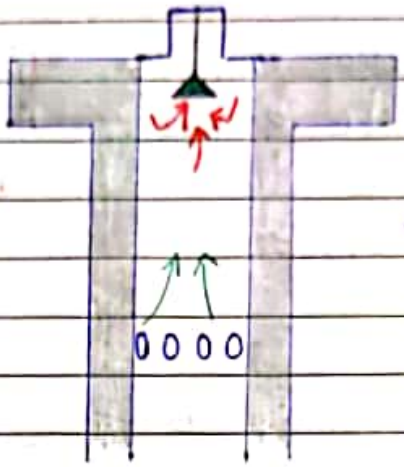
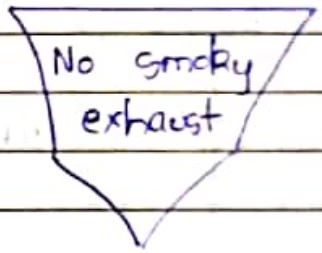


Uniflow Scavenging

* Here max exh gases are removed. So this scavenging gives max scavenge efficiency.

→ Good quality of air
→ Better combustion
→ Better thermal eff
→ Fuel consumption reduce



Power Developed by engine is IP
Indicated Power

But Power available at flywheel is BP
Break Power

BP will always be less than IP due to frictional losses

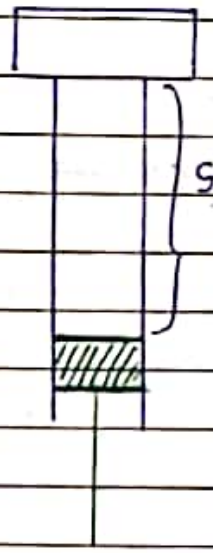
$$\frac{BP}{IP} \times 100\% = \text{Mech Efficiency}$$

- Long stroke
- Super long stroke
- Ultra long stroke

} all these are categorized based on $\frac{\text{Stroke}}{\text{Bore}}$ ratio

* K-MC short stroke engine (1 : 2.6)
* L-MC long stroke engine (1 : 3.2)
* S-MC Super long stroke engine (1 : 3.7~4)
* G-MC ultra long stroke engine (1 : 4.7)

* **Mean Piston Speed**
  - Should not go more than 10 m/s



In 1 rev, piston will travel 2 times

i.e 2S

Suppose speed = 10 rpm

$\frac{2S \times N}{60} = \frac{SN}{30}$ → Mean Piston Speed

S → Stroke (m)
N → RPM (rps)

* Mean Piston Speed is the avg speed with which piston travels inside cyl.

* The more stroke, the lesser the rpm & propeller eff will increase

* Thermal eff is max as sufficient time for fuel to burn

- Fuel consumption decrease
- Can burn low grade fuel
- Overall thermal eff increase

} Adv of long, superlong & ultra long stroke engines

Only dis-adv that NO_x will increase but CO_2 will decrease

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* Compression Ratio :-

$$\frac{\text{Vol in cyl at beginning of comp.}}{\text{Vol in cyl at end of comp.}}$$

- More comp. ratio, more thermal eff.
- More comp. means at end of comp temp will be high to self ignite fuel.

2 Stroke engine → 12
4 Stroke engine → 15

Lifeboat engines → 18

- If comp. ratio is more, engine can be started from COLD easily.
- For ME, power developed is already high, if we have more compression ratio, P_{max} will be too high & cause damage

Air - Fuel Ratio

- How much air req for burning of fuel
- We need 14.5kg of air to burn 1kg of fuel
- But in practice, we give more air for better combustion
- In actual practice we give 36.5kg of air

SFOC - Sp Fuel Oil Consumption

* It is the amt of fuel in grams to produce 1KW Power in 1hr
* Unit - gm/KW/hr
* Better to run engine at MCR (full load) as by running at max power SFOC will reduce

Flywheel

* To take care of fluctuations in rpm during ideal strokes.
* Units more than 8 do not require flywheel
* 4 Stroke engine will have a bigger flywheel with same power rating

4 STROKE ENGINE	2 STROKE ENGINE
- If once cycle of suc. comp. power, exhaust is completed with 4 strokes it is 4 stroke engine	If one cycle of suc. comp. power, exhaust is completed with 2 strokes it is 2 stroke engine
- Cycle is completed in 2 rev of crankshaft	Cycle is completed in 1 rev of crankshaft
- Can be naturally aspirated without tc	Requires supercharging
- Med/ High speed engine	Slow speed engine
- Less in height	More in height
- Normally utilized for developing power on-board	Normally utilized for main propulsion.
- Heavier flywheel - More vibration due to high speed	Lighter flywheel Less vibration due to low speed.
- Power to weight ratio low	Power to weight ratio high.

Firing Order

- It is the order in which the units will fire
- Firing order to be such so as to not overload crankshaft from 1 side

① ⑥ ② ④ ③ ⑤ ← example

- This will uniformly distribute power over crankshaft
- If firing order is not proper, heavy torsional vibrations will occur

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Calculations

- Firing Pr (P) acting on piston crown area (A) pushing piston down

$$P \times A = \text{FORCE}$$

but force x dist travelled by piston = WD

$$\therefore P \times A \times L = WD$$

WD per unit time

$$P \times A \times L \times N = WD/\text{unit time} \rightarrow \boxed{\text{Power}} \ (W)$$

N → rps

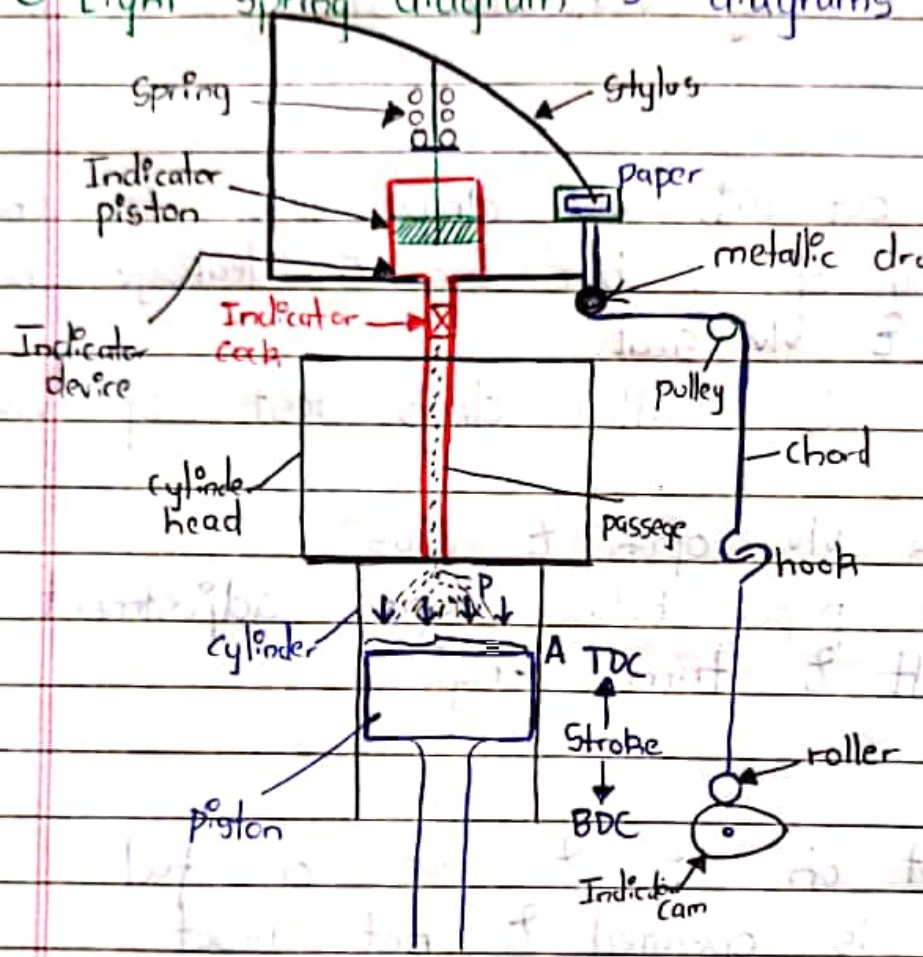
Indicated Power

P → Pressure (bar)
A → Area (m^2)
L → Length of stroke (m)
N → Rev/sec (rps)

CARDS

1. Draw Card
2. Power Card
3. Compression Card
4. Light Spring diagram

} 4 types of indicator diagrams



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* Indicator piston moves up due to gas force
* Spring will try to move the piston down
* Indicator cam mounted on same camshaft where fuel cam & exhaust cam is there

Now

Blowthrough indicator cock & open up
Now when pr rises, piston moves up, stylus will also go up
So vertical movement of stylus indicates pr

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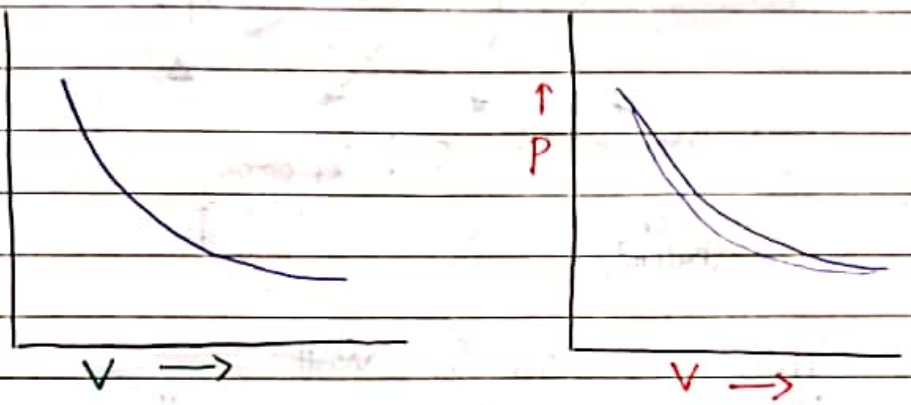
Drum connected to indicator cam, as cam moves, chord is pulled & drum oscillates
This indicates volume.
Now once stylus is pressed on paper an indicator card is obtained.

Compression Card (when fuel is cut off)



Single line indicates alignment of cam & indicator instrument is proper

Double line indicates misalignment of cam & indicator instrument

↓

In that case adjust the cam over camshaft

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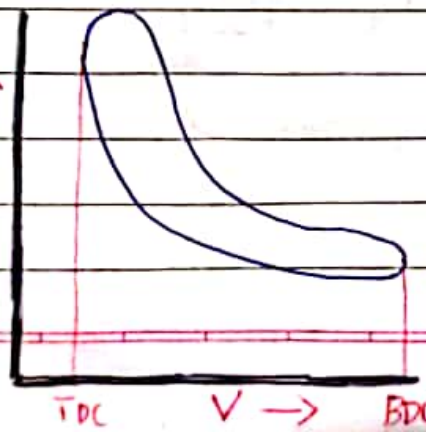
When compression card is OK
Open indicator cock
connect chord to hook

Power Card (Inphase)



Here drum movement is synchronised with movement of piston

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Pressure x Area = Force

Now, Force x Dist. travelled (Stroke) = Work Done

So we can say Work Done = P x L x A

Now work done / sec = Power

Power = P x L x A x N → rps

- P → Pressure (bar) or (kg/cm^2)
- L → Length of Stroke (m)
- A → Area of cross section of piston (m^2)
- N → Speed (sec)

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This we get in Watt

But we need in Kilo Watt, so x 1000

Now this P is v difficult to get as pr is not constant

So we take Pmean

$$P_{mean} = \frac{\text{Area of indicator diag } (mm^2)}{\text{Length of diag (mm)}} \times \text{Spring constant}$$

but when plunger moves up, it is opposed by spring pr

So we multiply by Spring Const.

Like to compress 1mm of spring, we req 1 bar

IP is power developed inside engine
BP is power available at flywheel

This power we finally get is called Indicated Power

& P_m is also called Mean Indicated Pr

Now Indicated Power x Mech eff = Brake Power
Brake Power is power available at flywheel
Mech eff usually 96% or 95%
due to losses in bearing.

IP - Frictional losses = BP

$\frac{BP}{IP} \times 100$ = Mech Efficiency

So we can say

$$P_m \times L \times A \times N \times \eta_{mech} = \text{Brake Power}$$

Now

Mean indicated pr x η_{mech} = Mean effective pr.

But how to calculate Area under curve

- By Simpsons rule
- Sigma meter
- Planimeter

Planimeter is the most widely used instrument onboard to find area under curve.

Mean effective pr will be less than mean indicated pr.

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CLYDE

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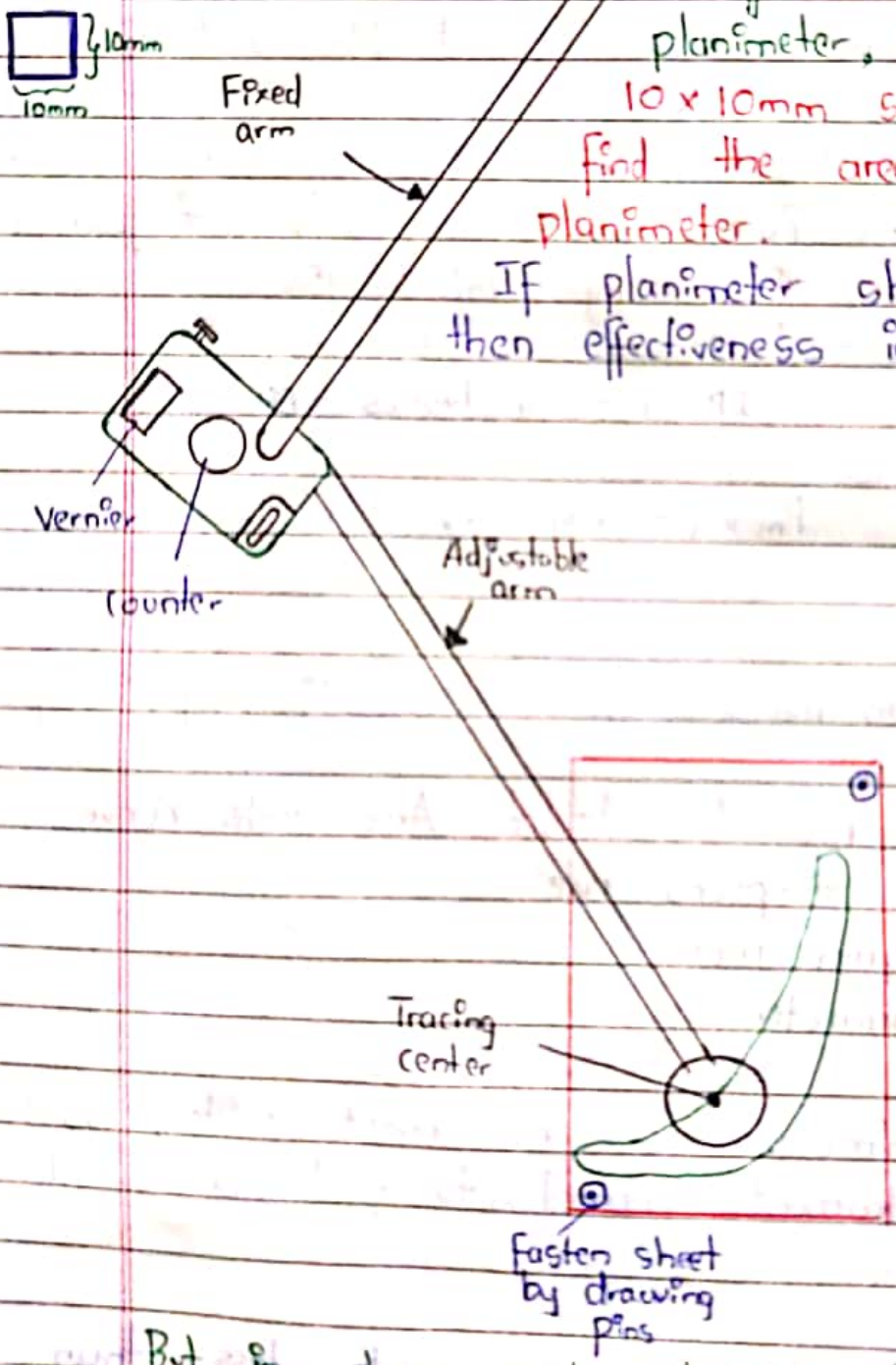
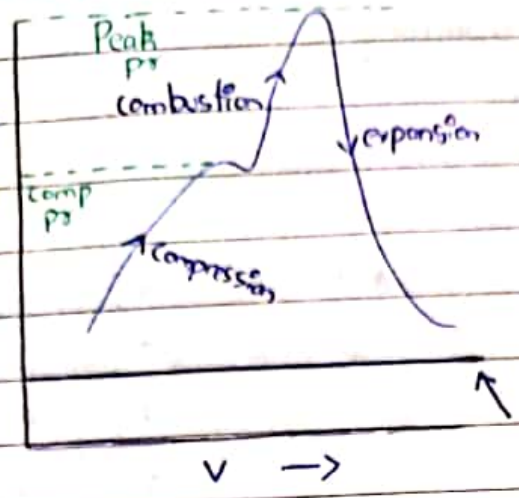
Planimeter

To check effectiveness of planimeter, draw a 10 x 10mm square & find the area by planimeter.
If planimeter shows $100mm^2$ then effectiveness is proper.



But in draw card, at TDC & BDC v small diagram will be obtained, as piston speed is 0 at TDC & BDC

Draw Card (Cut-of phase)

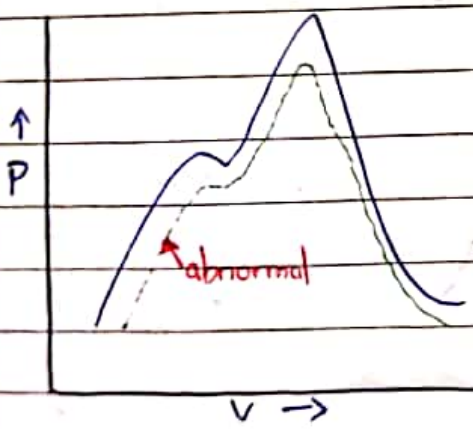


In this card it is easy to analyze
Compression
Combustion
Expansion

atmp (Indicator cock line shut & pull drum

This diag can be obtained by pulling chord on drum manually.

For example



Green dotted line indicates
comp pr low
peak pr low

This can be due to blowpast or exh v/v leak

If scaveng temp increases, this is surely blowpast.

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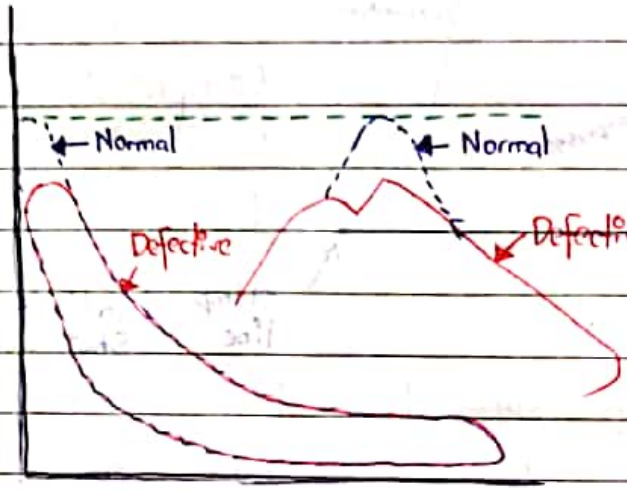
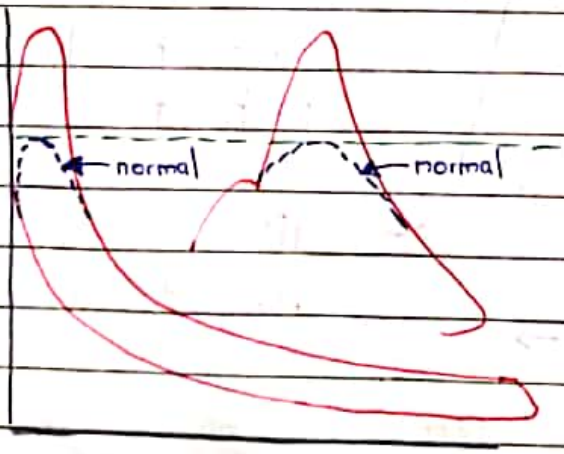
Case ① Comp. pr satisfactory
Peak pr low



* Fuel pr too low
* Defective fuel v/v
* Defective fuel p/p
* Poor fuel quality
* Low fuel p/p lead
* Fuel injection late

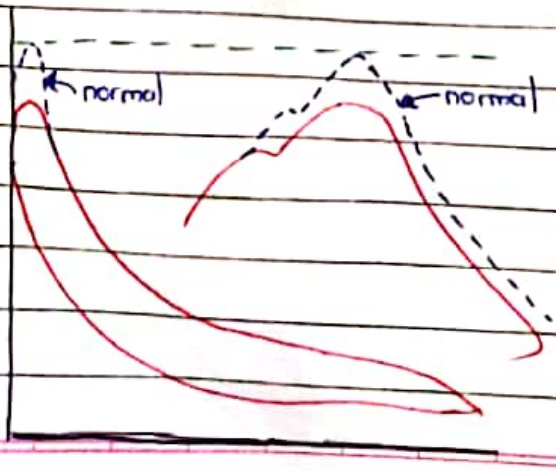
Case ② Comp. pr satisfactory
Peak pr too high

normally
Peak Pr
- Comp Pr
≤ 35 bar
or else
piston rings
will break



VIT
* ~~Fuel~~ index wrong
* Fuel p/p lead large
* Fuel injection early

Case ③
Comp pr
& peak pr
is also low



* Piston blow by
* Exh v/v leak
* Piston crown burnt
* Low sca pr

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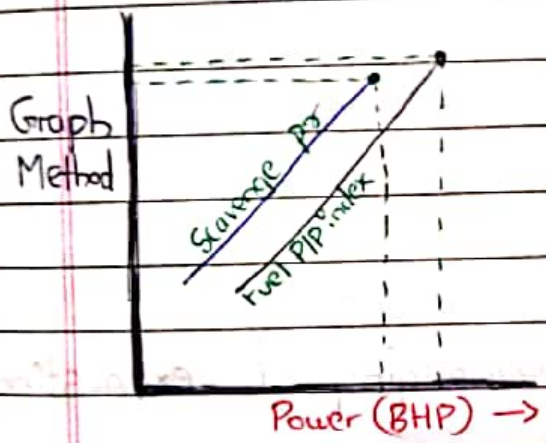
If no indicator instrument, how to find Power?

1. Graphs
2. Torsionometer
3. Electronic indicator system
4. Brake power
5. Strain gauges



* We use peak pr indicator gauge in 4 str

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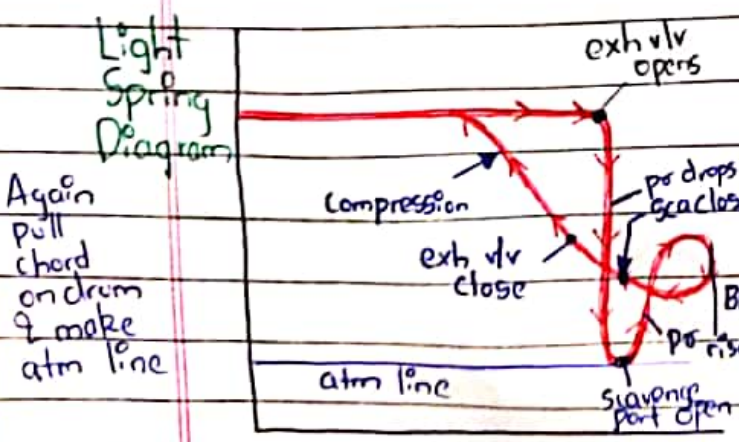
In 2 stroke, crankshaft & camshaft speed is same
But in 4 stroke, camshaft speed is half of crankshaft.

Hence we use a double peak cam to get indicator diag

Now inorder to scavenging & exhausting we draw



But scavenging & exhausting happen very less pr in cylinder
So normal spring is too hard to compress
Hence we add a very light spring

If the loop is small, scavenge ports may be choked

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SFOC → To calculate fuel used by power of enging

$= \frac{\text{Fuel consumed in ltrs}}{\text{Time}} \times \text{corrected sp. gravity}$

↳ In 1 hr, how much kg of fuel used

Sp gravity @ 15°C $\left(1-(T_1-15)R\right)$ $R = 0.00065$ HFO

T_1 → is that injection temp

But we want in grams

$= \frac{\text{Fuel consumed in kg} \times 1000}{\text{BHP}} \rightarrow \text{gm/kw/hr}$

If SFOC increases, some problem with engine.

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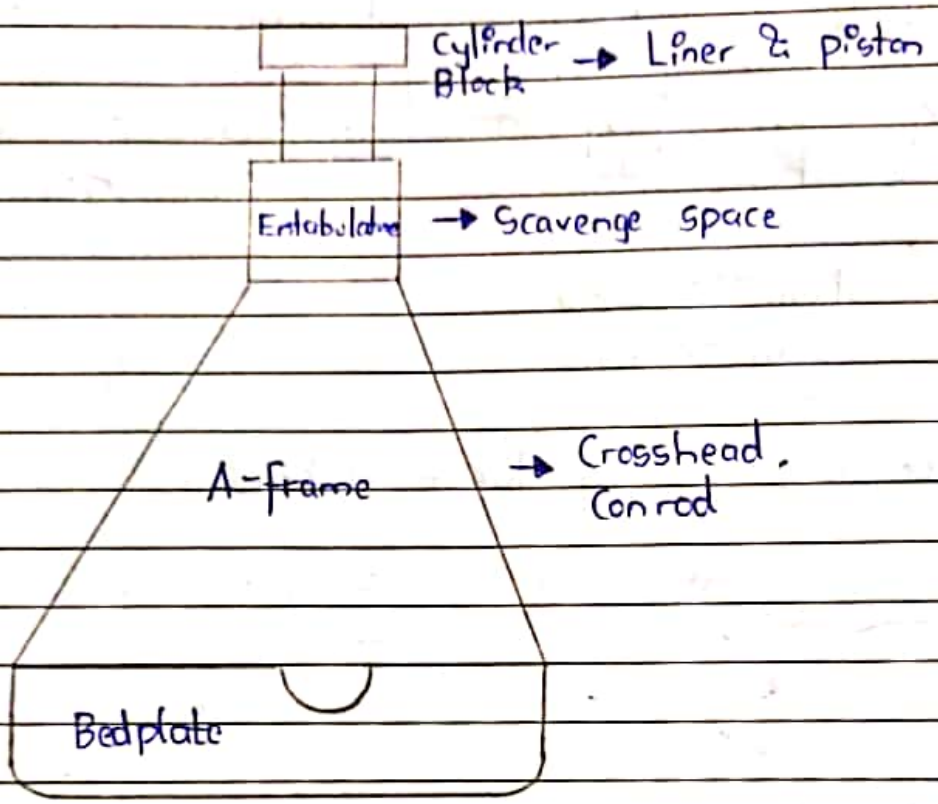
** Engine Structure **



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- Engine should be strong enough as well as lightweight

- Cyl block → Casted
- Entabulature → Casted or fabricated
- A-frame → Casted or fabricated
- Bedplate → Fabricated

* Bedplate is the structure on which engine stands
* In some small engines, entabulature is only Cyl block & liner is fitted

Bedplate
Foundation Plate
Hull

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Bedplate

→ Should be rigid enough to support the entire engine. At same time it should have flexibility also as hull will hog & sag

→ Before entire bedplate was casted & no proper cooling which caused stresses to induce. Also while casting if blow-holes or inclusions existed then entire bedplate had to be redone.

→ Also in fully casted, weight is more & also repair cannot take place.

→ Now fabricated bedplate is used

→ Bedplate consists of longitudinal & transverse girders

→ In this type, the casted steel plates are welded and makes a box type bedplate.

→ For large engine bedplate material to be used is low carbon steel with max carbon of 0.23%.

Bedplate connected to hull by holding down bolts

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Function of bedplate

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* To support the static load of the engine structure
* To support the dynamic load of the engine while running
* To support the crankshaft & hold it in perfect alignment
* To distribute the load of engine to hull of ship
* To collect crankcase LO & transfer it to sump where LO plp can take suction

→ Once entire bedplate has been fabricated annealing has to be carried out so as to relieve stress espcl in welding.

→ Welding joints to be specially checked by radiography to find welding defects.

→ Welding is done by hydrogen electrode

Cracks in bedplate

* Due to improper welding
* Due to overloading & uneven loading
* Slack tie bolts & hdding down bolts.
* Improper firing order of main engine

Transverse Girders - Cast steel
Longitudinal Girders - Fabricated steel

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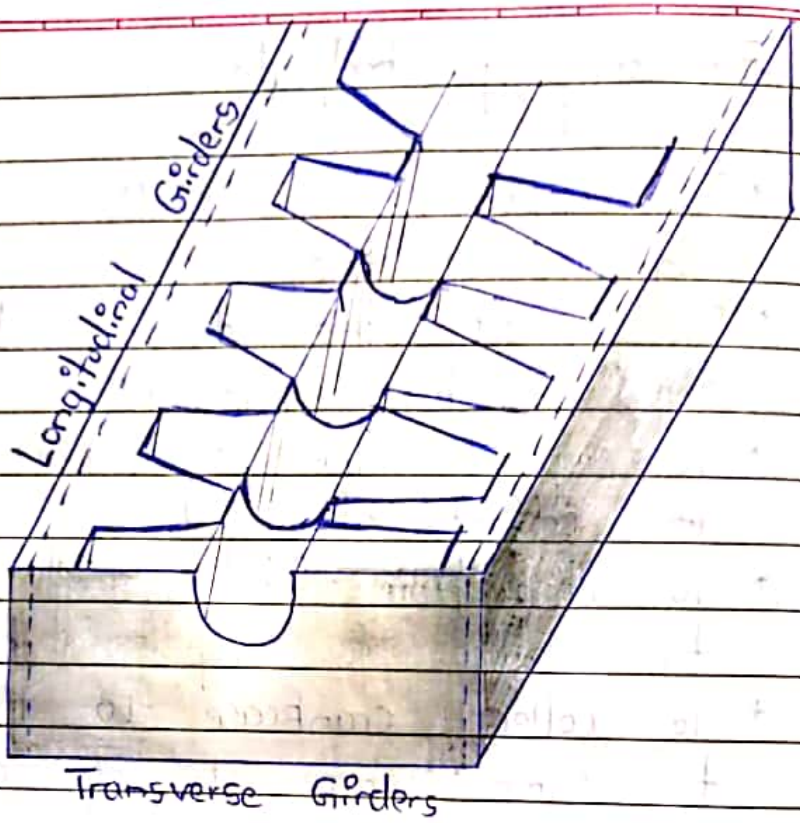

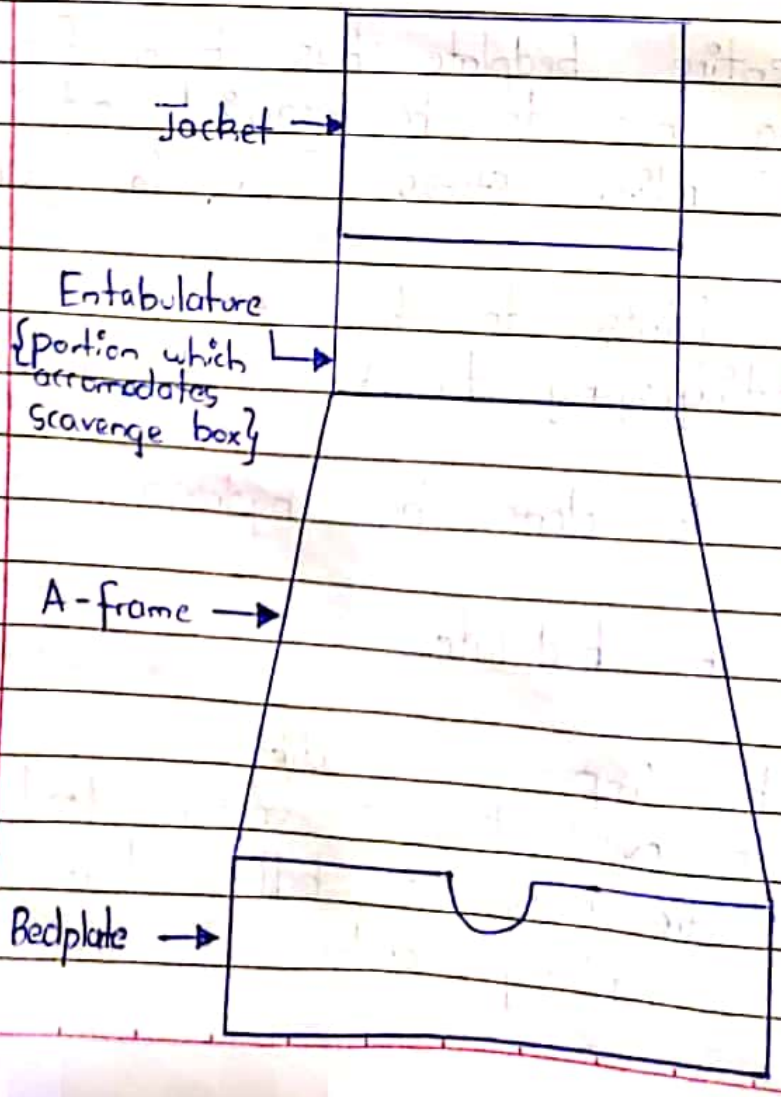

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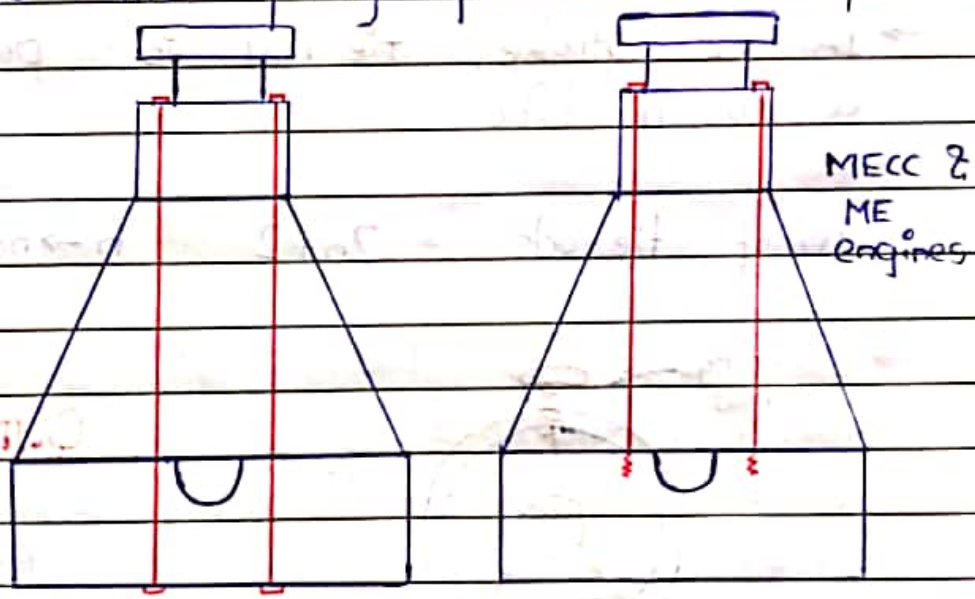
Tierods (Tiebolt)

→ We dont want any relative movement betⁿ entabulature, A-frame & bedplate. Hence we use tie-rods.

→ Tierod itself is in tension & holds the engine structure in compression.

→ Tierod also acts as medium to transfer the firing forces to bedplate.



→ In AE, entabulature & A-frame are 1 unit so sometime tierod not required & vibration is very less

→ Tierods are made of MS. If engine is too big, then tierod will be in 2 pieces

→ Both pieces can be joint by threading & coupling arrangement.

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Tie-rod

- It ties all components (bedplate, A-frame, entabulature) together in compression & tie-rod itself in tension.

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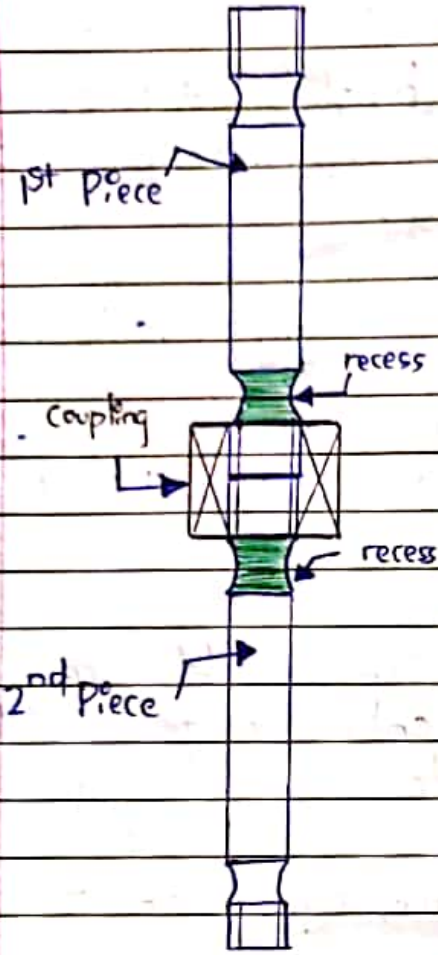
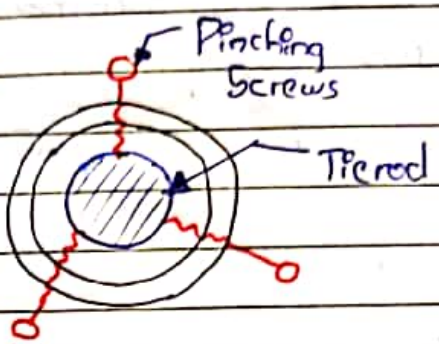
- Hence tie-rod will prevent any relative movement
- In long 2 stroke engines, tierod is there but sometimes in 4 stroke small engines no tie-rod is required.
- There A-frame & cyl block might be single casted. In that case only bolts will join A-frame to bedplate.
- In monoblock const. A-frame, cyl. block & bedplate are 1 structure itself.
- Here underslung crankshaft used
- Tie-rod usually made in 2 pieces fitted with a coupling
- Earlier tierod used to pass through a casted tube.
- Tierods are long & will vibrate & finally subjected to fatigue
- So tierod fitted with pinching screw at coupling.

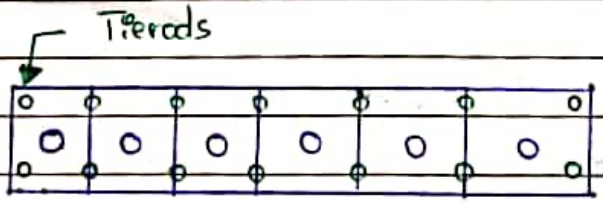




* There is a hyd nut at top & bottom

* First tighten to 450bar then tighten to 900bar.

6 Units



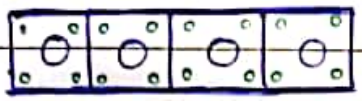
Tierods $2n+2$ where n is no of units
6 units means 14 tie rods

How to tighten?

- from center towards out so exp can take at free ends for correct tightening
- 2 tierods to be tightened together.

In MC-C engines

4xn = no. of tierods
So 6 units means 24 tie-rods



In MC-C tierod in 1 piece & it does not go all way down.

After every 1000 hrs tierods are checked
Once in 5yrs, tierod survey is done

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Knocking

2 types of knock
- diesel knock
- mech knock

* Knocking may be due to exh v/v as exh v/v seating v hard
* Knocking can also be due to vapour lock.
* Also delay in injection can cause knock
* In diesel knock, peak pr will be v high

Chokes

- Main choke
- Side choke
- End chokes

* Chokes are either of CI or resin chokes

* If proper alignment of holding down bolt & chokes are not proper, crankshaft can get damaged.

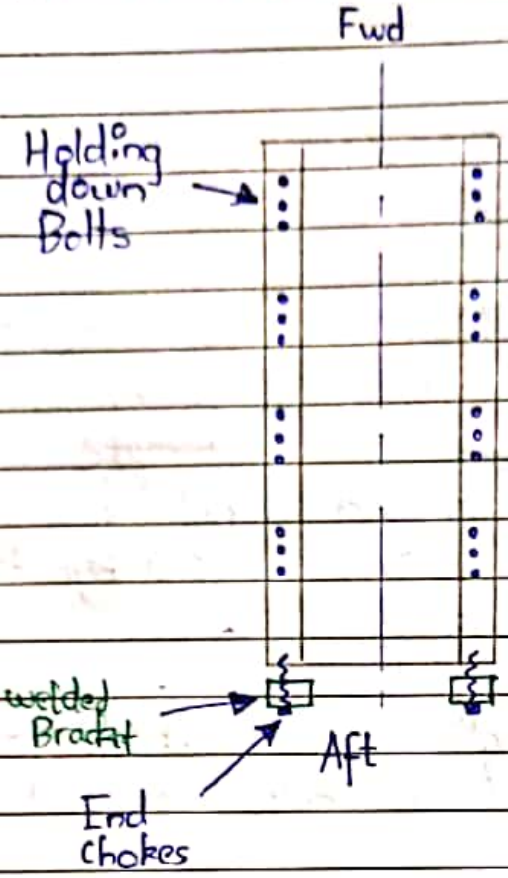
- You are holding engine over tanktop & hence it is called Holding Down Bolts or Foundation Bolts

Side Choke

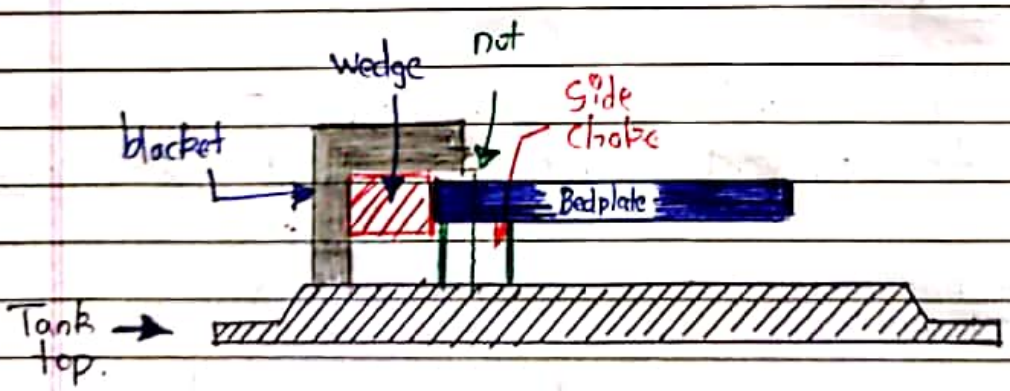
* Engine has tendency to move P & S & hence to prevent this, we need side choke

End Choke

* Engine has tendency to move Fwd & Aft & hence to prevent this, we need end choke



Wedge → Steel



* Regularly take a small hammer & tap on holding down bolt
* If irregular sound means loose

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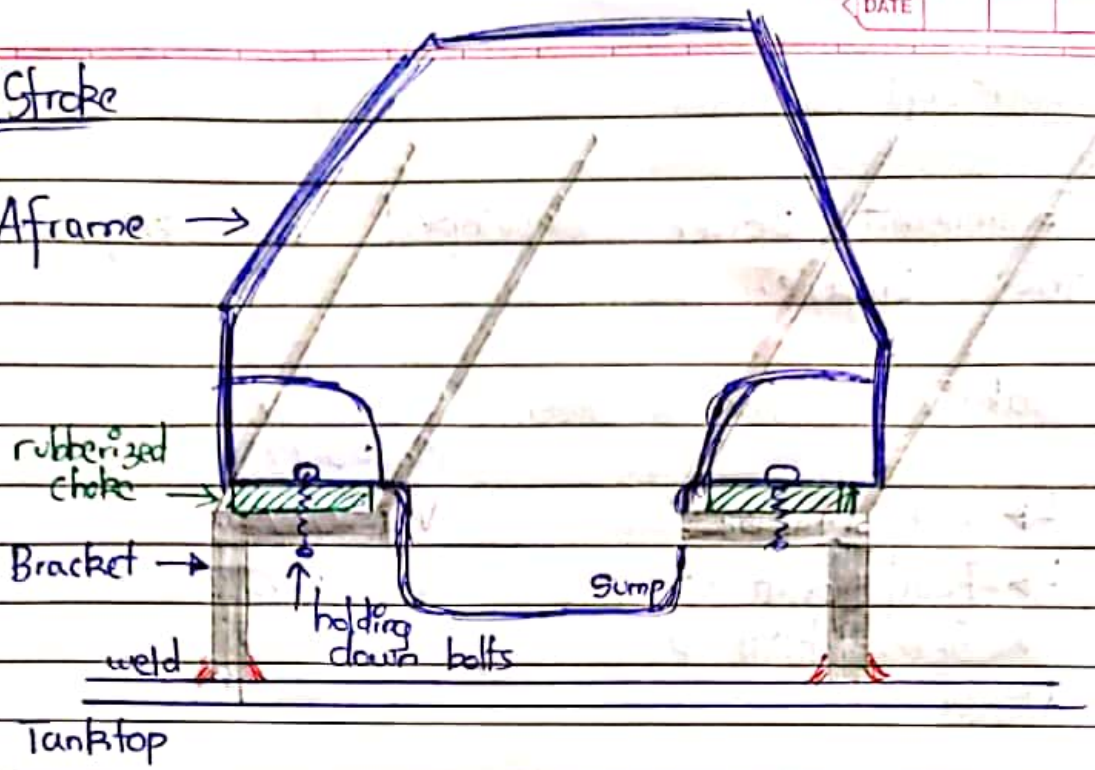
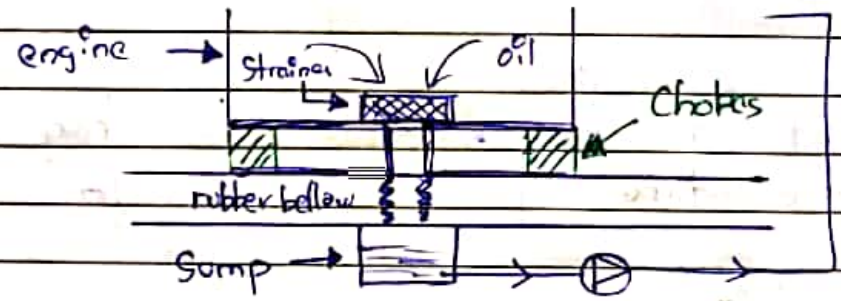
4 Stroke



CLYDE



CRANKSHAFT

Types

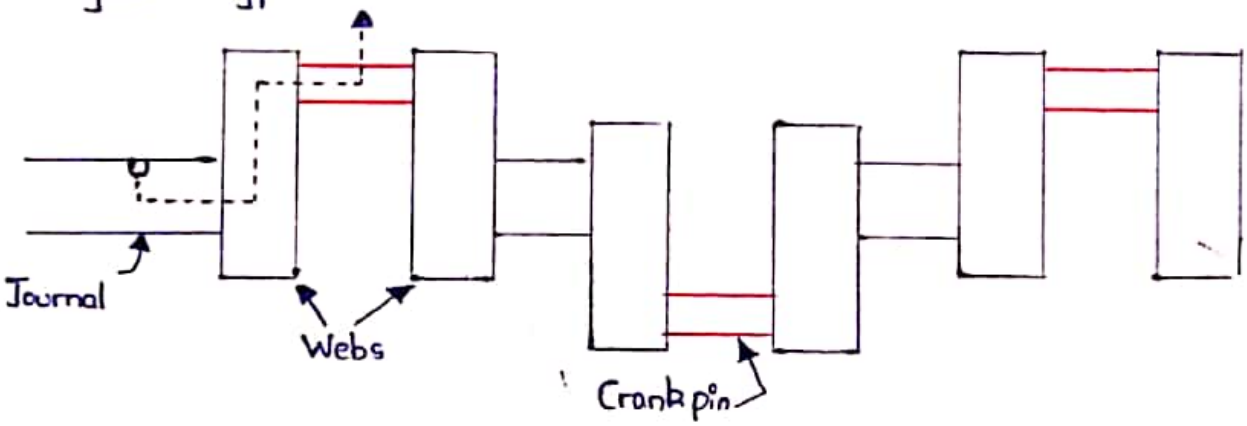
① Forged
② Fully built up
③ Semi built up
④ Welded

Crankshaft is subjected to shear stress, bending stress, torsional stress, fatigue stress.

Crankshaft made of low alloy steel

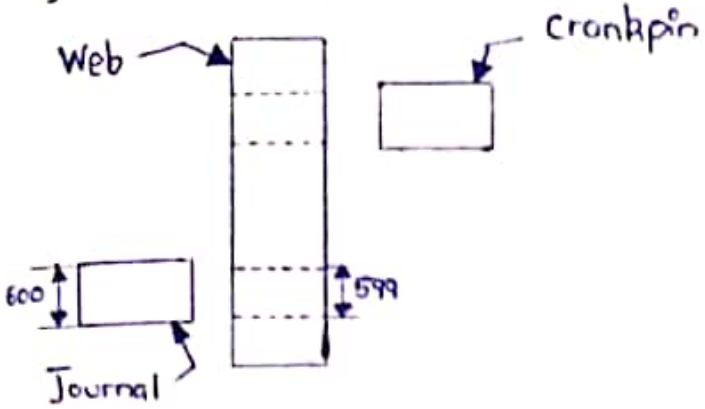
Mg = 0.75%
Tin = 0.1%
Vanodium = 0.1%
Carbon < 0.23%

① Forged Type



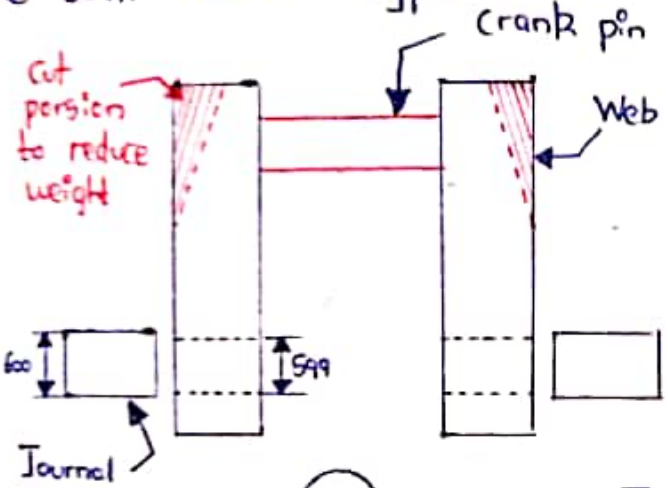
- This crankshaft is fully forged type.
- But this crankshaft becomes v rigid.
- It is difficult to make due to limitation in forging.
- It is forged by continous grain forging method giving fatigue resistance properties.
- Here the journal, webs, crankpin are all together.
- Used for small engines like AE.
- There are no oil holes in crankshaft in 2 Stroke engine

② Fully Built Type



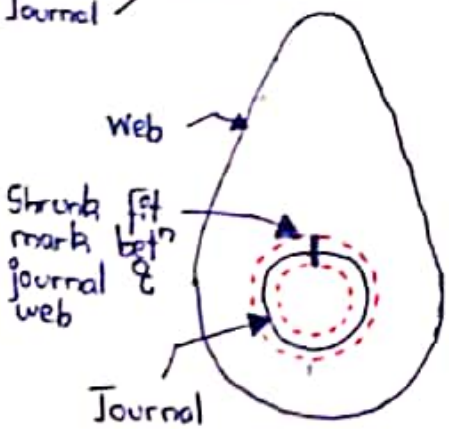
- In this type, the journal, web & crankpin all are seperated.
- The crankpin & journal are shrunk fit in crankshaft.
- But this crankshaft becomes too heavy & difficult to manufacture.

③ Semi Built Type



- In this type, the webs and crankpin are together.
- The journal is shrunk fit in webs.

CLYDE

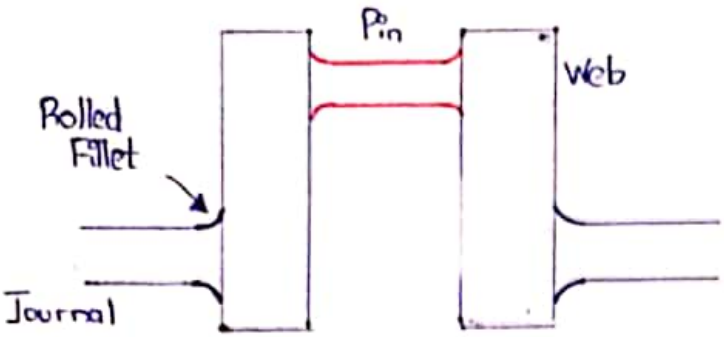


- In the web there are hoop tensile stresses & in the journal there are hoop compressive stresses.
- These stresses are useful stresses used to transmit power.

Because of v high torque, crankweb slip takes place

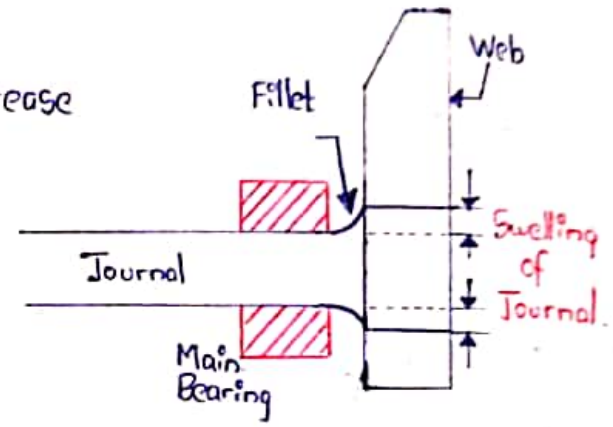
- ↳ Compressing liq above piston
- ↳ Collision
- ↳ Grounding
- ↳ Propeller hit rocks

* Rolled fillets are used to protect crankshaft from cracks



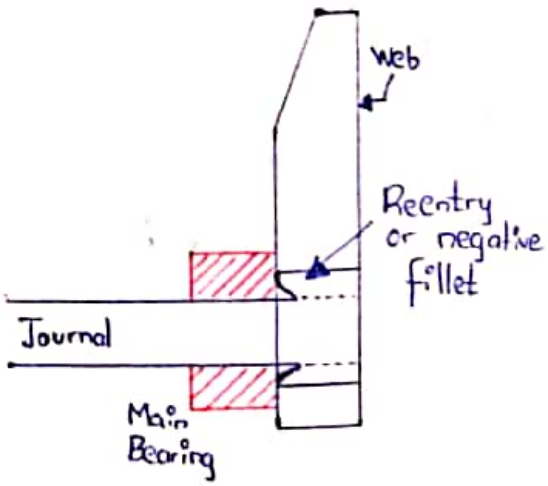
* Oil holes are also to be avoided or they need to be rounded up.

* Swelling of journal is used to seperate 2 surfaces as only 1 surface would increase hoop stress.



* But in this design there is gap bet^n main bearing & web due to fillet.

* Hence negative fillet / re entry filled is used.



* In 2 Stroke, max fatigue Stress takes place in Crankshaft. → No oil holes

* In 4 Stroke, max fatigue stress takes place in bottom end bolts. → Oil hole

CRANKSHAFT DEFLECTION

① Crankshaft deflection is basically to find out relative vertical misalignment. (to check 1 main bearing w r t the neighbouring one.

② Deflections are normally taken once a year otherwise when
- ↳ Main bearings are renewed.
- ↳ After extreme weather.
- ↳ Before & after drydock.
- ↳ After vessel has been grounded.
- ↳ After renewal of chocking arrangement.
- ↳ Loose foundation bolts.

CLYDE

③ Deflections to be taken when the vessel is afloat.

④ Indicator cock to be kept open & turning gear to be engaged.

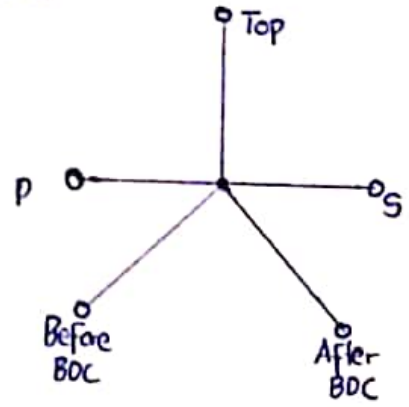
⑤ If possible, take deflection and previous trim & crankcase temp.

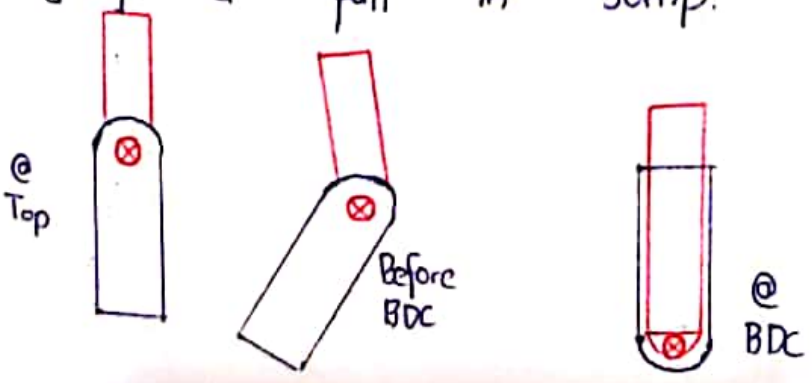
⑥ Deflections can be measured by ~~either~~ ~~Bridge~~ ~~gauge~~ ~~or~~ ~~telescope~~ ~~type~~ ~~feeler~~ ~~gauge~~. Dial Gauge

⑦ Deflections are taken at 5 places.

⑧ Dial gauge is always fitted opposite to crank pin.

⑨ It is not taken at BDC because con rod will hit gauge & fall in sump.





Centerline of crankpin intersects centerline of journal. → location where dial gauge is fitted.

Procedure :

CLYDE

① Make the table ready

P						
S						
T						
Before P						
Before S						
Avg $\frac{BP+BS}{2} = B$						
T-B						
P-S						

* Normally (T+B) should be equal to (P+S)

② Now turn the engine in 1 direction of rotation with turning gear.

③ Note the values at every pt

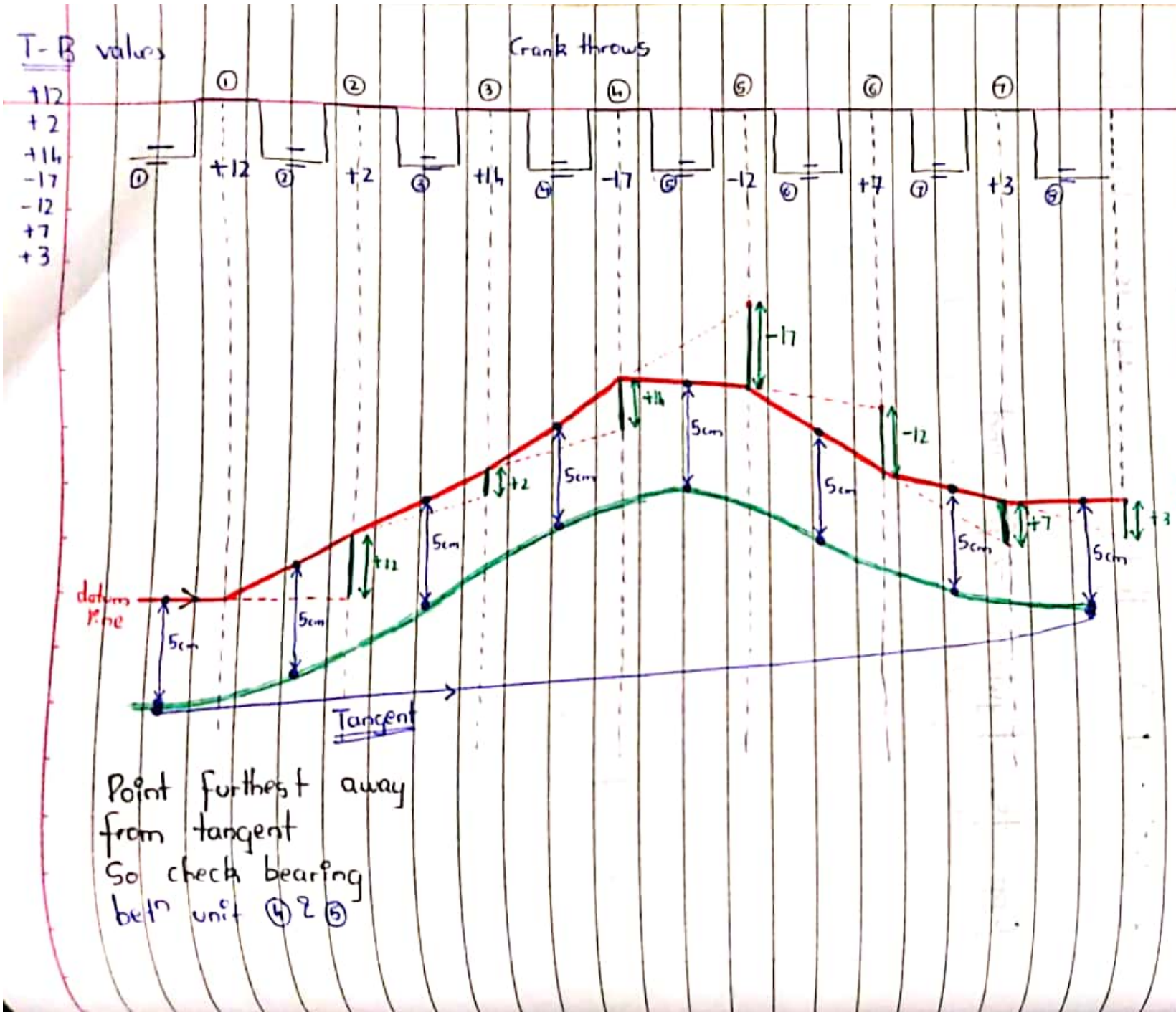
④ When you reach a position, slightly reverse to release pressure on teeth of turning gear. This is called Releasing Tangential Load.

⑤ This releases pressure or rxn force on webs.

⑥ While taking readings, make sure there is no clearance betn journal & bottom half of main bearing. If gap is there → Overhanging of journal.

T-B values

+12
+2
+14
-17
-12
+7
+3



All this deflection of crankthrows
But we need to see deflecton of main bearing.

Point furthest away from tangent
So check bearing betn unit ④ & ⑤

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PISTON

* Piston crown → Cr-Md Steel
* Piston skirt → CI
* Piston rod → Forged Steel (flame hardened)

* Piston crown has piston ring grooves
  → In MAN B&W, grooves are flame hardened
  → In Sulzer, grooves are chromium coated.
* Lifting ~~are~~ grooves are also available on piston crown.
* Top of crown coated with inconnel 625 (high temp corrosion resistant)
* On piston skirt, there are usually 2 wear/rubbing bands
* Wear band → Phosphor bronze.
* Crown is connected to piston via stud & nut arrangement
* Piston rod is hollow to mount telescopic pipe.
* Piston skirt (CI) which contains graphite. & graphite is known for its dry lubricant properties.
* Burning of piston crown usually occurs due to high temp corrosion (presence of sodium & vanadium) in fuel.
* Piston can be either oil or water cooled.
* If water cooled
  ↳ initial cost of tank, plp, cooler will increase
  ↳ can cause scale formation.
  ↳ can cause contamination.

CLYDE

* When piston rings or liner is new, proper contact is not there & chances of blowpast can happen.
* Wear / rubbing band has high thermal resistance & also expand due to heat.
* This will help to form a seal & prevent blowpast while "breaking in" & "running in" is carried out.

① Breakin In :-

* Here aspirities bet^n piston rings & liner is most.
* So here crankcase oil is used which has low TBN. & gradually load is increased.
* This is carried out for 24 hrs upto max load.

CLYDE

② Running In :-

* Here aspirities bet^n piston rings & liner is less
* Here good cylinder oil to be used
* Running in takes about 2000 hrs & reduce cyl oil every 500 hrs upto normal feed.

* Piston cooling usually done in 2 ways
  - Jet shaker method
  - Cocktail shaker method.
* In Jet shaker method, oil enters from inner pipe, sprays from nozzle as a jet & leaves from outer pipe.

* In 4 stroke piston slight changes are there.

2 stroke : Side thrust is taken by crosshead guide & shoe.

4 stroke : Side thrust is taken by piston skirt

Hence piston skirt → Al alloy

* In 4 stroke, due to the exhaust & inlet valves, recess is provided on piston crown.
* In 4 stroke, the lifting screw threads are at center.
* In 4 stroke, con rod small end is connected to piston & in 2 stroke, piston rod is connected to piston.

CLYDE

REMOVAL OF PISTON :

① Initially, take piston to BDC & from cylinder head, buff the top inner side of liner to remove the carbon.
If not removed, piston may stuck up

② Loosen the piston palm nuts at bottom which connects piston rod to crosshead.

③ Before removing piston, piston cleaning ring needs to be removed.

④ Also before lifting piston, we have to ensure liner doesn't get pulled up.

⑤ Lift piston via chain block.

Checks On Piston :

① Remove piston rings with piston ring expander. Clean the grooves nicely of all carbon. Inspect groove for any wear & measure width of groove.

② There is recess in groove to prevent sharp edge of groove from cracks.

③ Use template on piston crown, to check burning of crown.
Max allowable burning is 18mm.

④ Check locking of skirt & piston in good condition.

Also we have to do hyd pr test on cooling space.

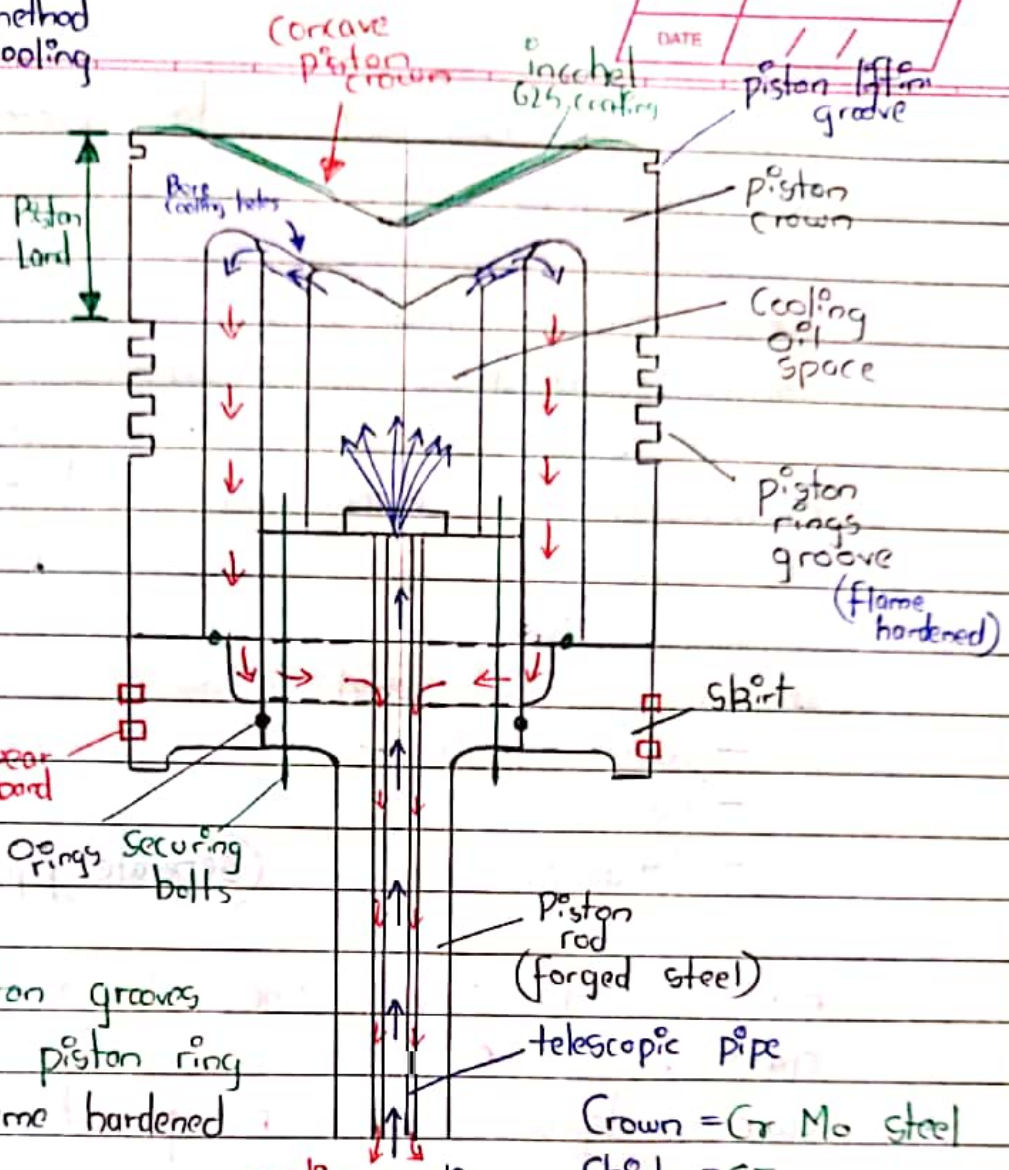
① Turn piston & piston rod upside down.
② Connect flange at end of piston rod.
③ Connect another flange with hyd p/p.
④ Pressurize upto 7 bar & hold.
⑤ Check for any drop in pressure.

Splashing of oil due to moving of piston crown → Jet shaker effect

Nozzle - Jet
Splash - Shaker

This is method of cooling

2 Stroke piston



CLYDE

MAN B&W
Piston grooves for piston ring Flame hardened

Crown = Cr Mo steel
Skirt = CI
Piston rod = Forged steel

SULZER
Piston grooves for piston ring Chromium coated

Flame hardened

Hot Corrosion
Burning of crown happens due to high temp corrosion due to sodium & vanadium in fuel
Hence crown coated with inconel 625

Wear band / Rubbing band → Phosphor bronze

Crown & piston rod connected by Stud & Nut arrangement

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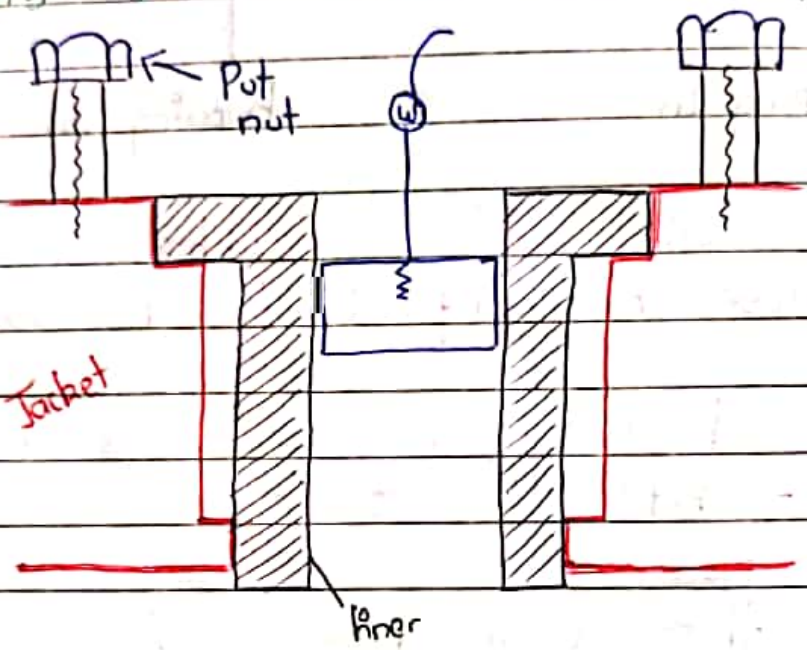
Removal Of Piston

- 1st piston cleaning ring needs to be removed
- Initially take piston down, & with buffing wheel, buff top inner side of liner. This is to remove carbon deposits



- Put nut on stud to ensure liner doesn't lift while lifting piston.
- Now connect chain block to piston lifting groove & take out piston.
- Before that also remove the piston palm nuts

Checks

① Remove piston rings with piston ring expander

② Clean grooves nicely of all carbon

③ Now inspect groove for corrosion or

④ Measure width of groove.

→ Burn of piston crown
→ Grooves, piston rings
→ Pr test of cooling water space.

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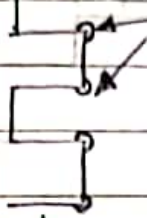
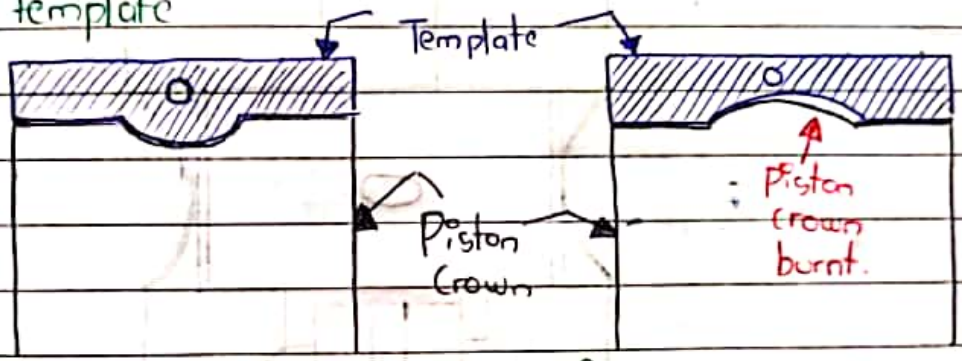
⑤ There is a recess in groove to prevent groove from cracking



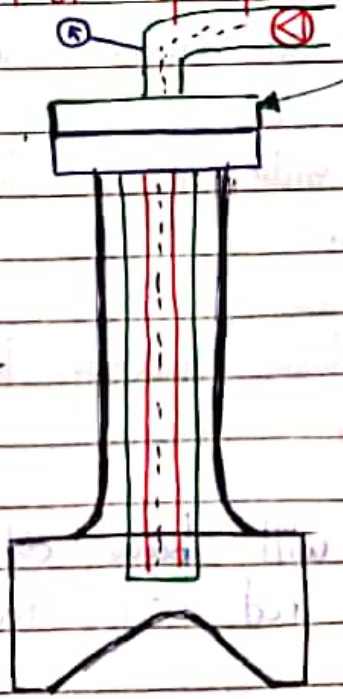
⑥ Now check piston crown for any burning by template



max burn of 18mm acceptable.

⑦ Check locking of skirt & crown in good condition

Hyd Pr Test of piston cooling space.



check for no drop in pr. Pr test upto 7 bar

Recession as inlet & exh vlv opens

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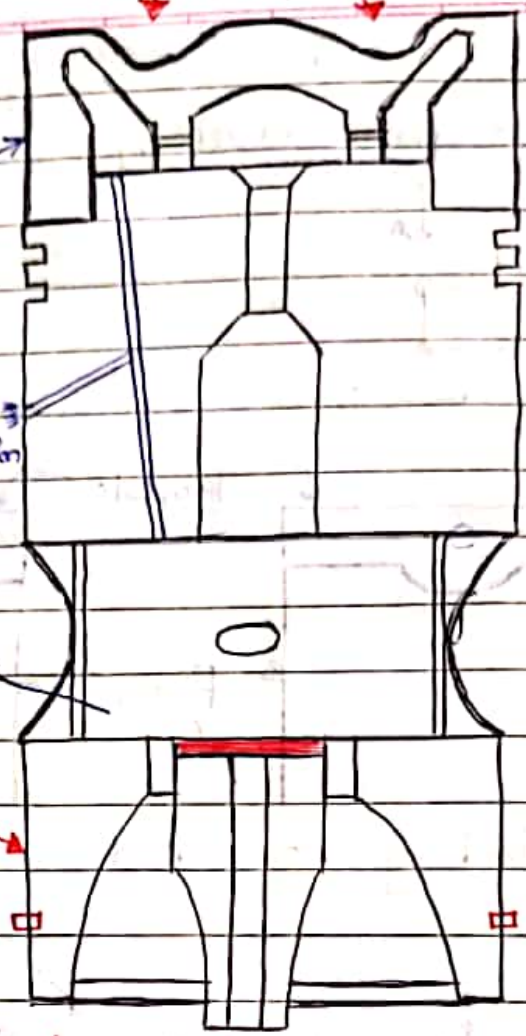
4 stroke piston



CLYDE

In 2 stroke, side thrust is taken by crosshead shoe & guide
In 4 stroke, side thrust is taken by piston & liner directly

Hence skirt always touches liner & rubs
Skirt = Al alloy

Piston rings will have oil scraper ring
Skirt & con rod connected by gudgeon pin

Gudgeon pin is not allowed to come out as there is circlip.

Control pressure relief ring

CPR - POP port on plane

gas will escape at bottom of ring.

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4 Piston Rings

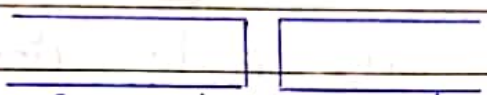
Piston rings → CI

* Ring should be elastic in nature

This purposely allows some gas to leak as pr difference accross this ring is too much.

Lap joint (1st piston ring)

Seal is good but joint can break



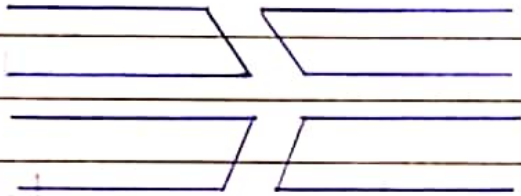
Straight joint

Seal is not good but joint is good.

2 Stroke

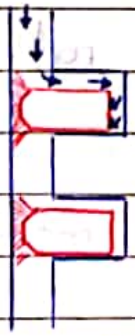
1 → CPR Ring

2] 3] → Comp. Ring

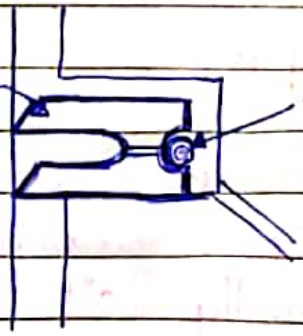


Bevel joint or angle joint

* Seal is also good & joint also strong
* This will help ring to rotate in groove & also keep butt space clear of carbon. (Self cleaning effect)



Surface of piston ring coated with Al - coat.



Axial clearance

Radial clearance

Butt clearance.

LINER

* Liner made of CI
* Now according to formula

$$t = \frac{Pd}{25}$$

If dia of liner increases, thickness will also increase.

→ If thickness is too large, cooling won't be sufficient enough.
→ If thickness is too less, more possibility of liner to crack.

* Liner is tapered at bottom
  ↳ at bottom pr & temp is less, so we can decrease thickness & reduce cost.
  ↳ also this will give "fin effect" & keep top of liner cooler.
* Inside of liner is bored so that cooling water (jacket water) can pass through.
* JCW enters from bottom & leaves from top.
  If JCW enters from top
  ↳ Thermal stresses will increase.
  ↳ If there is air or vapour, it won't be able to escape.

CLYDE

Liner Calibration

* We use a template to check condition of liner.
* Make sure you check 0 selling of micrometer.
  {LC of micrometer = 0.01 mm}
* With help of template mark P & S & F & A on liner.
* Now insert micrometer & take readings.

Unit No	(P-S)	(F-A)	Running hrs	Ovality (P-S) - (F-A)
①				
②				
③				
④				
⑤				

CLYDE

* $\frac{\text{Present value} - \text{Previous value}}{\text{Running hrs bet}^n \text{ decarb}} \times 1000$

  This will give wear rate /1000 hrs (mm/1000 hrs)

  (Max allowable $\underline{0.05\text{mm}/1000\text{ hrs}}$)
* Due to liner ovality, piston rings can break leading to blowpast.
* If wear down is 1% of liner dia then replace liner

Liner crack reasons

① Overload on that unit
② P_{max} too high
③ Fuel impingement
④ Scale formation
⑤ Insufficient cooling

How to know liner cracked

① Hot gases will come in contact with JCW increasing JCW temp.
② High pr exhaust gases will go upto the de-aerator.
③ Exh gas will go along with water making water black.
④ JCW will enter liner & evaporate giving white smoke in funnel.
⑤ JCW consumption will increase.
⑥ Exhaust temp of that unit will drop.

Polishing Of liner

* After prolonged period, ash & carbon will accumulate on land of piston.
* It keeps getting thicker until it starts to touch liner.
* Due to piston movement, this will rub against liner & polish liner (mirror finish)
* As liner gets polished, oil flows down liner easily & rubbing takes place of piston rings leading to "scuffing"
* Scuffing is a type of contact wear

Abrasive Wear :-

* Due to presence of hard fine particles bet^n piston rings & liner, the liner wears down.
* Hard fine particles are due to silica & alumina in fuel which are called catalytic fines.
* This can be avoid by proper draining of settling & service tanks. and also good purification.

CLYDE

Corrosive Wear :-

* Due to presence of sulphur in fuel, sulphuric acid corrosion takes place which is called cold corrosion.
* This can be avoided high TBN cylinder oil. The alkalinity in cylinder oil neutralizes the acid
* Also low sulphur fuel can be used.
* JCW should be kept at higher temp.
* Also proper quantity & distribution of cyl oil over liner.
* Clover leafing is one of problems which happens due to improper distribution of cyl oil.

→ Anti-polishing ring also called flame ring, anti-scuffing ring, piston cleaning ring is used to prevent contact wear

* Micro-weld on liner due to high temp is also type of contact wear

Removal Of Liner :

① Shut JCW & drain JCW from liner.
② Take precautions so that while lifting liner no mud goes into crankcase.
③ Also before shutting JCW. put SAF acid to clear all scales
④ Mount the liner withdrawing tool & start jacking up.
⑤ Before lifting liner, ensure quills are not damaged
⑥ In 2stroke, a beam arrangement is used to lift liner.

Fitting new liner :

① Check for approval mark on liner.
② Where liner sits over jacket put a forma A gasket.
③ let liner go down by its own weight.
④ Check O ring of liner to have no twist
⑤ Open JCW to check for oring leak.
⑥ Now insert piston in liner.

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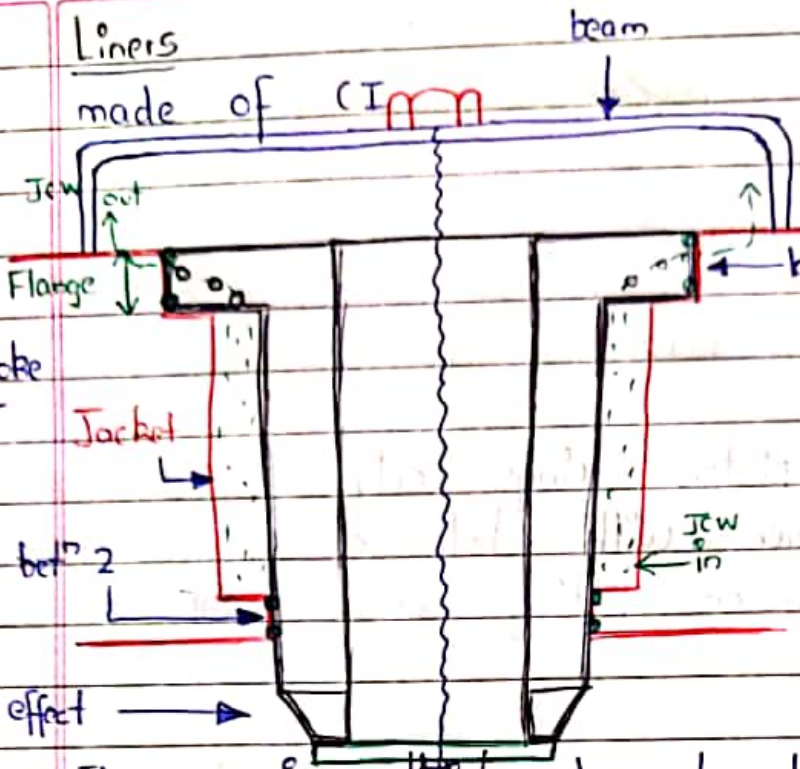
Liners made of CI



If dia of liner increases thickness also increases.

If t is large cooling won't be sufficient.

If t is small cracks can be developed.

* Flange is thick due to high temp
Liner fitted inside jacket

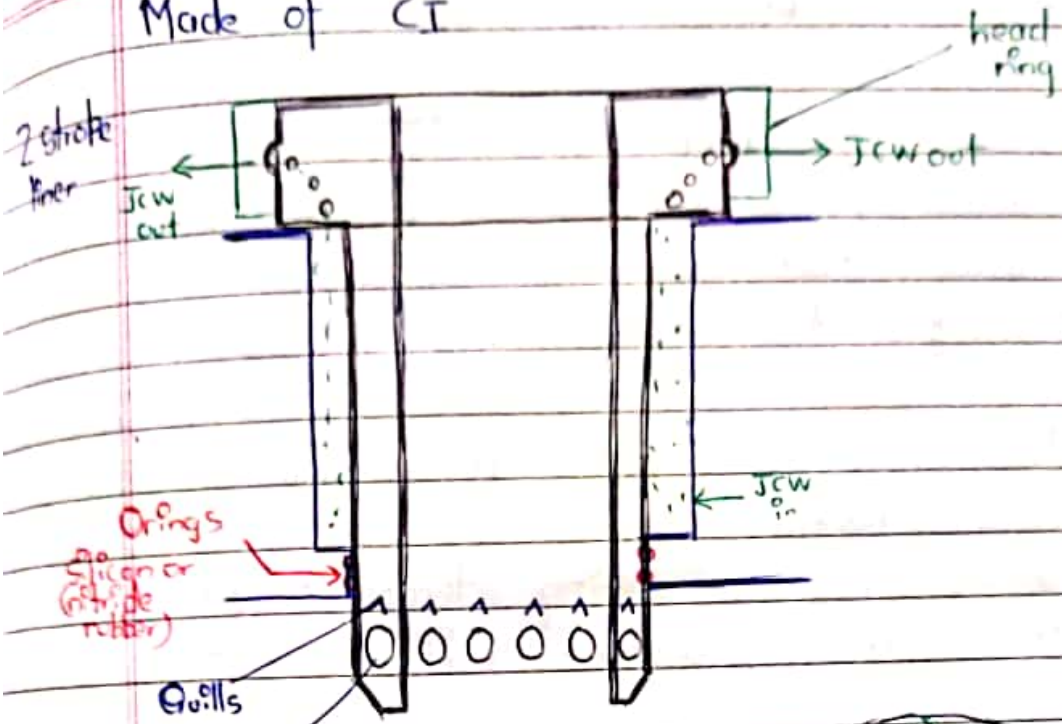
$t = \frac{Pd}{25}$

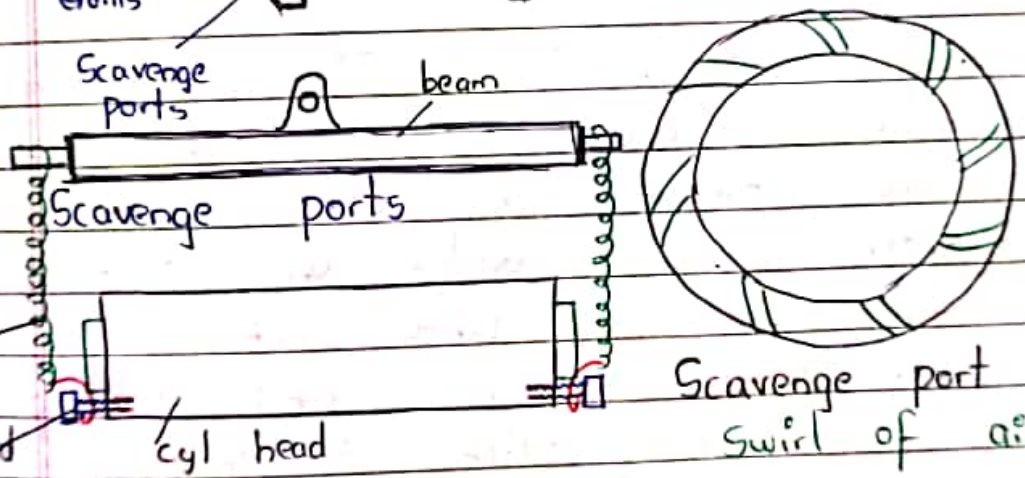
If d of liner increases, thickness will increase, then insufficient cooling will happen

Inside of liner is bored & machined
Liner tapered at bottom
- at bottom pr & temp less, so we can decrease thickness & reduce cost
- this will give fin effect & keep top of liner cooler

Cooling water enters from down & goes out through top.
- air lock / vapour lock prevention
- thermal stresses will develop

Made of CI



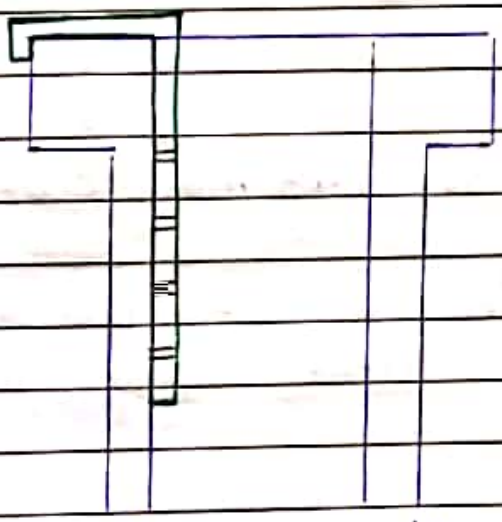


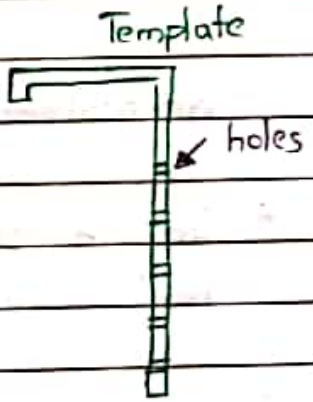
* A beam arrangement is used to lift liner
* Put SAF acid in Jcw space to clear of scale formation.

Q If liner cracked, what actions to take

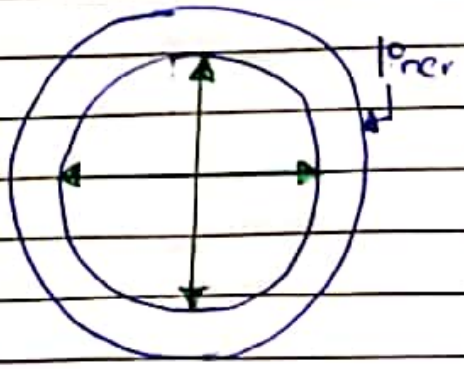
- Stop firing
- Shut JCW in & out
- Open Drain
- Increase cyl oil
- Keep indicator cock open
- Keep exh v/v open

Gauging of Liner

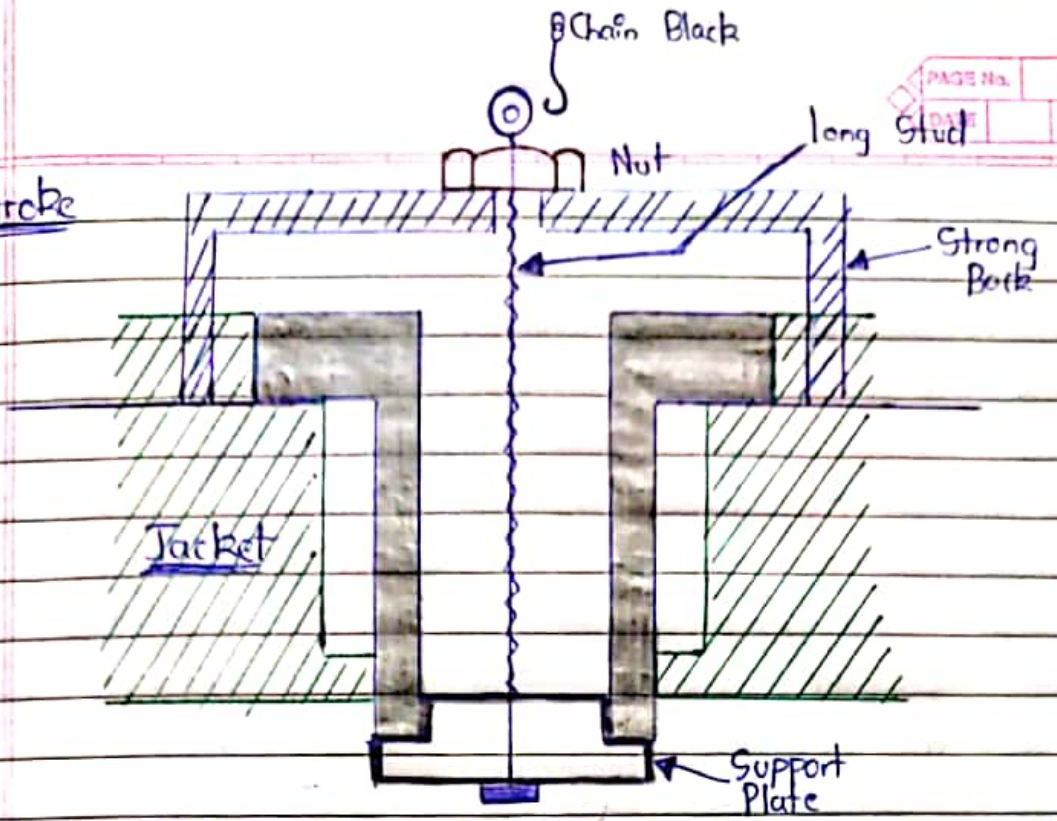




* Put the template over line
* Make marking P-S & Fwd - Aft on liner
* Now use inside micrometer with extensions
* Put inside micrometer & take readings

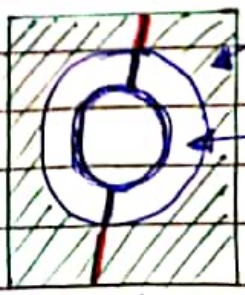


4 Stroke



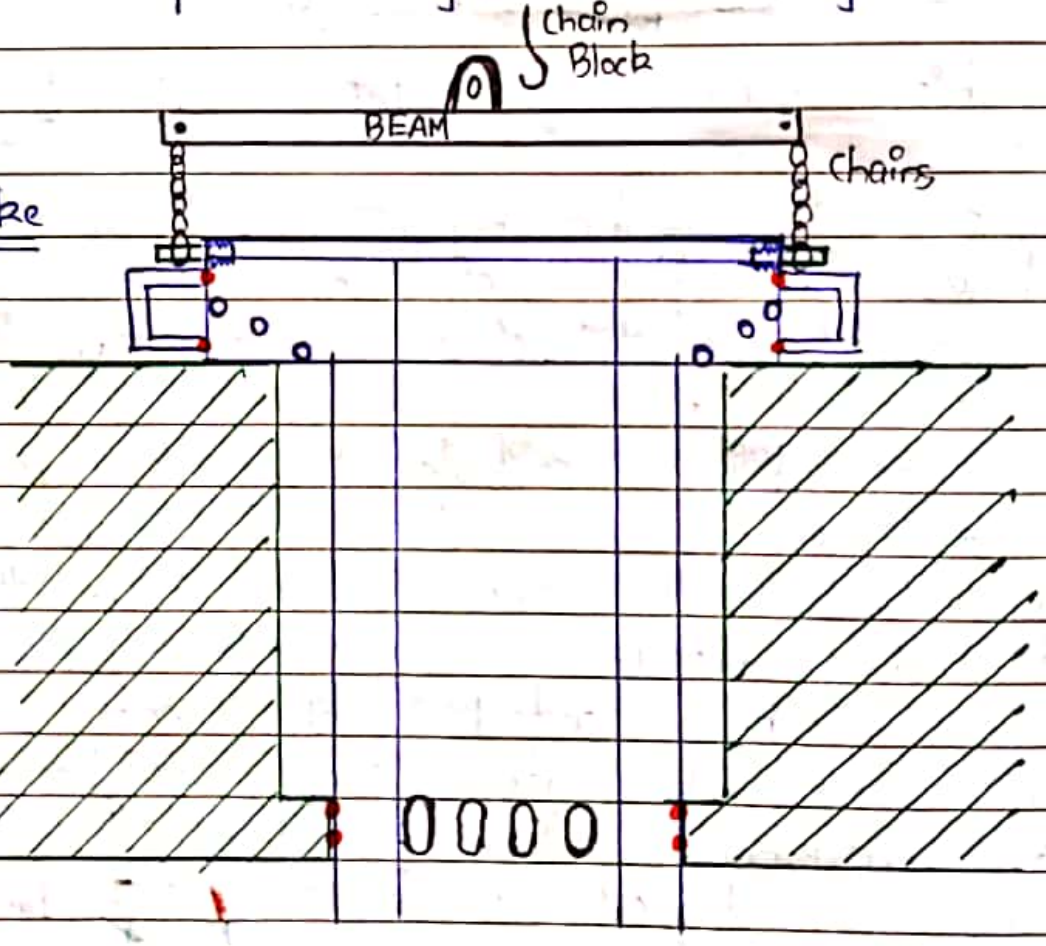
* Use this assemble to take out liner

- Clean new liner throughly
- All holes in flange of liner blow through it
- Check marking of class society on liner & note
- Now before fitting, calibrate liner
- Put new orings in liner in groove provided
- Twist oring with screwdriver such that no twist while fitted
- O-rings to be coated with soap solution.
- lower liner with its own weight
- Jacket marking & liner marking should coincide
- Once after fitting do liner calibration again.
- Let some Jcw to check if O rings are leaking
- Once all ok, then lower down the piston



- Now do breaking in & running in
- Keep rack of this unit minimum to reduce load. Then slowly increase load
- Breaking in - breaking aspirities
  Running in - Smoothening aspirities
- Take power cards & you'll come to know of breaking in & running in.

2Stroke



* Insert lifting pins on side of liner
* Connect the lifting beam chains to the pin to lift it up
* But before all this, make sure quills are removed.

* If liner gets stuck up, put SAF acid betn liner & jacket & close drain

* While lowering liner, make sure markings coincide. Also put a forma-A gasket before fitting.

* Same procedures as before

Liner Cracks

- Fuel injector holes enlarged
- Load-up programmed not followed
- If Pmax - Pcomp should not be more than 35bar.
- If JCW insufficient
- No proper cyl lubrication

Effects

- High temp/pr gas will enter JCW side
- Jcw of that unit will rise
- Deaerator will give alarm (gas in water alarm)
- Exp tank water will become black
- Gases & bubbling from exp tank vent.
- Exp tank level will go down.
- Water coming in comb space & white smoke from funnel.
- Exh temp of that unit will drop.

Troubleshoot

- Cut off fuel to that unit
- Stop JCW in & out
- Drain JCW
- Open indicator cock
- Keep exh v/v open
- Let cyl lub keep going

Purpose Of Exp Tank

- To take expansion of JCW due to heat
- To provide positive head for JCW pumps thus preventing entry of air
- To release any gases or air
- To keep track of JCW consumed
- It acts as JCW reservoir
- Provides for chem dosing

1500 ppm → * Nitride → To protect liner walls from corrosion
* Borate → Give alkalinity to water to maintain pH

* Too much nitride may form precipitate & block passages

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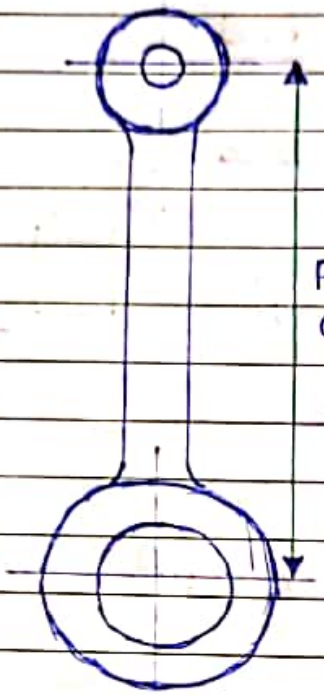
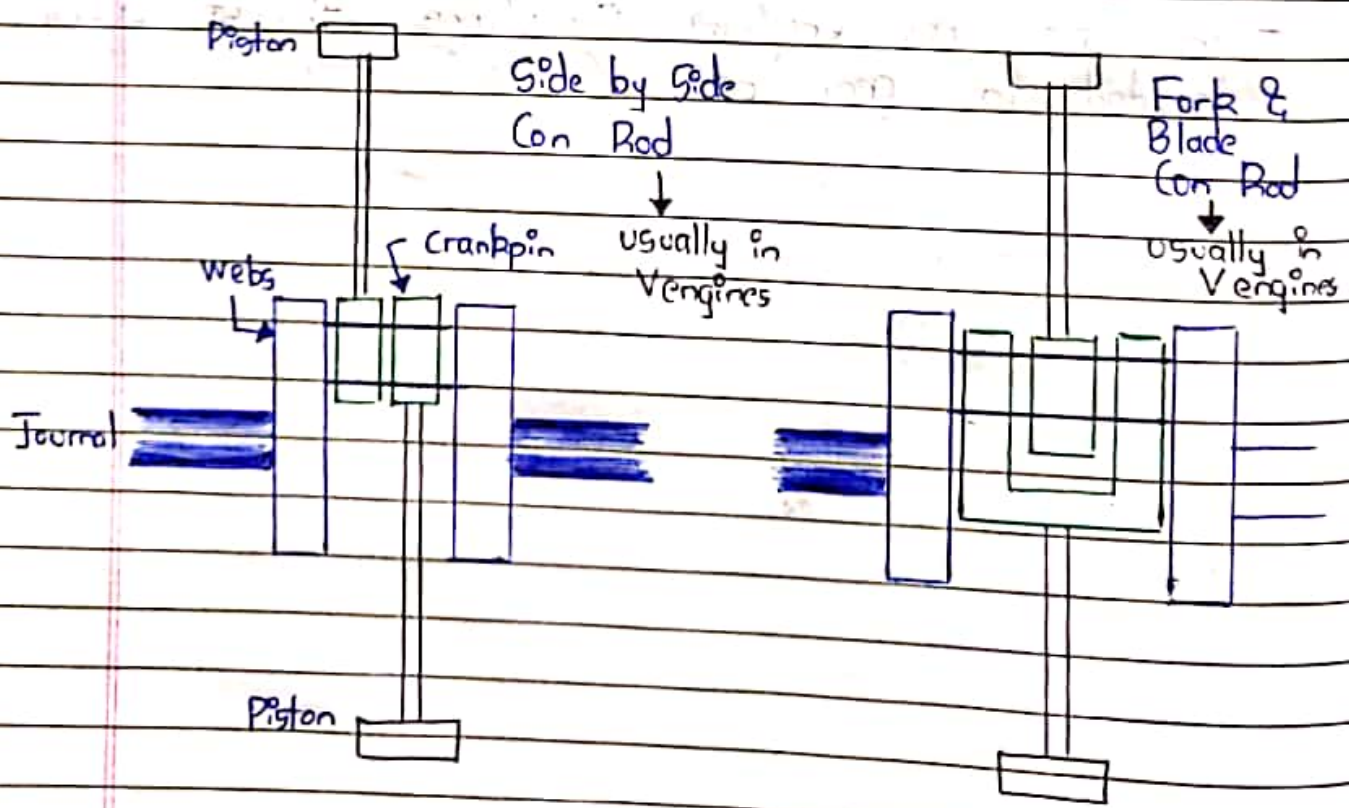
CONNECTING ROD → Forged Steel

CLYDE





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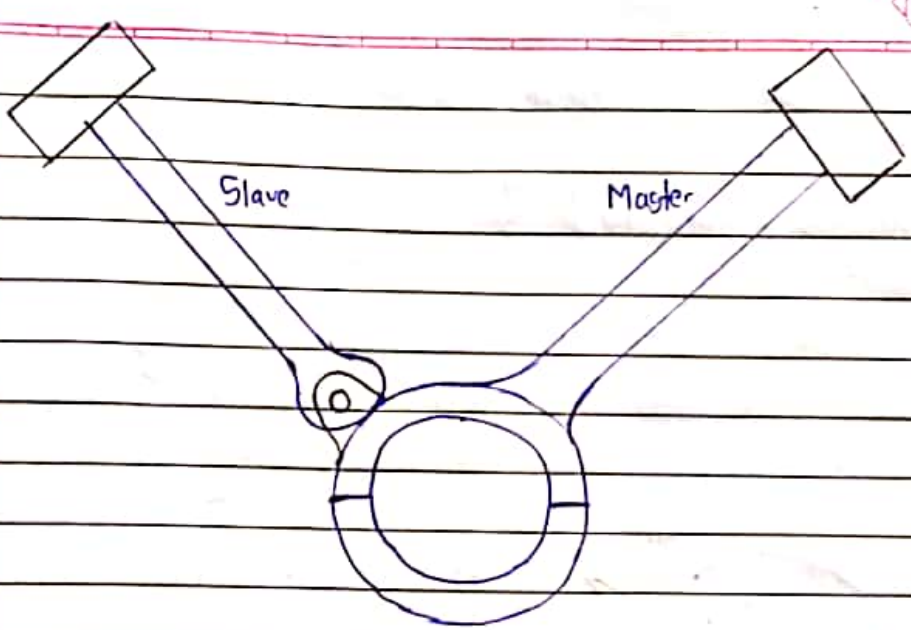
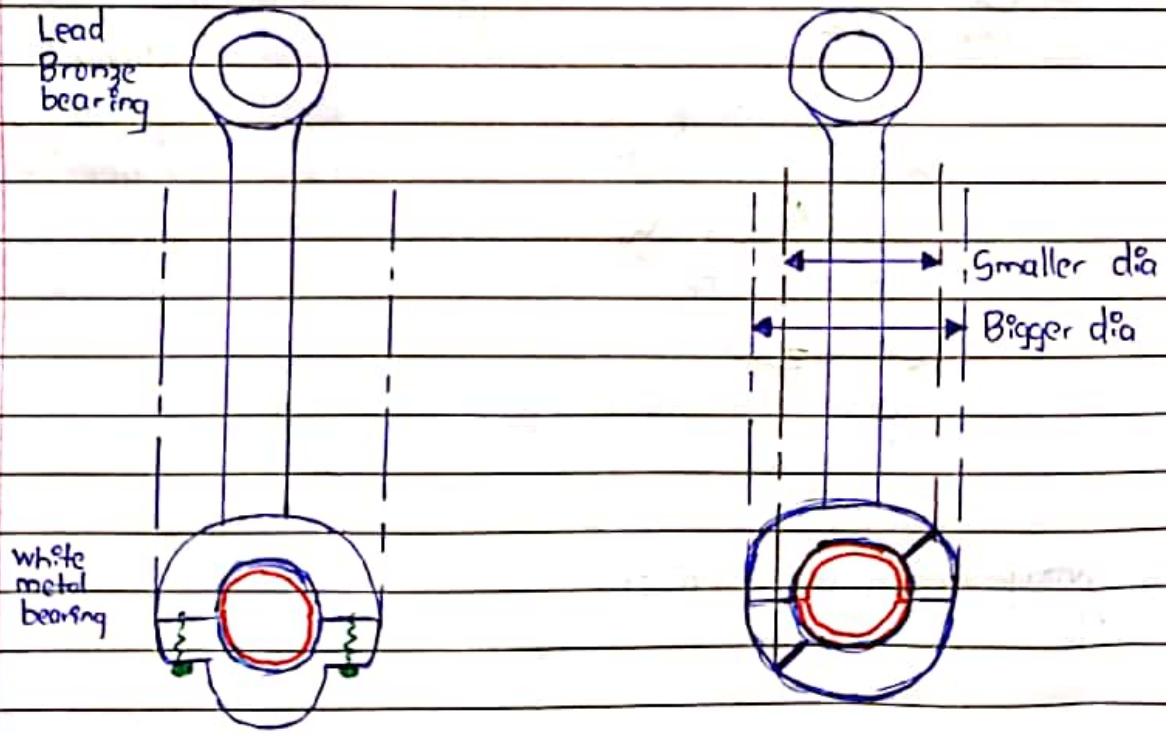
Master & Slave Con Rod



→ 4 Stroke Con Rod — I crossection
→ 2 Stroke Con Rod — Round crossection

CLYDE



Horizontal Cut for bottom end

↓

Requires bigger dia liner to remove bottom end

Angular Cut for bottom end

Requires smaller dia liner to remove bottom end

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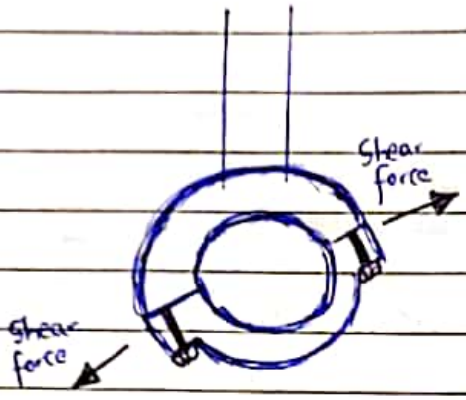
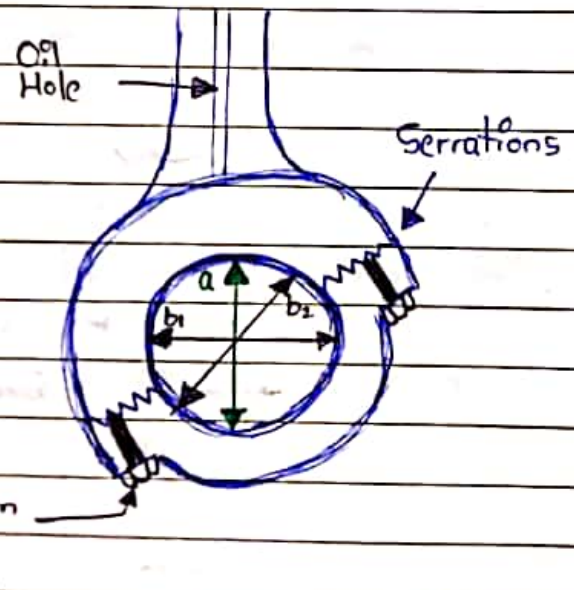
Bottom End Bearing Bolts

Q Why serrations required ?



* when engine is running shear stress will act on bolt & may shear off the bolt

* Here we take Shear Force by adding serrations



* Serrations also provide better contact area bet^n 2 halves & better tightening

Q Why I - Crossection ?
- to reduce weight
- to reduce fatigue stress

* Oil flow in this con rod oil flows from bottom to top

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Checks On Con-rod ?

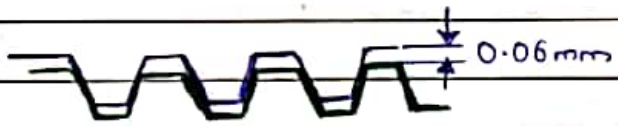
- Ovality check :
  * So remove the bearing & tighten back the 2 halves of con rod with required torque
  * Now use a inside micrometer

$$\left(a - \frac{b_1 + b_2}{2}\right) = \text{ovality}$$

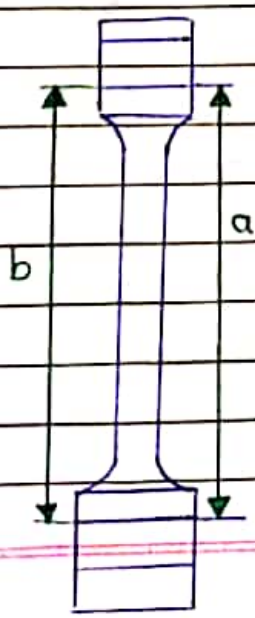
  * Ovality not be more than 0.05mm

* Ovality takes place due to wear down of serrations

CLYDE



- DP Test :
- Trueness check :
  * Insert a rod in oil hole
  * If it goes till top means con rod is not bent
  * Do not do with pipe as pipe can bend.



Also if a=b then Con rod is true.

* Cannot turn easily the engine with turning bar

- Check floating of con rod in engine.

* Floating is necessary to allow for expansion due to heat
* It should float freely over crankpin.

4 Stroke → Oblique cut
2 Stroke → No oblique cut

4 Stroke → Has serrations
2 Stroke → No serrations

4 Stroke → Oil flow bottom to top
2 Stroke → Oil flow top to bottom

On bottom end bolt of → 4 stroke engine
* During power stroke
  ↳ piston is pushed down due to firing force
* During exhaust stroke
  ↳ piston is pulled up due to CF

* This causes fluctuating tensile stress on bolt leading to fatigue

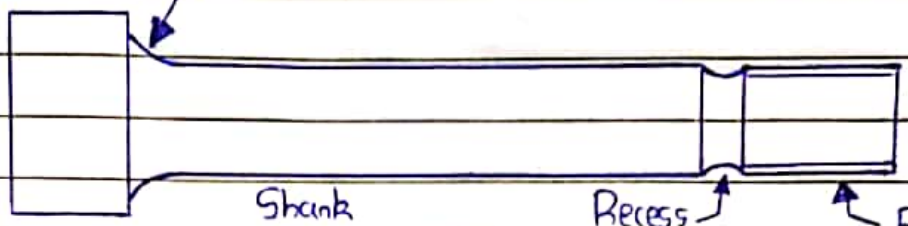
* Under fatige, life of bolt automatically reduces

* FORGED STEEL → Bottom end bearing bolts

C < 0.23%
Mn < 0.2%
Tensile Strength = 400 MN/m²

* No abrupt change in c/s So fillet provided to reduce concentration of fatigue

* Also fillets are rolled to induce compressive stress



* Shank to be absolutely mirror finish.
* High tensile bolts have recess where threading begins.
* Recess is to allow of expansion when bolt is tightened. as we dont want expansion to happen at threads.
* Do not drop bolt or mark anything on shank.
* Check fillet, recess & threads for any cracks by DPT
* Check for no change in length with original bolt.
* Port bolt & Stbd bold should not be interchanged.
* Spray molycote on threads

CLYDE

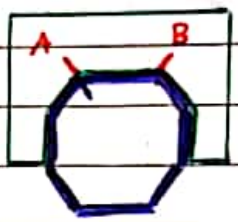
Tightening Of Bolts

- Torque tensioning
- Angular tensioning
- Hyd tensioning

Q How to check torque spanner?

–

* First tighten with hand
* Then put torque spanner
* Insert template over bolt head
* There will be 2 markings on it



* Transfer the other mark B to ~~bolt head~~ bearing housing & A to bolt head
* Now remove template
* Now coincide A mark to B mark
* Lock bolt using lock washer
  tab washer
  lock plate

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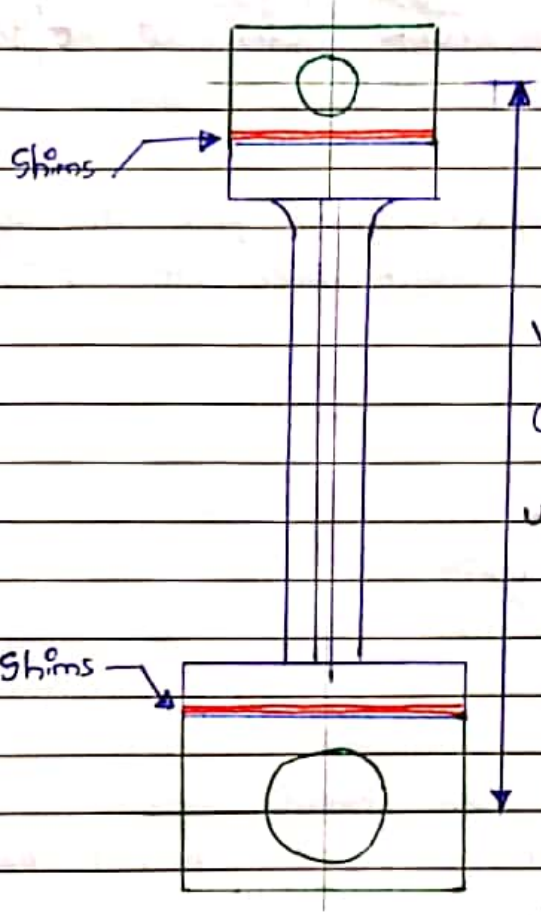
Variable Center Con Rod → 2 Stroke



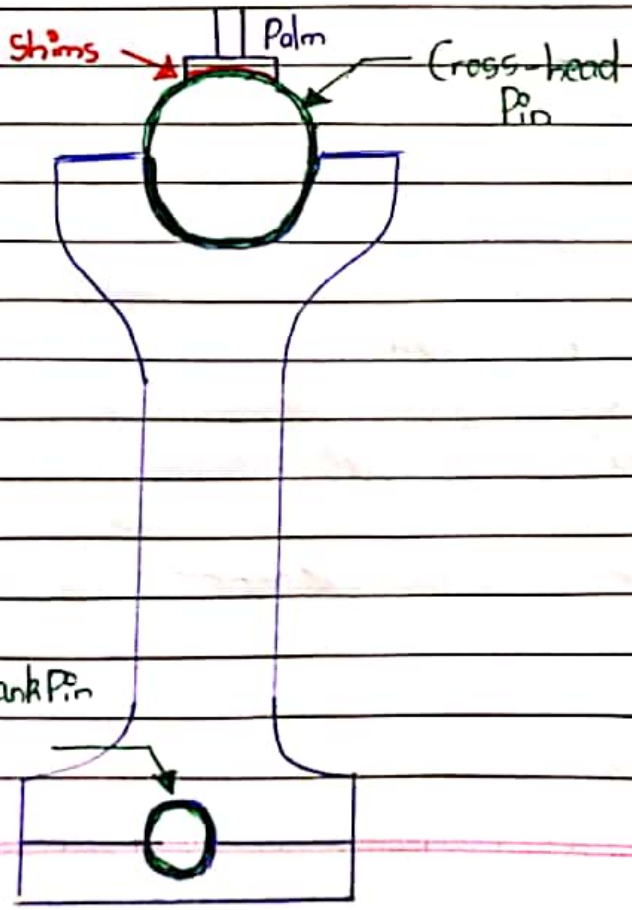
Variable Center Con Rod

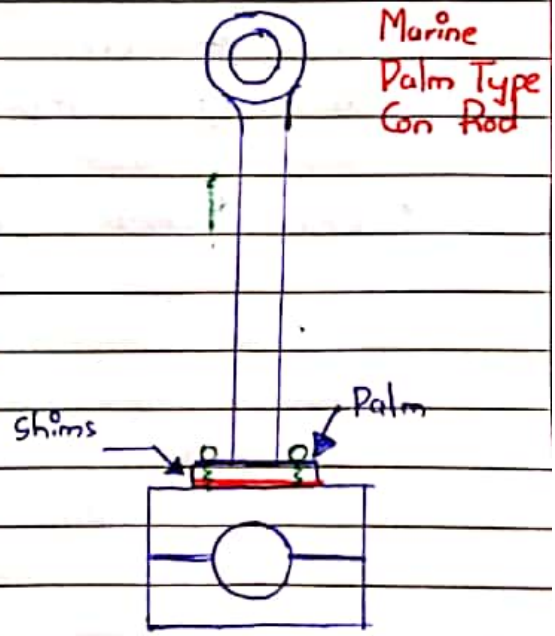
↓

usually in 2 stroke

* To increase compression ratio, it is possible to add shims at top & bottom end

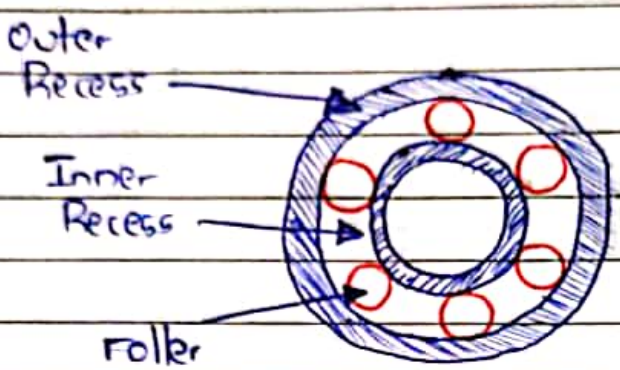
* This type is called Marine Con Rod.





Bearings

- Ball bearing
- Baller bearing
- Needle bearing



* Rollers rotate around own axis
* Also rollers rotate around inner & outer recess

* This bearing, load is transmitted because of contact from roller → Outer Recess → Bearing housing

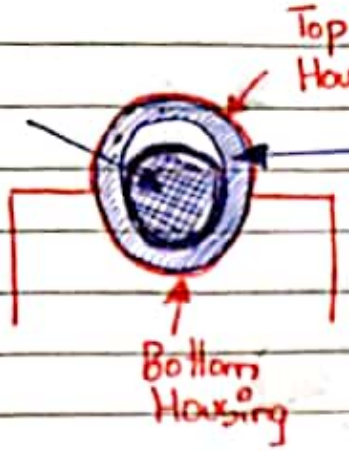
* Grease is provided to reduce friction bet^n roller & inner / outer recess

* Found in centrifugal pumps, ele motors etc

* Double deep groove ball bearing used in t/c

* But in ME & AE we use shell bearing Here load is taken by oil film

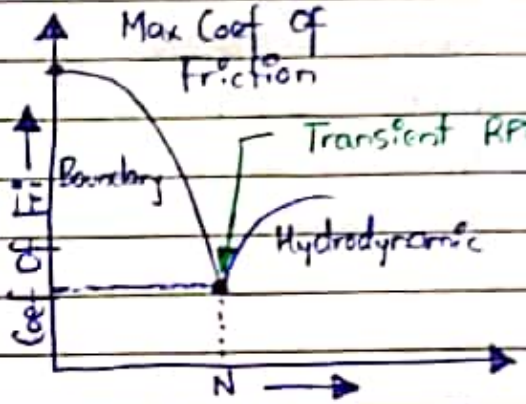
CLYDE



* The oil enters from top through oil hole
* Now when journal is stopped @ 0 rpm journal rests on bearing
* So here BOUNDARY LUBRICATION Occurs.
* Here coef of fri is max

CLIDE

- When journal starts to rotate
- Now oil layer in contact with journal will rotate at same speed of journal



- Once journal starts to rotate, oil film begins to form below journal
- At 1 pt of time, enough oil film will form such that it is able to lift journal.
- Once journal is completely lifted up, Coef of fri is minimum → Transient RPM
- This is called Hydrodynamic Lubrication. where relative motion betn journal & bearing.

* After transient rpm, coef of fri increases slightly. This is due to fri. betn layers of oil film.

Thicker oil film
↳ More load carrying capacity

Thinner oil film
↳ Less load carrying capacity

So Oil film thickness $\propto \frac{\mu N^2 RL}{C}$

μ = Viscosity of oil

- Higher viscosity
- Thicker oil film
- More load carrying capacity

→ Too viscosity then less oil will flow

→ Less viscosity then oil film wont form

N = RPM

- More RPM
- Thicker oil film
- More load carrying capacity

RxL = Projected Area

- More RxL
- More load carrying capacity

C = Bearing Clearance

- Less bearing cl
- more thick oil film
- more load carrying capacity

→ Too high clearance oil will escape & oil film not form

→ Too low clearance oil wont circulate enough leading to heating

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Why we need oil

↳ to form oil film
↳ to cool bearing
↳ to keep bearing clean
↳ to reduce vibration
↳ to protect against corrosion.

CLYDE

Bearing Cl to be 0.001 to 0.00075 x journal dia

→ As bearing becomes hot, fatigue resistance reduces

Inner Surface Of Bearing

* must be strong enough to take load
* must be soft enough to avoid damage to shaft

Fatigue Resistance $\propto \frac{1}{\text{Thickness of bearing}}$

Nickel Dam - prevents corrosion of main layer

White Metal Bearing
- Tin (85%)
- Antimony (12%)
- Copper (3%)

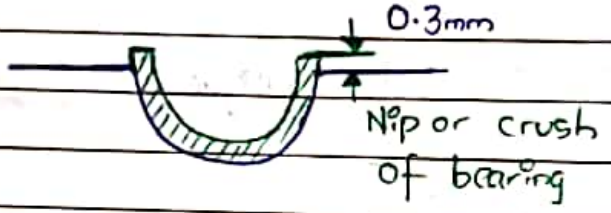
Tin - Al Bearing
- Tin (40%)
- Al (60%)

Lead - Bronze Bearing
- Tin
- Zinc
- Cu

If bearing thickness is less than 2-4% of bearing dia
↳ thin shell bearing

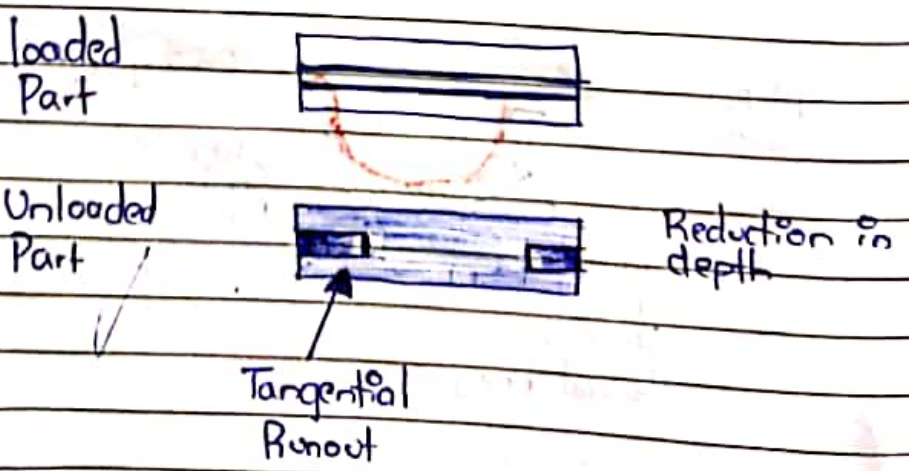
If bearing thickness is more than 2.4% of bearing dia
↳ thick shell bearing

* NIP OR CRUSH



- It helps to provide a good circumferential contact.

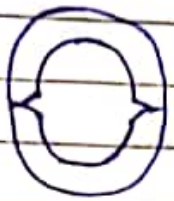
- For main bearing, load part of bearing has no oil hole while unloaded part has oil hole



* Tangential Runout

- Required for oil to enter loaded part.

* **Bore Relief**



In case bearings are misaligned with each other, they wont be able to damage the shaft

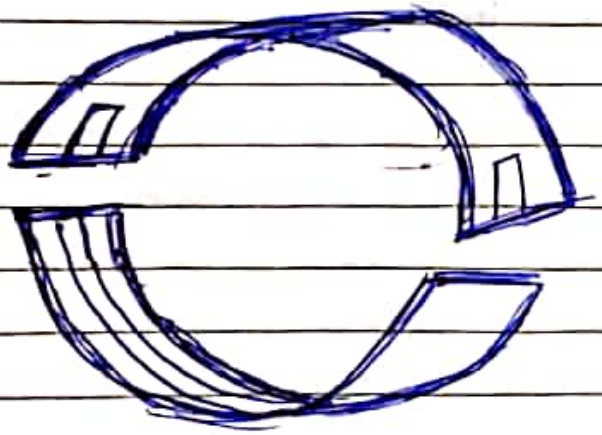
* **Nick or tongue** CLYDE

To locate bearing inside housing

Bearing Can be
- bimetal
- trimetal.

* **Free Spread of bearing**

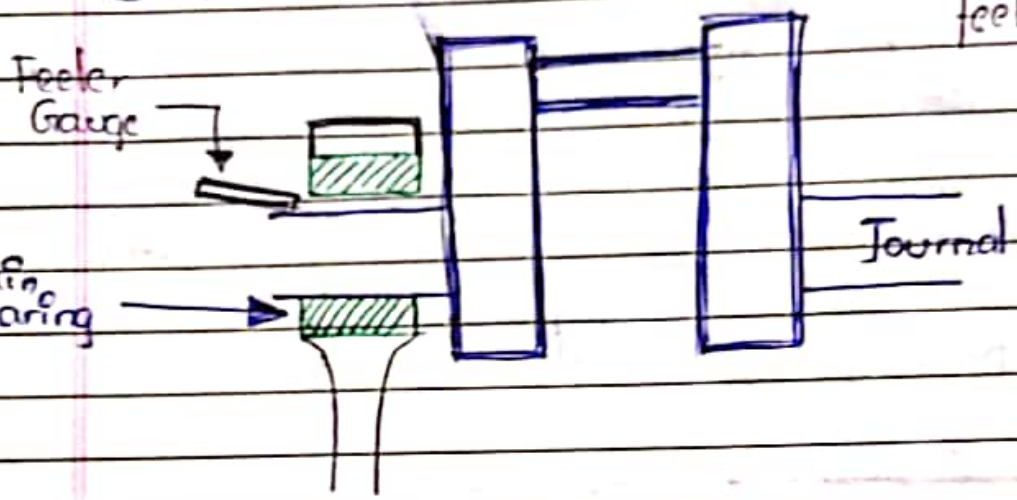
- Main Bearing — bottom loaded part
- Bottom End Bearing — top loaded part
- Crosshead Bearing — bottom loaded part.

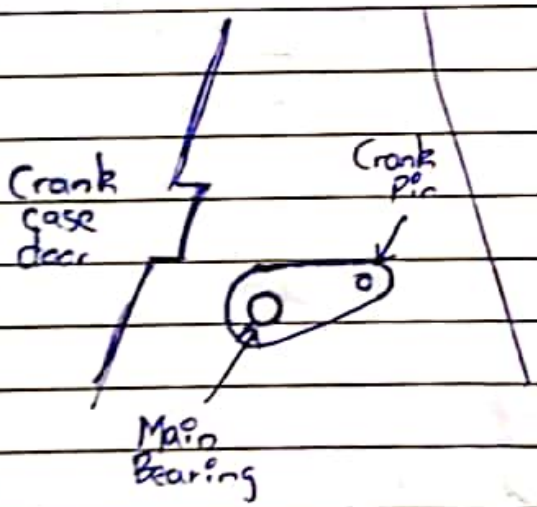


Main Bearing Clearance

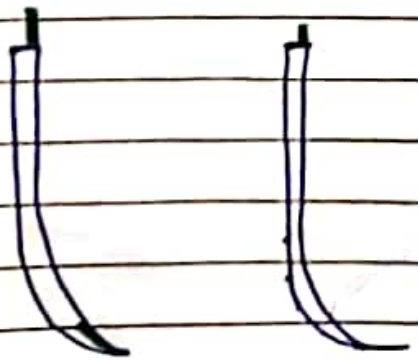
Clearance to be taken @ TOP

- Feeler Gauge
- Telescopic feeler gauge





- When you open crankcase, crank pin to be exactly opposite to door
- Can sit on web & take clearance

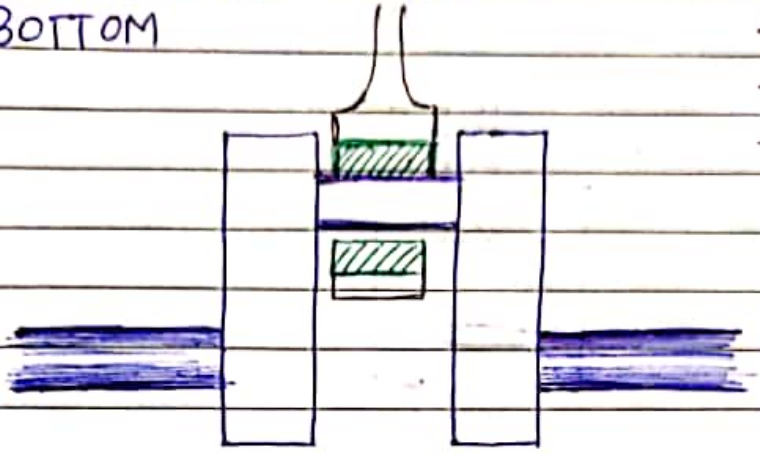


Telescopic Feeler Gauge

Bottom End Bearing Clearance

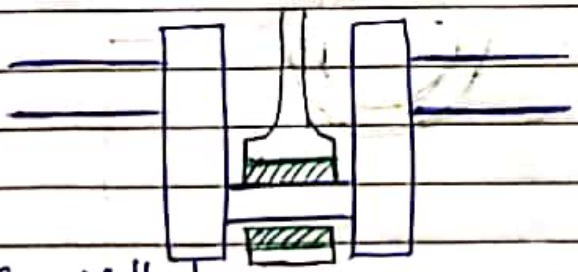
Clearance to be taken @ BOTTOM

- Feeler Gauge
- lead wire
- Plastic gauge



CLYDE

- Difficult to put feeler gauge due to 2 webs at side when piston @ TDC
- ∴ Take piston to BDC



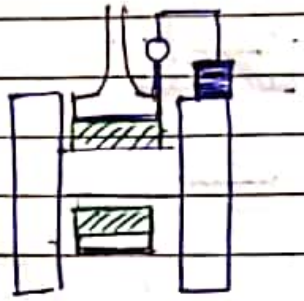
Now at BDC, we can easily insert feeler gauge

* Lead Wire Method

- Remove top half
- Put lead ball wire (1.5x expected clearance)
- Tighen top half
- Now remove & measure thickness

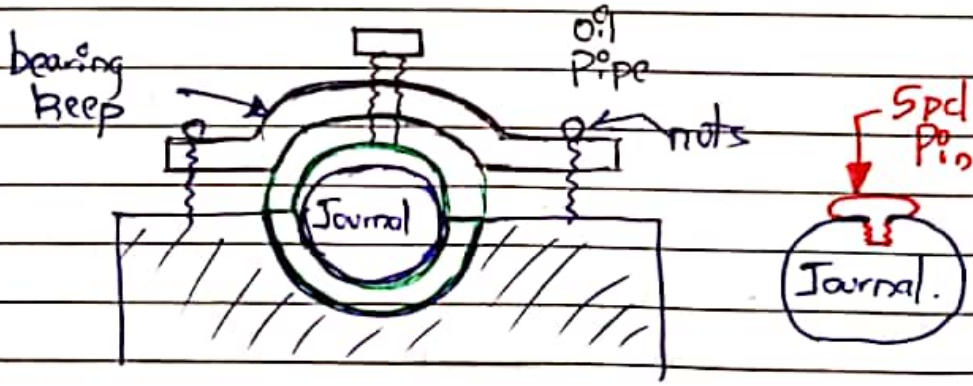
* Method without putting feeler gauge

- On web put a magnetic block with a dial gauge
- Take throwbar & lift bottom part of con rod



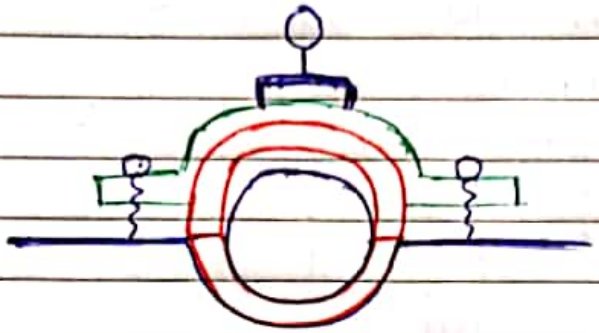
- Also continous bearing wear down analysis method electronic is available

How to remove MAIN BEARING (AE) -



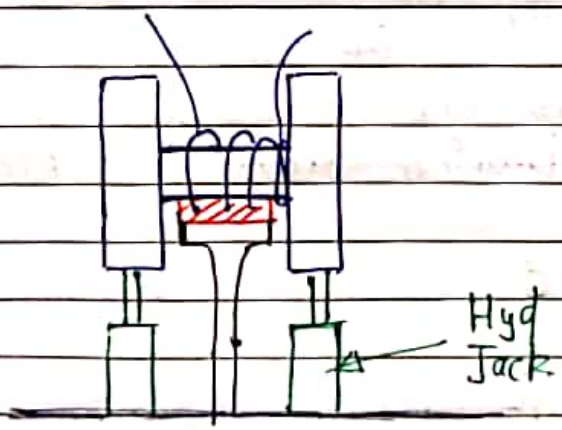
- Take out oil pipe
- Take out keep nuts
- Now remove keep
- On top bearing shell put i-bolt & remove
- Now to remove bottom half, journal has oil hole
- Insert a spcl pin provided in oil hole
- Turn engine pin will touch 1 end & push bearing out.

How to remove MAIN BEARING (ME)



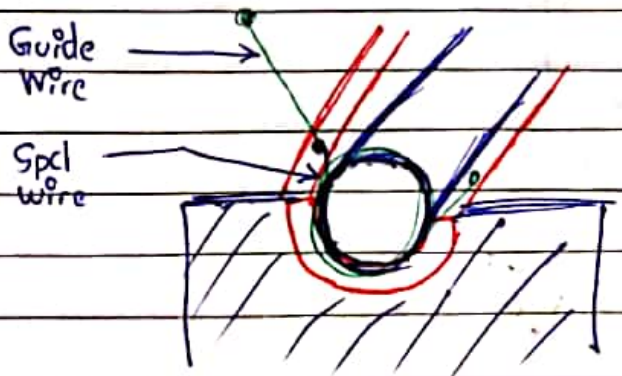
CLYDE

- remove the oil pipe to top bearing shell
- remove out keep nuts
- remove keep & remove from crankcase
- Put i-bolt on top half of bearing connect chainblock & remove.



* Connect Hyd jack below webs
* Jack up crankshaft
* Max jack up should not be more than 0.2mm

- Now with spcl wire & plate, roll it along with bottom shell & remove it



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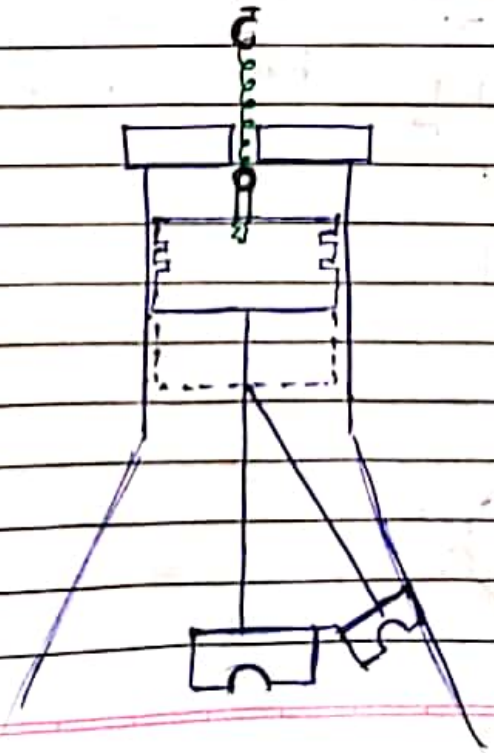
How to remove BOTTOM END BEARING (AE)

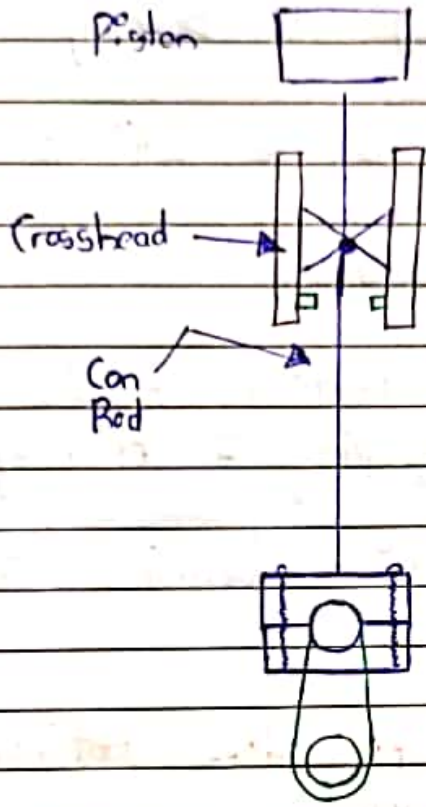
- Take piston to BDC
- Open crankcase door
- Loosen bottom end bolts & take out bottom half.
- Now top half will come along with piston & con-rod.

What if without overhauling you want to check bottom end bearing.

- Take piston to TDC
- Remove fuel injector from cyl head pocket
- Put by a long i-bolt on piston crown.
- Open crankcase door
- Bring piston to BDC
- Remove bottom end bolts & lower half
- Now inspect bearing from crankcase



How to remove BOTTOM END BEARING (ME)



- Take piston to BDC
- Open crankcase
- Remove bottom end hyd nuts
- Connect with chain block
- Take out bottom half from crankcase

* Now we want to check the top half which is loaded part

- Put piston supporting pins on crosshead guides
- Start turning engine such that crosshead rests on supporting pins
- Now full wt of piston will come on pins
- Only web will move away & the top shell can be easily inspected.
- Make sure you remove the pins after inspection

CLYDE

Crosshead Bearing

* One of the most difficult bearing to lubricate
* Hydrodyramic lubrication is v difficult to take place

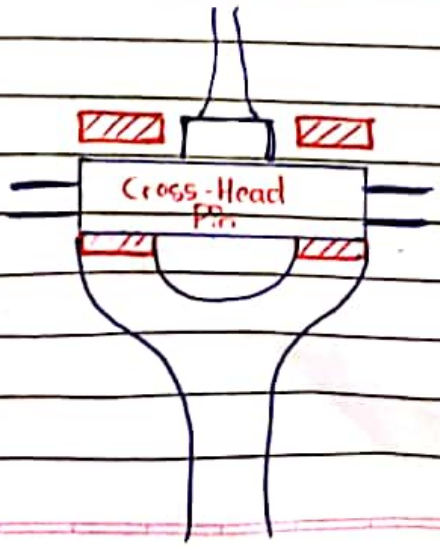
Why?
- because for hyd lub, relative motion should be there bet' pin & bearing

* This not case in main bearing & bottom end bearing.

- In crosshead bearing, pin does not rotate only the con rod swings so relative movement is v less Only wiping movement occurs.

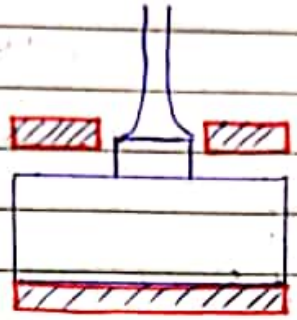
- Also in 2 Stroke, load always act downward & no reversal of load : So difficult to put oil here

Earlier this was construction



* But problem was pin used to bend leading to cracking

So now,

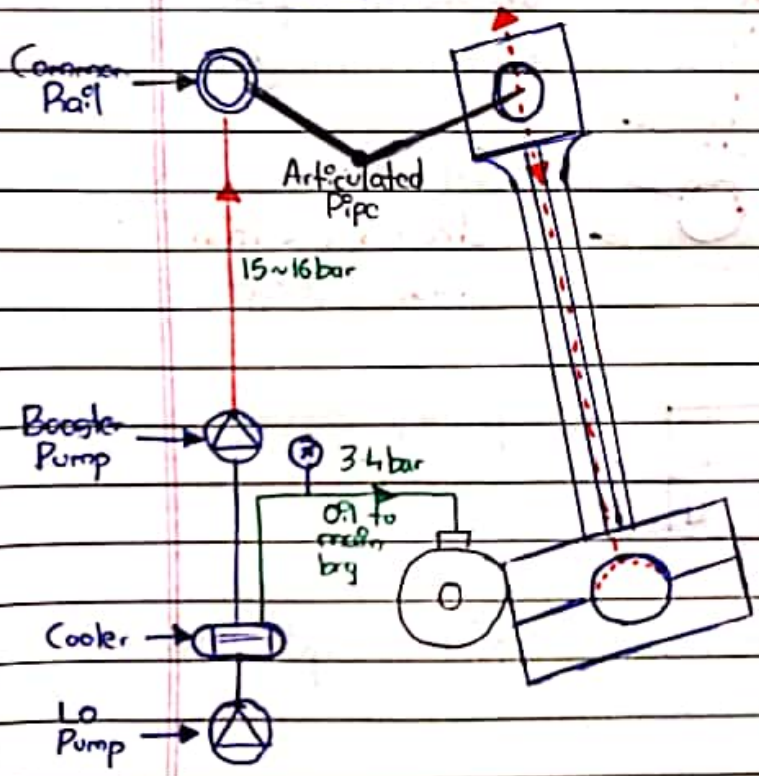


* Here bearing is provided completely.

* So bending of pin wont happen

* Also fitting bigger bearing, same amt of relative motion is there & lubrication is possible.

SULZER



* 15~16 bar oil from Articulated Pipe will go to crosshead
* from crosshead it will pass through con rod & go to bottom end bearing
* from crosshead it will also pass through piston rod to piston cooling.

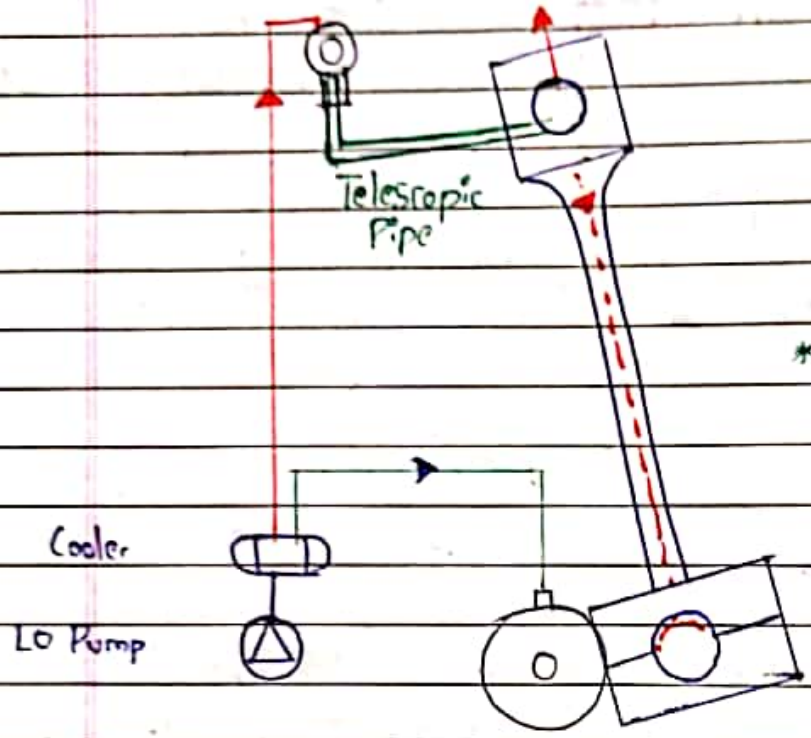
CLYDE

- Since high pr oil is given betn pin & bearing, we call it Hydrostatic lub

But MAN B&W has different design.

CLYDE

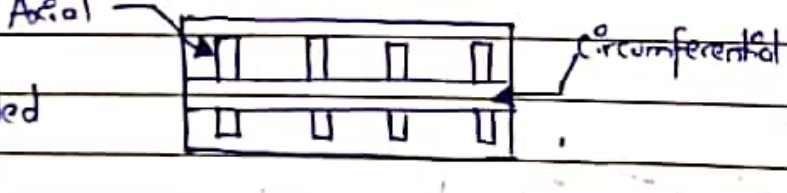
* Here crosshead pin has a telescopic pipe



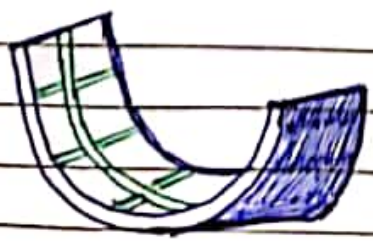
X-head brg lub pr is low as

* crosshead loaded & unloaded part also has oil grooves

* Oil grooves are in circumferential & axial direction



* Geometry is such that oil film gets formed at low pr itself



Axial Grooves are tapered.

So here hydrodynamic lub is achieved only by spcl design of oil grooves

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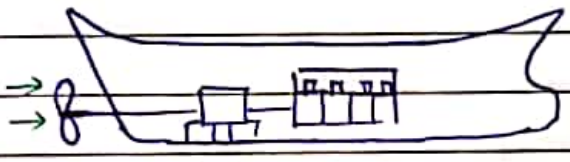
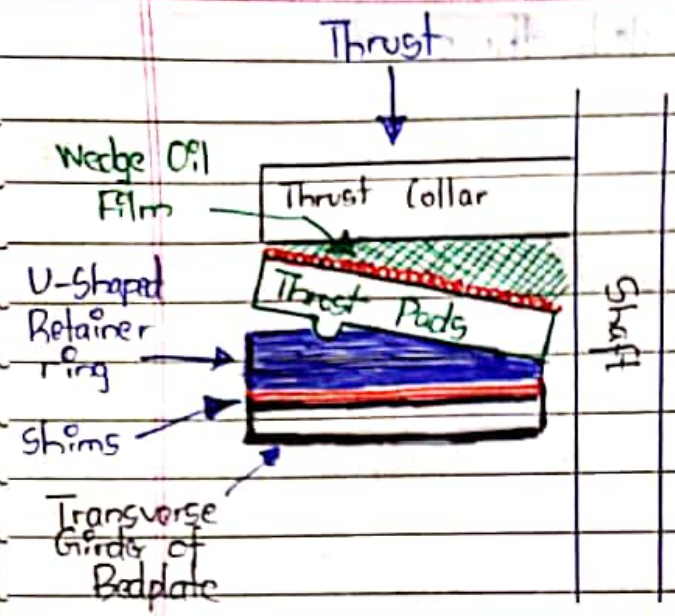
THRUST : Axial force is called thrust.

* In ship, all power we want to convert to thrust
* With propeller, we want this thrust to push the ship FWD
* But some thrust causes the propeller to move in



* This will cause crankshaft to shift & touch engine frame & damage engine.
* ∴ we need a thrust block before engine
* Thrust Block fitted at aft of the engine so that crankshaft does not get thrust
* Thrust Block consists of thrust collar & thrust pads & we need hydrodynamic lubrication to absorb this thrust.



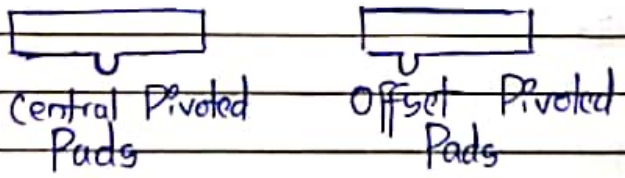
* Thrust pads made of cast steel or forged steel & coated with white metal
* There is a retainer ring located below thrust pads
* Below U-shaped retainer, there are shims to adjust clearance
* Below shims is the transverse girder of bedplate.

* These all are ahead pads. same like that astern pads are there.

The thrust is transferred like this

- Thrust Collar
- Wedge Oil Film
- Thrust Pads
- U-shaped retainer
- Transverse girder of bedplate

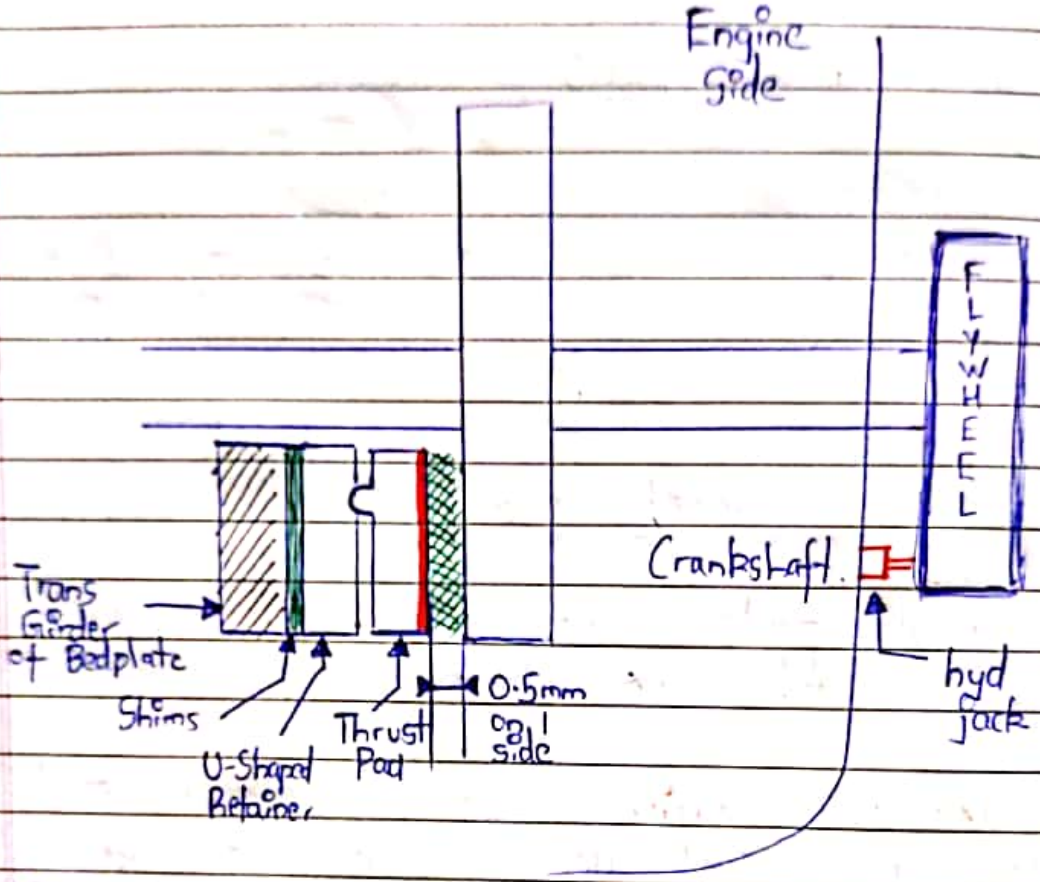
- In engines, there is a sprocket & on both sides collar is filled
- On the thrust pads, there are temp sensors
- When temp comes to 65°C → alarm
  75°C → engine trip
- These pads we use a asymmetrical. Similarly symmetrical pivoted pad.
- Asymetrical pads can have a better oil wedge to take up load.
- In non-rev engine, offset pivoted pads cannot be used. Here central pivoted pads are used.



Feeler gauge is put betn pads & collar to find Thrust Bearing Cl

Normal value is 0.5m & max allowable 1mm

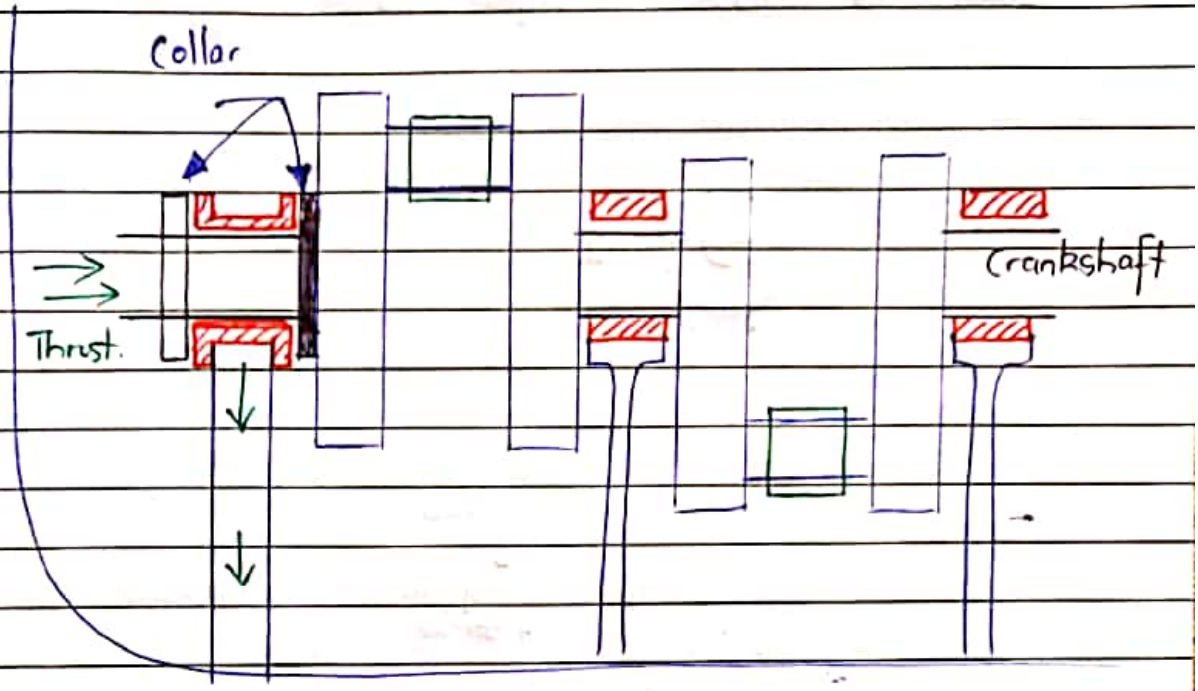
- Pads are fitted only 240° not 360°.



- Stop engine
- Put up hyd jack bet" flywheel & crankshaft
- Now crankshaft will move in & put feeler gauge

In Aux Engine

* Thrust is taken by thrust bearing.
* Here very less thrust is created.



- Here last main bearing acts like a thrust bearing

- In non-rev engine, sometimes thrust bearing located in gear box

** TURBOCHARGER **

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* Supercharging & Turbocharging both mean to supply air above atmospheric pr for bet^n burning of fuel & thereby increasing thermal efficiency.

Supercharger takes power from crankshaft typically by gears belts or pulleys

* Supercharger uses energy from engine to run compressor & bring fresh air.

* Turbocharger uses waste heat energy from engine to run blower & bring fresh air.

* Every tlc is a supercharger but every supercharger is not a tlc.

* One of the method of supercharging is turbocharging

CLYDE

Turbocharger

- Consists of 2 sections
- Gas turbine :- utilizes waste heat energy of engine which also drives blower
- Blower :- blower draws fresh air compresses it & sends to engine

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* Inlet to t/c = 460°C (H_1)
Outlet to t/c = 260°C (H_2)

* Means loss of heat energy which gets converted to KE

$$(H_1 - H_2) = \frac{V^2}{2g}$$

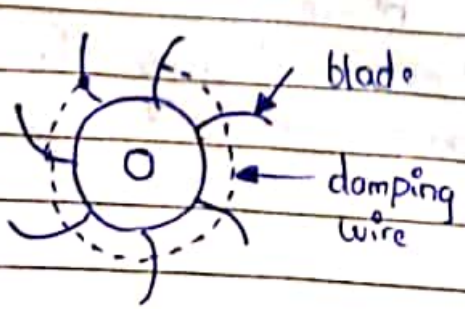
CLYDE

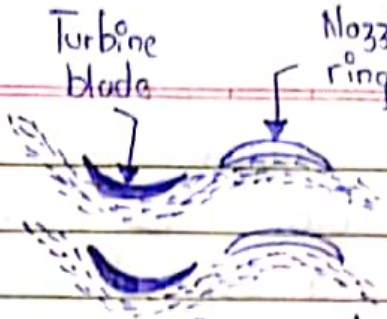
* Turbine → Nimonic alloy (Ni based)
* Nozzle ring :- Gas passes through nozzle ring & changes direction.

* Turbine blades are fitted with an inverted fir tree arrangement.

* Due to centrifugal force ~~blade~~ blade will get locked & at same time allow for expansion due to heat.

* These blades have a damping wire to dampen vibration.





CLYDE

* Due to change in direction of gas, momentum is formed causing turbine to rotate.

* Shroud ring :- Gas should not escape betⁿ turbine blade & casing otherwise turbine efficiency will reduce.
It will act as casing ring of p/p

* Betⁿ turbine & blower side there is a diaphragm in between

* Blower → Al alloy
Blower is considered into 2 sections

* 1st section when fresh air guided into blower is called inducer

* Due to centrifugal force, air comes out of blower with lots of KE

* Diffuse :- It converts KE → PE
area increases
pressure increases
velocity drops

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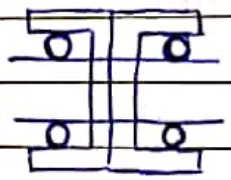
* The bearing used is a double deep rooted ball bearing which also takes thrust due to rxn force.

* Turbine side has roller bearing which copes with expansion due to heat.



Double deep rooted ball bearing.

CLYDE

* Both bearings are fitted in spring casing to protect it from brinelling effect.

TCA = Axial flow t/c (Gas flowing parallel to axis of shaft)
TCR = Radial flow t/c (Gas flowing radially to axis of shaft)

* Blower side is always radial flow.

* Labyrinth seal is used to prevent mixing of exhaust gas with oil. Sealing air sent to labyrinth seal which prevents mixing. → Turbine side

* Labyrinth seal is used to prevent mixing of fresh air with oil. Due to blower suction is created, so a vaccum breaker is used → Blower side.

* There is also labyrinth seal at back of blower to prevent mixing of fresh air with exhaust.

* Due to accumulation of ash & carbon on nozzle & turbine fouling of tlc takes place

Water Wash turbine

- Reduce rpm to slow ahead
- Wait for some time for temp to drop
- Keep drain open
- Now water sent @ 4 bar
- Once black water stops coming & clean water appears, stop washing.

Dry Wash turbine

CLYDE

- No need to reduce rpm
- Use crushed walnut shell with air pressure
- It will burn & blow out with exhaust cleaning turbine & nozzle.

Water Wash Blower

- Reduce rpm
- Water will clean inducer & blower.

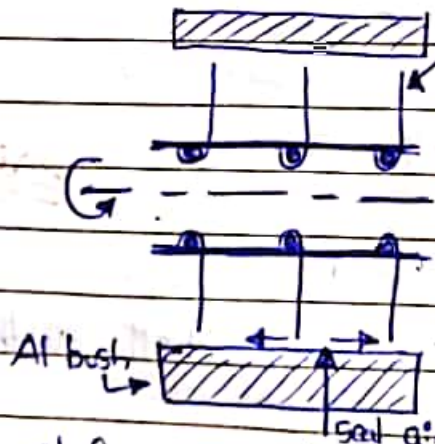
* Blower side water wash need to be done daily
* Turbine side cleaning need to be done weekly.

* Now pr drop across air filter shall not be more that 50mm of water gauge.

CLYDE

* Also oil has to be changed after some fixed hrs to oxidization.

* After 10,000 hrs, full overhaul of tlc carried out.



Strips are fitted on shaft with help of wire.

Seal strips rotate along with shaft

* It works with gradual drop in pressure at each stage.

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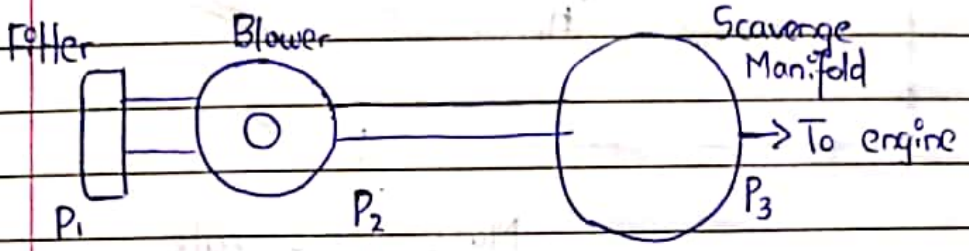
* TCA → End loaded bearings
* TCR → Central loaded bearings (shell bearing) + thrust bearing

CLYDE

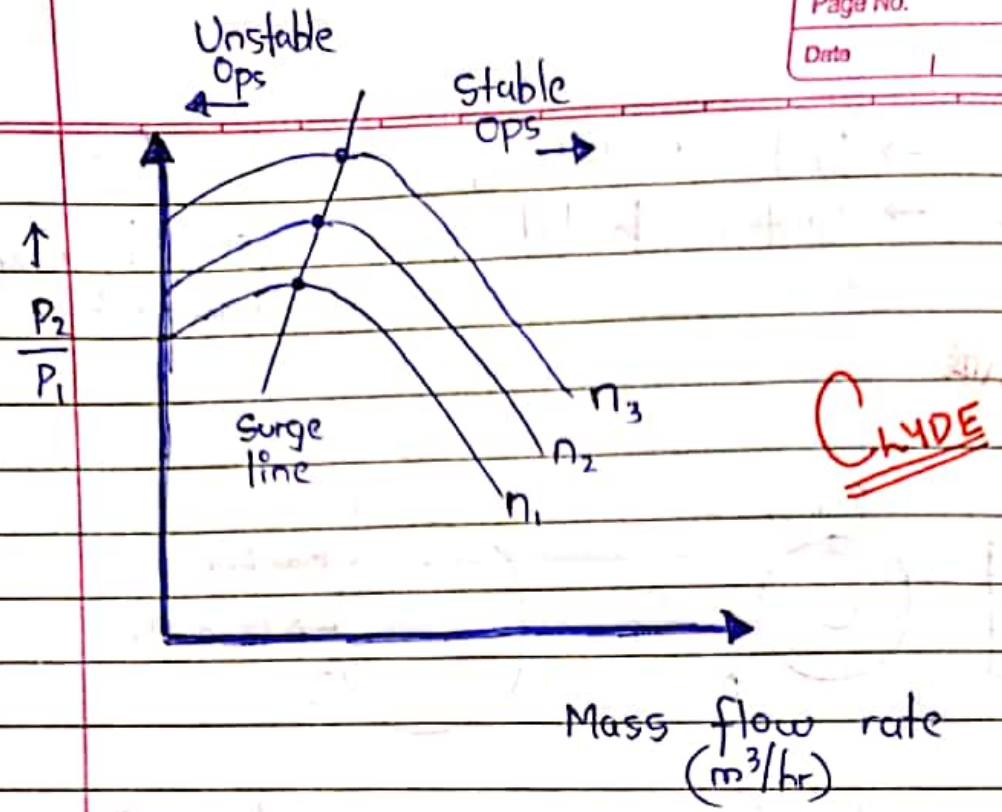


- P_2 should always be greater than P_3
- But if P_3 becomes more than P_2 & flow reversal will take place via blower to ER atmosphere

* The reverse flow of air from manifold to blower to ER atmosphere is called t/c surging

* For given pr ratio (P_2/P_1) quantity of air flow below critical value, instead of air flowing from blower to manifold manifold air will reverse flow through blower in ER atmosphere called surging

* Obstruction / reduction in air flow causes it
* During this time, rpm of t/c reduces, noise & filter of t/c gets blown off.



As flaps start opening, eddy losses reduce & P_2 goes on increasing upto a limit & the flow takes over & pr drops

Reasons :

1. Air filter choked
2. Fouling of blower side
3. Air cooler choked
4. Scavenge ports choked
5. Scavenge fire causing P_3 to increase
6. Load on engine too high
7. Bad weather
   Propeller comes out
   Gov try to reduce fuel
   But tlc rotates with same rpm
8. Fouling of hull
9. Fouling of turbine
10. Nozzle choked

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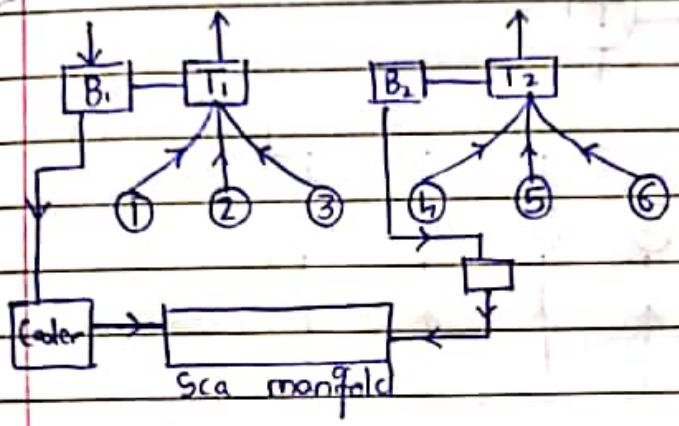
Types of t/c System

* Const pr t/c system
* Pulse type t/c system



Pulse Type

- More efficient at low load operation
- During change of load, it will act faster
- In AE, changes in load are high
- But at high load eff is less
- Exh manifold is complicated as t/c need to be kept near to ME
- Cannot connect acc to firing order otherwise backpr will exist.

T/c η = Turbine η × Blower η × Mech Eff

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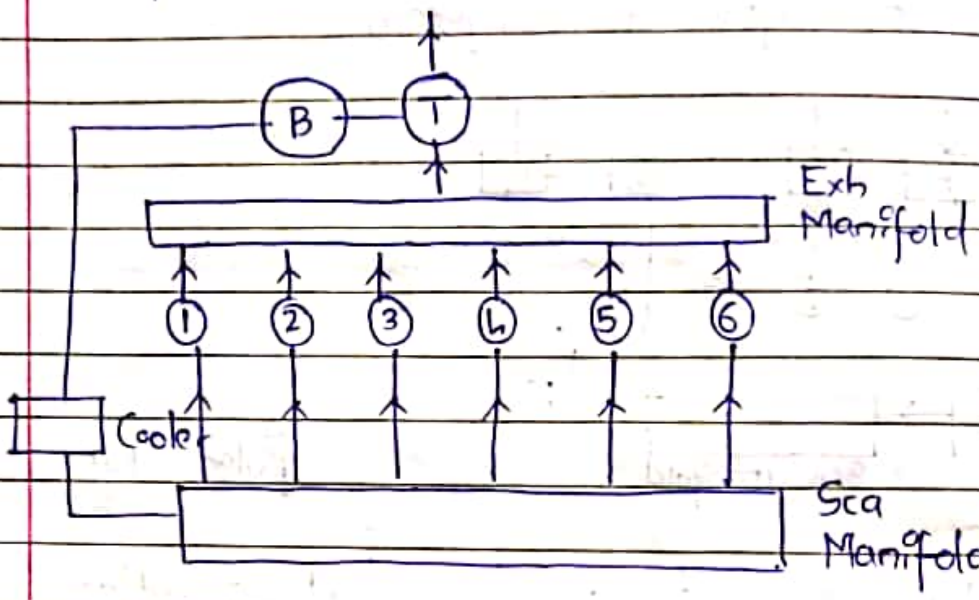
- All pulse of exh gas are converted to pr by sending it to 1 manifold



- Turbine eff better
- Good eff @ high & const load.
- Poor eff at low load & slow response to load change
- For low load op. aux blower is required.

* 1 kg of fuel req 14.5 kg of air, but we give 36 kg of air
* This air is supply by t/c

Air fuel ratio 14.6

36 kgs of air
1 kg of fuel

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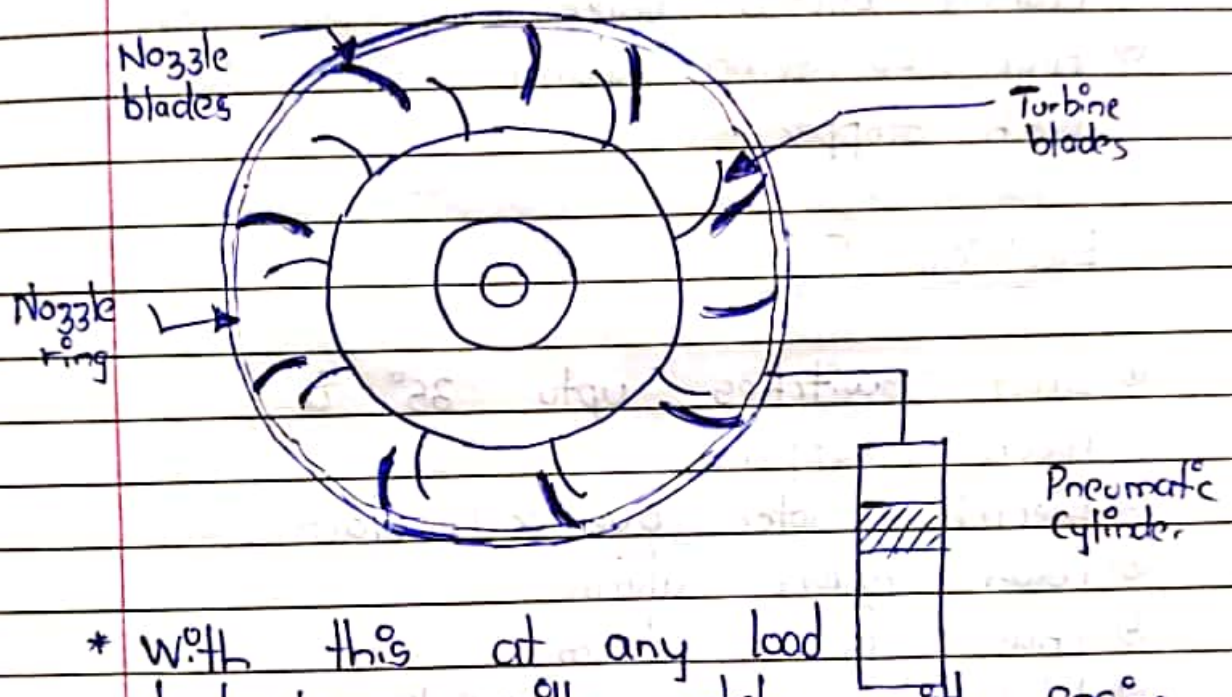
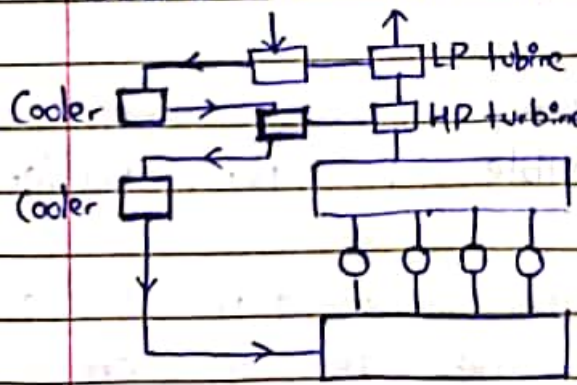
* For the purpose of ~~defo~~ matching t/c at different loads it must be possible to change angle of nozzle ring
* This is called VTA/ VTG



* With this at any load turbocharge will match with engine

SEQUENTIAL T/c :- Cutting of 1 t/c at lower loads



Series t/c

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** Fuel Valve **

Job of fuel valve

① Atomization :- It is the breakup of fuel into minute vapour mist so that fuel vapour particles posses a very high surface area to self ignite.

If less atomization : Large fuel particles will possess more KE & deposit on liner causing after burning & poor combustion.

If more atomization : Very small fuel particles will not possess enough KE to go through the whole combustion space causing starving & after burning.

② Penetration :- It is the distance travelled by fuel particles into the combustion space before ignition begins.

Penetration depends upon → Size of fuel particle
Dia of nozzle
Length of nozzle hole

③ Swirl :- It is the motion given to charge air entering the combustion space chamber

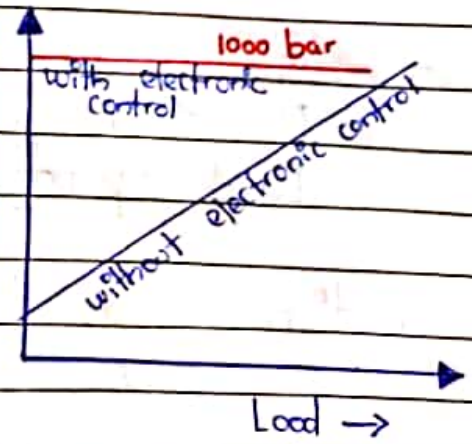
Swirl depends upon → Shape of combustion, Scavenge ports

* If atomization is more then penetration will be less & vice-verca.

4 STROKE INJECTOR

→ Injecting pressure / opening pressure of fuel v/v can be adjusted by spring
→ If spring is compressed more, lifting pr will be more.
→ If spring is compressed less, lifting pr will be less.

→ This valve opening pr we check in wkshop. It is not injection pr as we are testing it outside combustion chamber with atmp pr.
Injection pr
↳ 1000 bar - 2 stroke engine
↳ 800 bar - 4 stroke engine
→ The injection pr in common rail sys is fixed @ 900 bar



* In normal engines, as load increases injection pr increases
* But at low loads injection pr will also be less
* Hence to avoid this electronic control common rail sys have const injection pr of 1000 bar

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→ Fuel injectors needs to be overhauled based on PMS or CMS.

① So first remove the injector from the cylinder head pocket when the engine is topped & fully cooled.

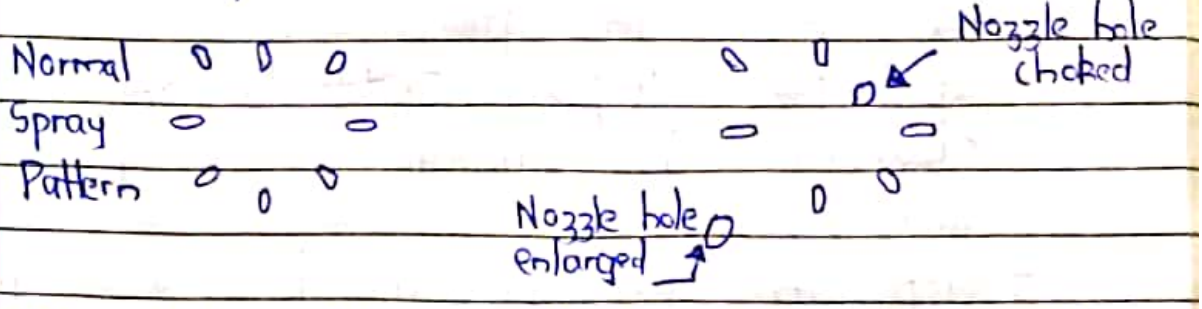
② Mount fuel injector over the testing rig in wkshop

CLYDE

③ Now once mounted & all connections are done, give fast kicks by the pump. This is to remove all oil inside the injector.

Test ① Spray pattern test

- Keep a cardboard below fuel injector
- Now inject fuel on cardboard
- Check the spray pattern. if all sprays are equal



- If hole is choked, clear by wire or drill tap.

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Test ② Check exact opening pr.

- Raise the pressure slowly by pump
- Check exactly at what pr the injector will inject.
- If not opening at correct pr, adjust compression nut.

Test ③ Drip test

- This is to check sealing bet^n nozzle & needle
- So raise the pr slowly to nearly opening pr. (ex 290 bar if opening pr is 300bar) & keep it at 290 bar
- Now check if injector is dripping fuel
- Lapping may need to be done

Test ④ Leak test

- After raising pr to 300 bar check the drop in pr
- If pr drops suddenly then the clearance bet^n needle & body is increased
- Drop in pr should be very graded

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* If 2 fuel injects are fit on cyl head, then holes will only be on 1 side of injector.

2 STROKE INJECTOR — CLYDE

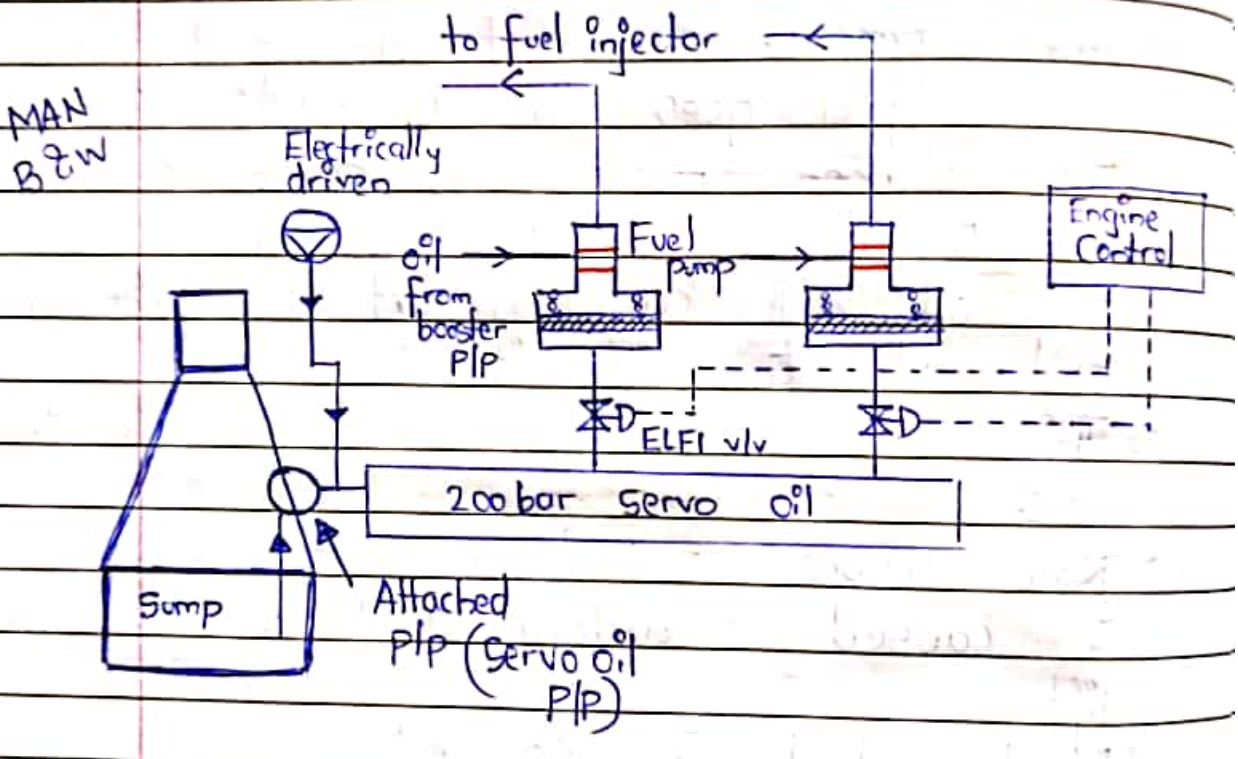
* When pressure is not developed, the same fuel goes in recirculation (9bar)
* Once plunger moves up shuts suction port & pr begins to rise. This high pr oil will come & act on primary slide v/v & lift it
* This will cause recirculation v/v to close
* Now more pr begins to rise & caused secondary slide v/v to also lift
* Finally fuel is sprayed.
* To adjust the opening pr, insert a washer above the main spring.

→ Fuel injector is also responsible to reduce NO_x emissions.
→ So a slide v/v is fitted in sac called 0 sac vol.
→ If no slide v/v the oil remaining in sac after v/v has shut will drip causing NO_x & smoky exhaust
→ Sac will help to keep needle v/v away from combustion chamber.

→ Sac helps in proper distribution of fuel in liner

Common Rail Sys

- It is used in electronic controlled engines



* Instead of fuel p/p getting actuated by cams on camshaft, here we have Electronic Fuel Injection v/v.
* This v/v is controlled by engine control.
* This sys is available in MAN B&W ME engines
* Also exhaust v/v also is operated with same concept.

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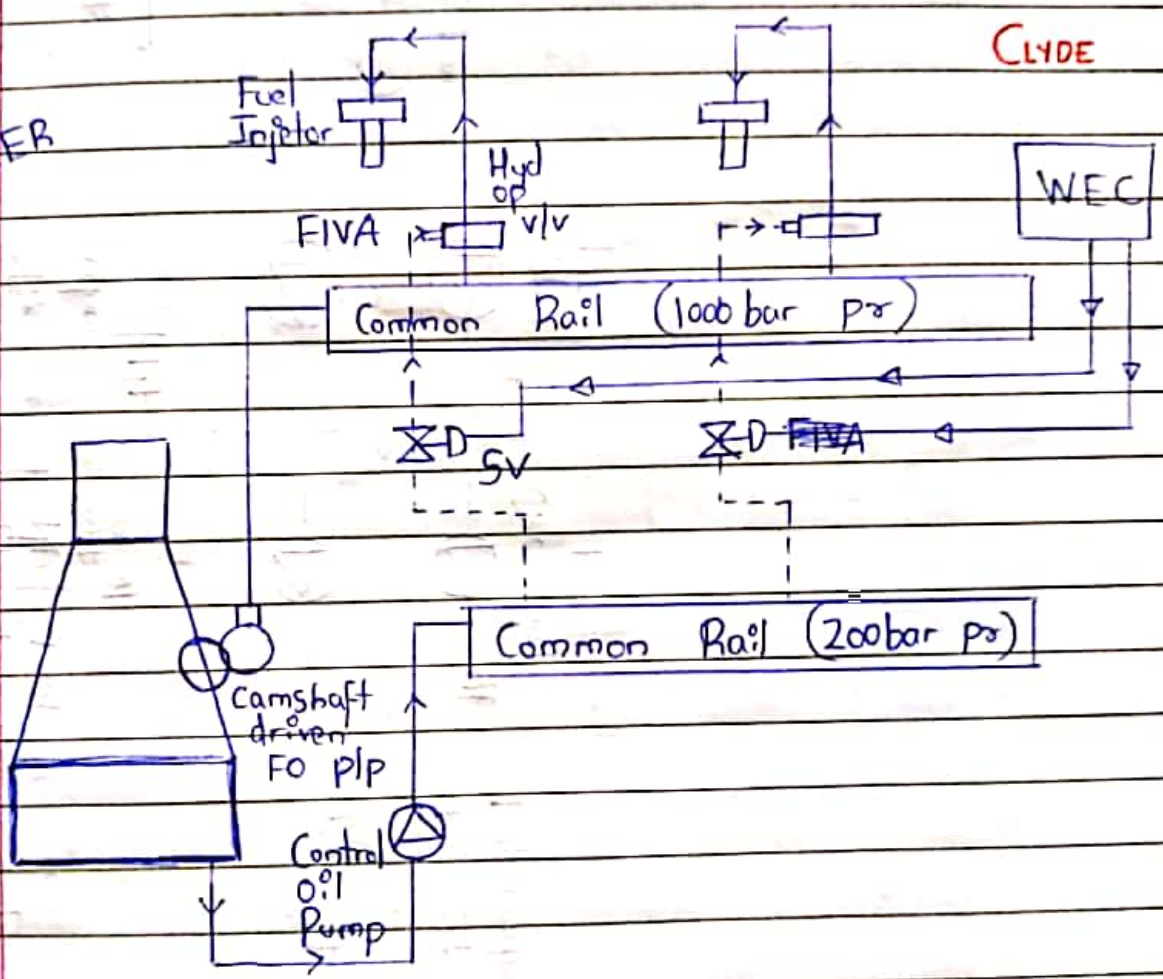
* In MAN B&W ME-B engines, fuel v/v is operated by ELFI but exhaust valve camshaft operated.
* ELFI & FIVA are both the same



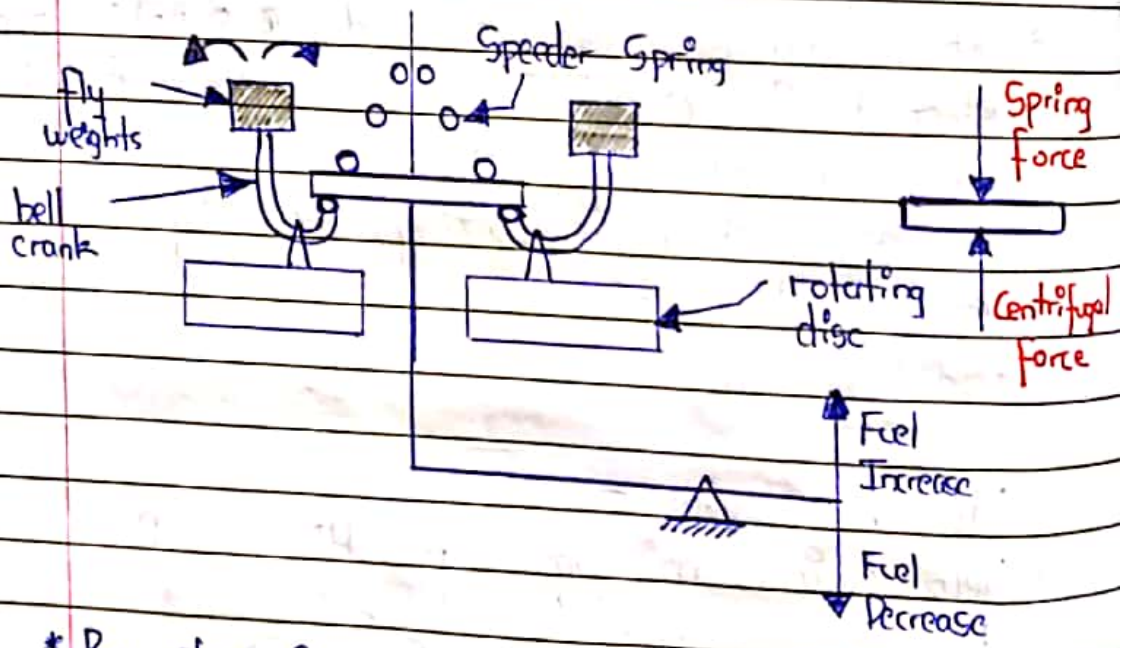
* In SULZER, the electronic control sends signal to SV
* The SV will actuate the FIVA v/v & injection begins
* Here no separate fuel oil p/p, only attached
* Another attached pump (servo oil p/p) for the operation of exhaust v/v
* This is a complete camshaft-less engine

Governor

Job:-

* For 4 stroke, governor controls the rpm (AE governor)
* For 2 stroke, governor controls the rpm & load (ME governor)

① Mechanical Governor



* By changing compression of speeder spring, engine speed can be increased or decreased
* As engine rotates, the rotating disc also rotate
* Now as load increased, rpm drops. So centrifugal force will reduce and this will cause flywts to come in
* This disc will be pushed down & lever also pushed down & fuel lever set to increase

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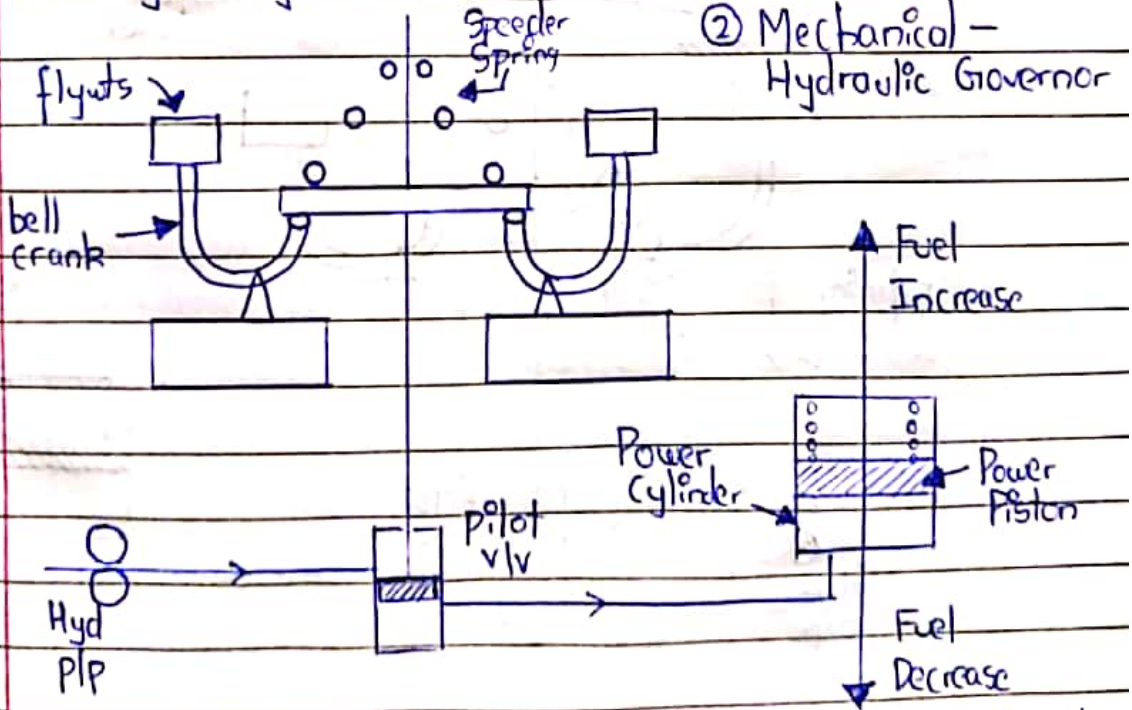
* Now as load decreased, rpm increases So more centrifugal force which will push flywts out
* This disc will be pushed up & lever also goes up & fuel lever set to decrease
* Pure mech governor is used for small engines, where governor effort is sufficient to move fuel rack

But this sys cannot be used for large 2 stroke engines. Hence we use a hyd sys.

② Mechanical – Hydraulic Governor



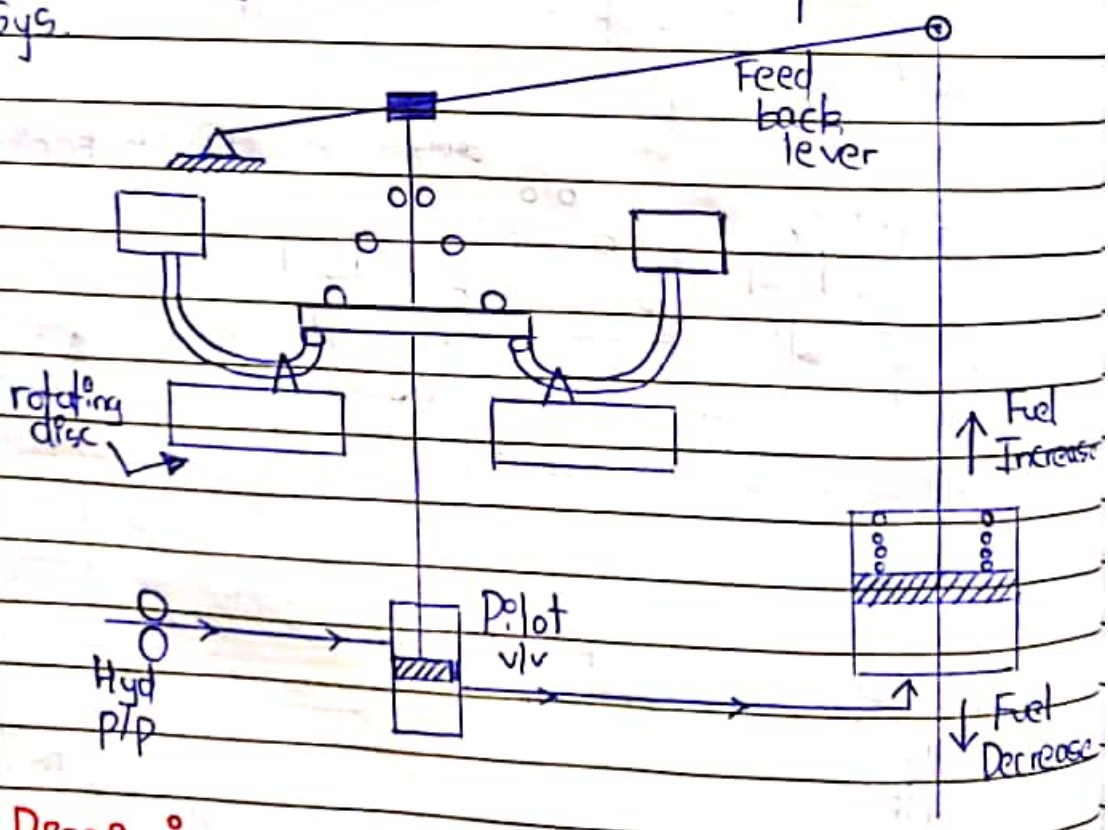
① Here when load increases, rpm drops, flywts come in. Thus disc is pushed down which pushes pilot v/v down. Now HP hyd oil is sent to the power piston for fuel to increase.

CLYDE

② Here sensing part is mechanical & operational part is hydraulic.

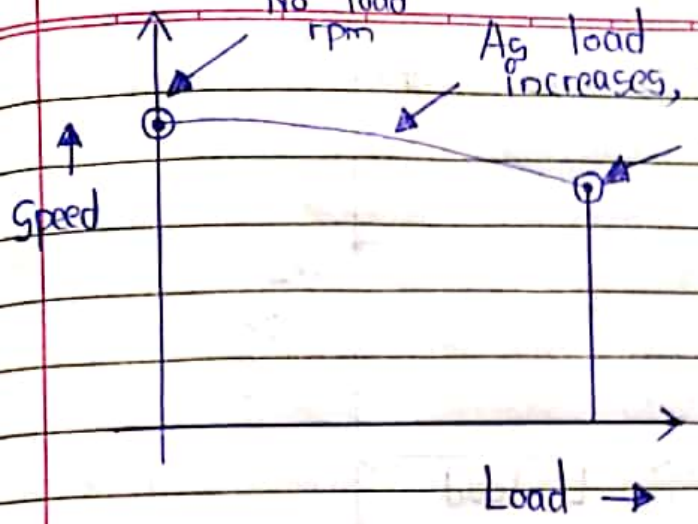
③ When load decreases, rpm increases, flywts go out. Thus disc goes up & pilot v/v moves up. This will stop the passage of hyd oil to power piston & fuel decreases

Now for these 2 systems to work satisfactory, we need a feedback sys.



DROOP :-

* Drop in speed with increase in load.
* It is a essential characteristic

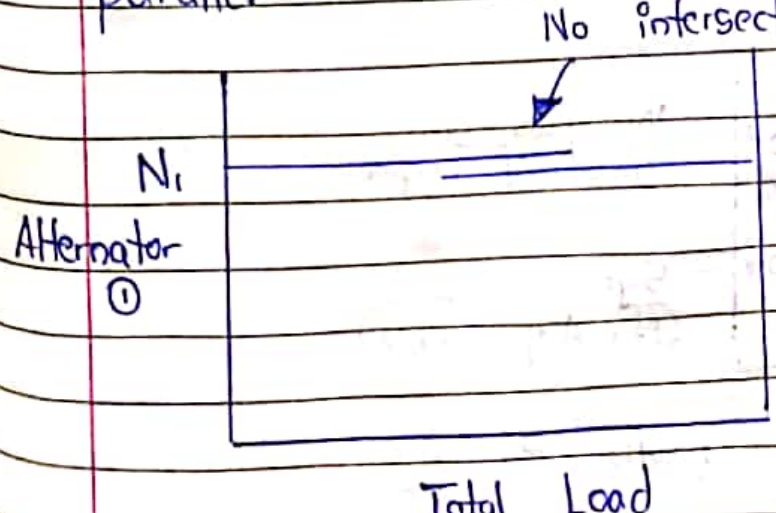


CLYDE

$$= \frac{N_{no\ load} - N_{full\ load}}{N_{no\ load}} \times 100 = \%\ droop$$

* If droop = 0 it is called isochronous governor.
* If some droop exists, it is called droop governor

* Droop is essential to parallel to alternators. If both the alternators do not have droop, they cannot be parallel



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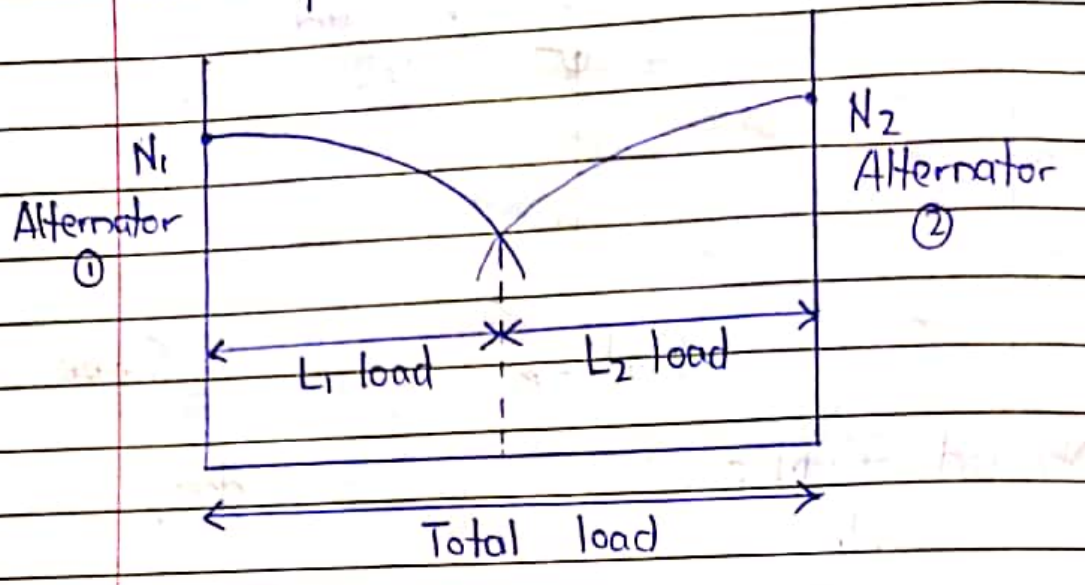
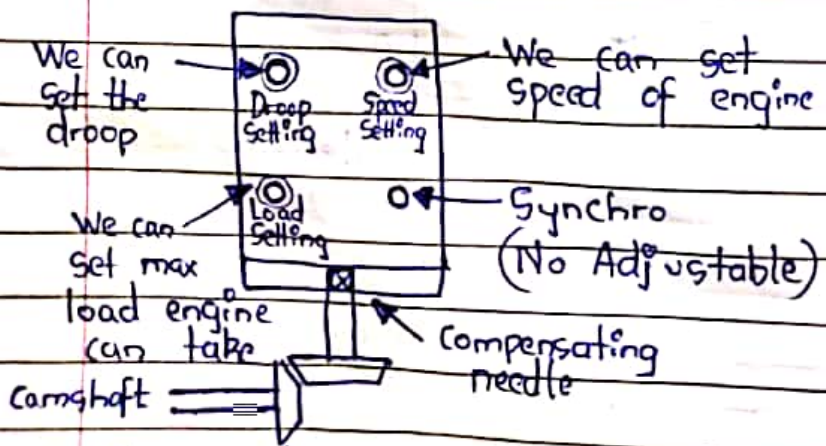
But if droop is there,



* If 2 generators are paralleled & load sharing is not equal that means droop setting has changed

* The one with less droop will take more load

Now on governor panel, there are 4 settings :



* To check overspeed trip, start 4Stroke engine & increase speed setting till

the engine trips.

* We can adjust droop setting, so that both alternators take equal load.
* Load setting can be changed if you do not require the engine to operate at 100% load due to some problem.
* Synchro actually shows difference bet" actual speed & set speed.

CLYDE

* Now-a-day load & speed sensing, speed control governor is used.
* Normally only speed was sensed. But earlier when load increased, speed would drop & more fuel had to be given to match the load. This could take time & also cause under freq trip.
* To avoid this, as load increases, it has to be sensed & fuel to be given accordingly.

Compensation :- Transient change in droop inorder to avoid excessive fluctuation of rpm when there is change of load.

- This fluctuation of rpm due to change in load is called Hunting
- This compensates for hunting.

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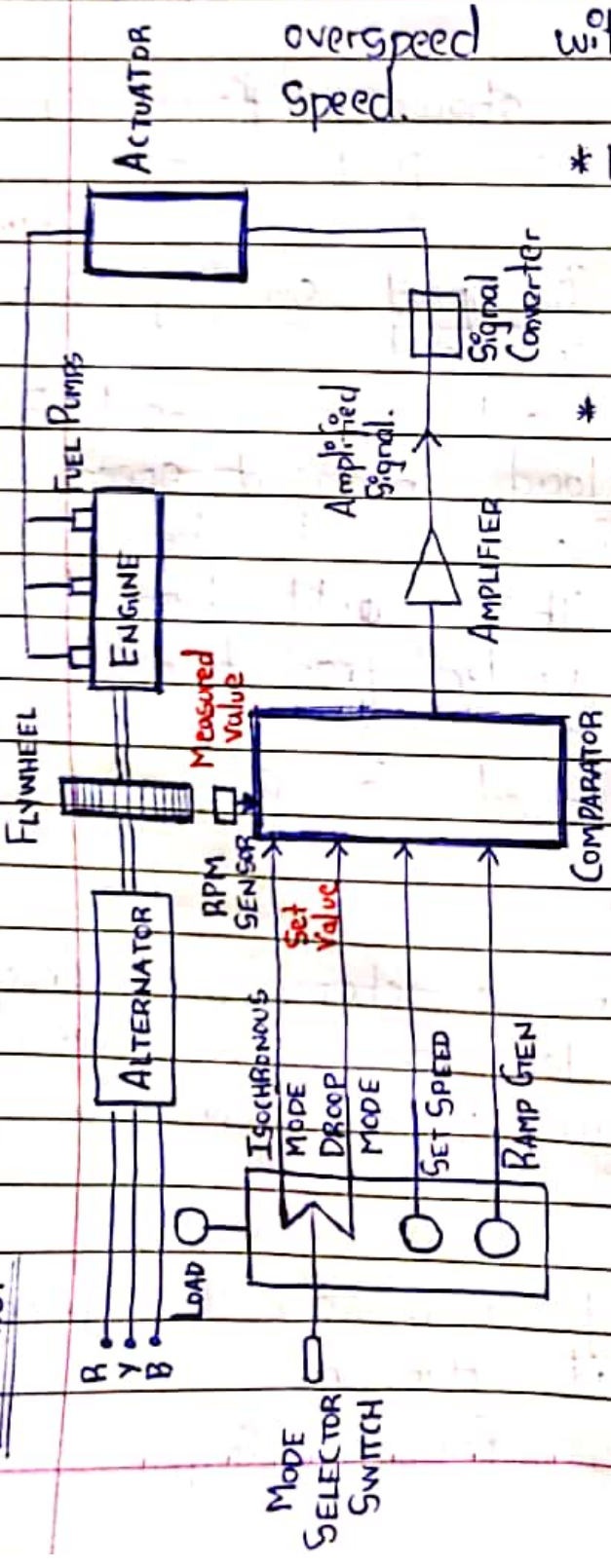
* We can run the AE in either droop mode or isochronous mode
* But in isochronous mode, it is not possible to parallel two alternators.
* Ramp generator mode is used as a simulator to check safeties like overspeed without actually increasing speed.
* Electronic governor is compact, highly sensitive & quick action.
* But here the problems like humidity, temp & vibrations can cause faults & malfunction.



Electronic Governor (AE)

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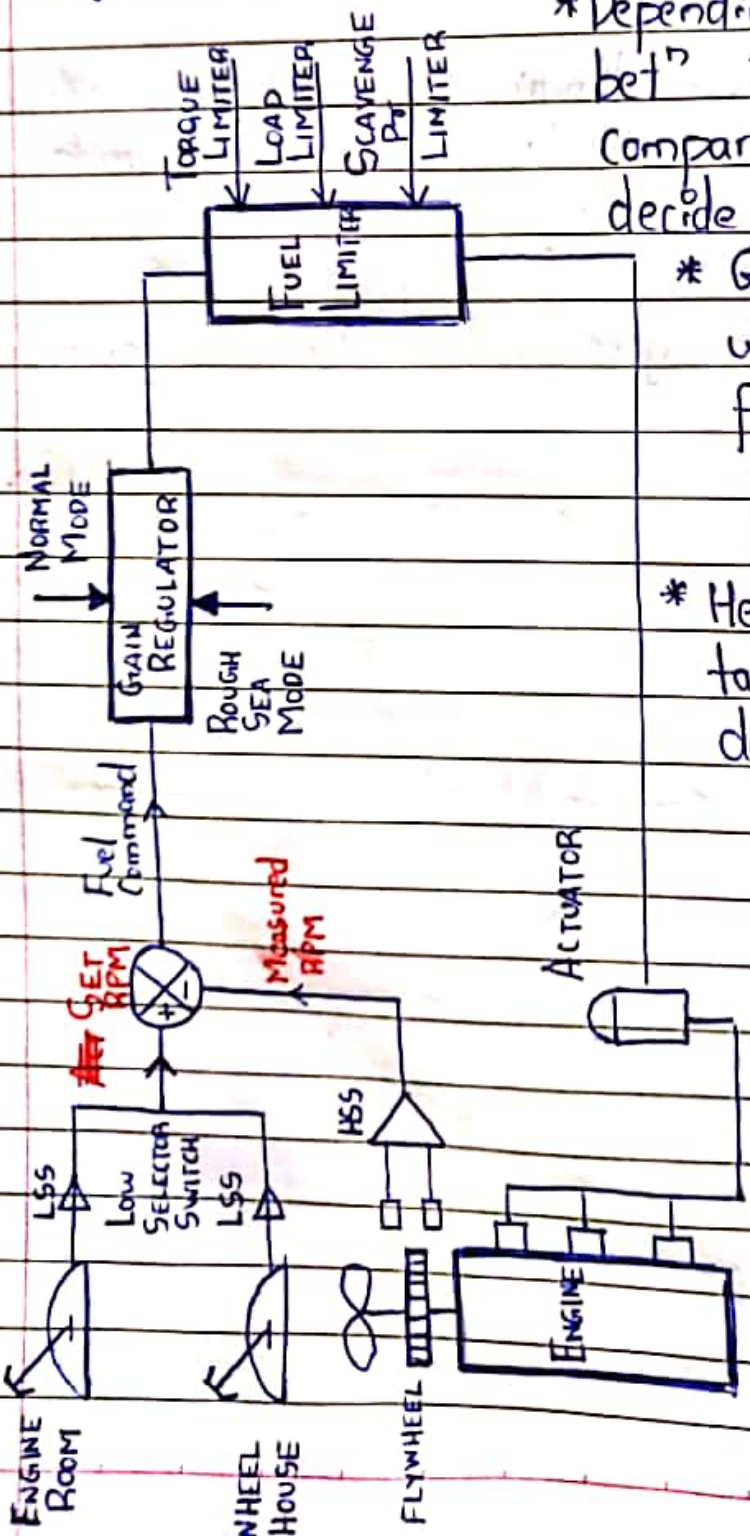
	ME Governor	AE Governor
①	Variable speed governor	Constant speed governor
②	Load & speed control	Speed control
③	No droop setting	There is droop setting
④	It has load limiter, Scavenge pr limiter & torque limiter.	It has only a load limiter
⑤	Isochronous governor	Droop governor

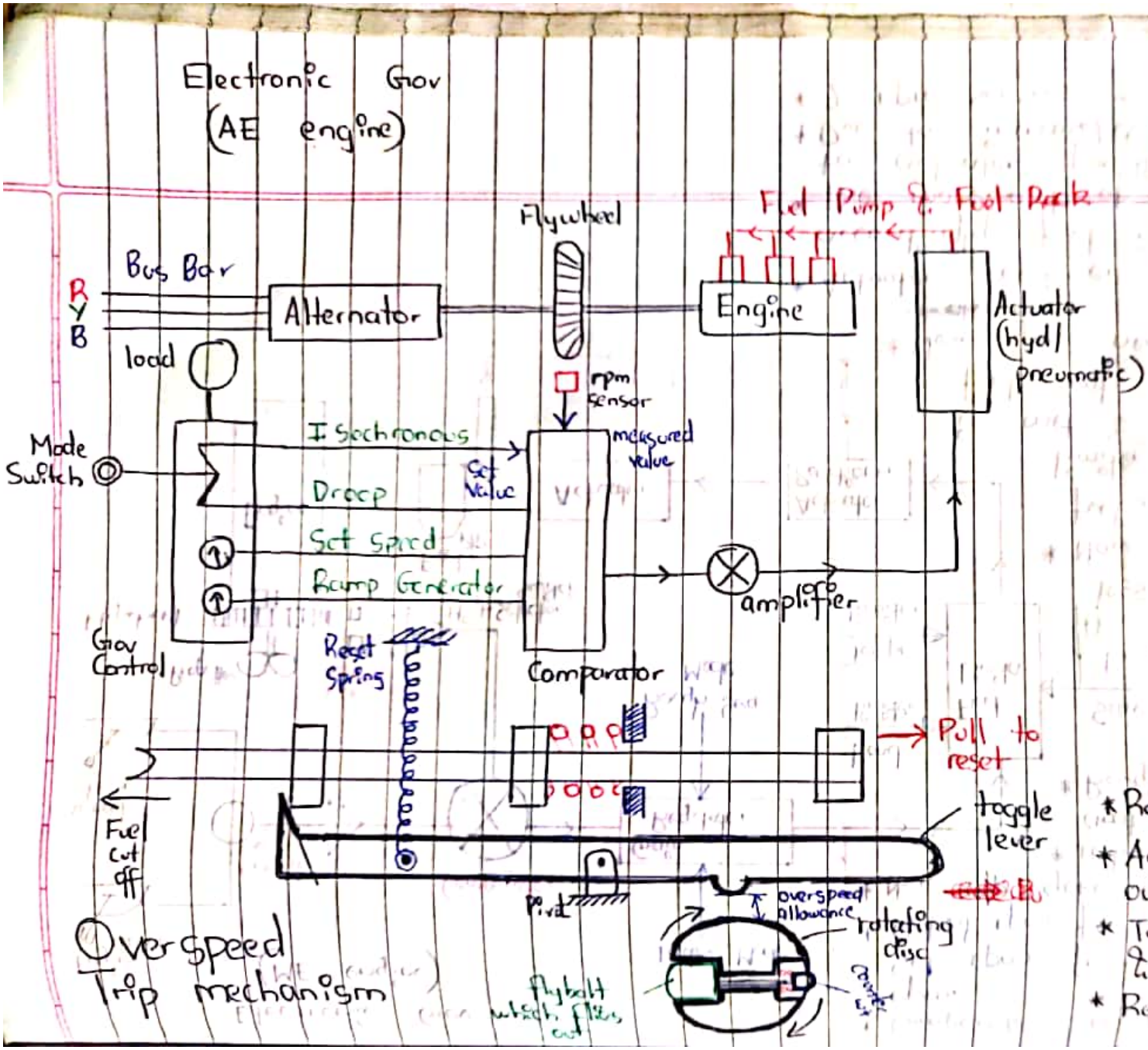
CLYDE

* Bet" ER & WH whichever rpm is low, that signal is sent to comparator.
* Comparator also receives signal from 2 rpm sensors & transmits the higher rpm signal.
* Depending on error bet" 2 values, comparator will decide the fuel common
* Gain regulator will decide if fuel has to be given suddenly or slowly
* Here gov does not take action in deadband



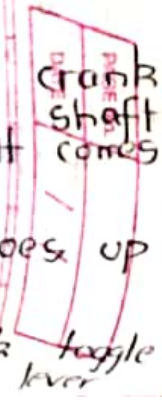
CLYDE

Electronic Gov
(AE engine)



Overspeed Trip

* Overspeed trip is a safety device not a control device
Governor is a control device
* More rpm, means more centrifugal force, that means Mean Piston Speed will exceed 9~10mls
* Hence overspeed trip.
* Gov → Modulating Control
* Overspeed → ON/OFF Control
* Diagram is Mechanical Overspeed trip.



* Rotating disc coupled to crank-shaft
* As speed increases, flyball comes out & hit on top.
* Toggle lever 1 side goes up & other goes down.
* Reset spring brings back toggle lever

In AE
Electric Air Starting motor used

Hand cranking
Electric motor
Pneumatic starting
Hyd motor
Direct air injection

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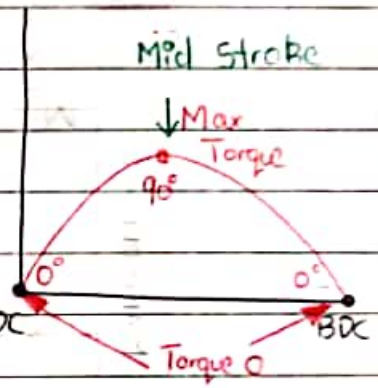
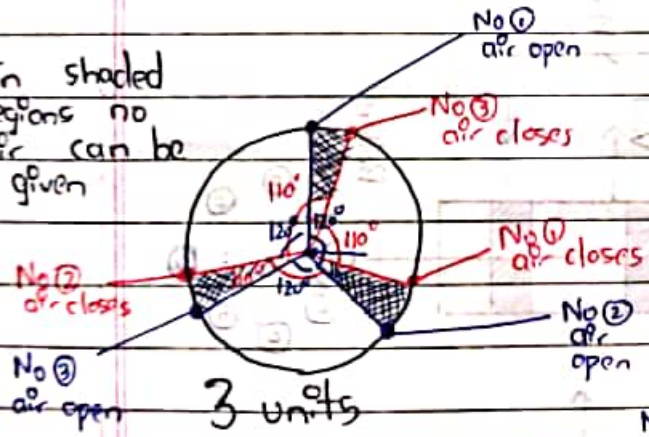
STARTING

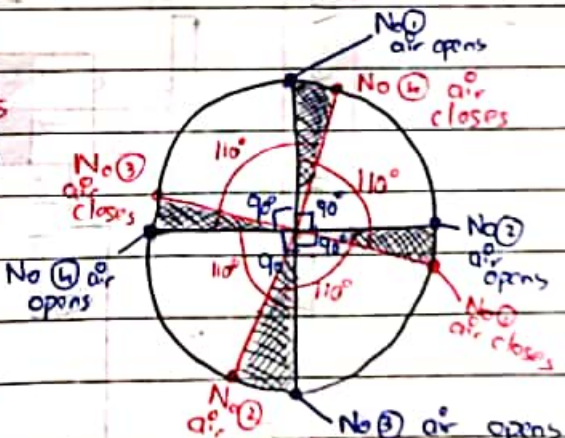
* Direct air injection starting → Gives more torque
* This is used as high starting torque req
* Now air injected at TDC or BDC, the torque would be 0 & engine will not turn

* So from graph, if we inject air at mid stroke i.e after TDC, we will get max torque & engine will turn.



In shaded regions no air can be given





Overlap period is req. to enable the engine start from any position

Here there is v/v overlap period bet^n 2 units. Hence atleast 1 unit will surely get air

Hence min 4 units req.

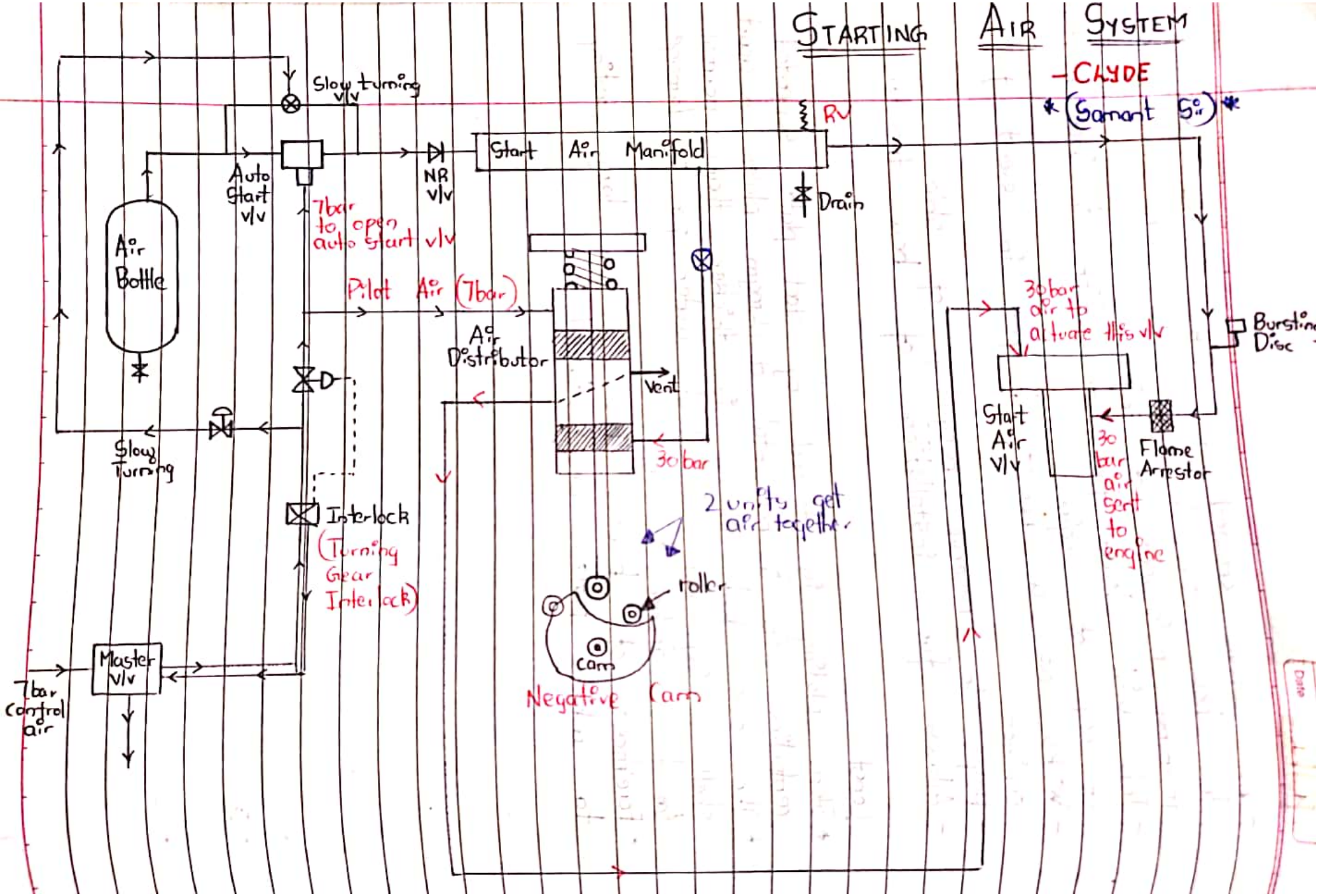
$$\text{Overlap} = \text{+ve starting angle} - \frac{360}{\text{no of units}}$$

$$= \frac{110 - 360}{4} = 20^\circ \text{ Overlap}$$

More the units, less the overlap, ⇒ Lighter Flywheel

STARTING AIR SYSTEM

- CLYDE
* (Samart 5") *



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Safeties in starting air system
- Relief v/v on cylinder head
- Relief v/v on starting air manifold
- Non return v/v
- Automatic air starting v/v
- Automatic drain before every start
- Bursting disc
- Flame arrestor
- Temperature bands on branch pipe

Interlocks
- Telegraph interlock
- Lo low pressure interlock of camshaft
- Turning gear interlock
- Aux blower interlock
- Running direction interlock
- Exhaust v/v spring air interlock.

Starting Air System

* 30 bar air from bottle comes & waits at Auto Start v/v
* When master v/v is actuated, it sends the 7 bar air to open the Auto Start v/v for 30 bar to pass
* Now once opened, air will pass through start air manifold & wait at start air v/v.
* That air will go to distributer & pass out to vent till signal is given.

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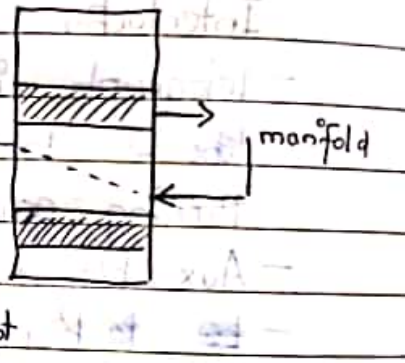
* One line from starting air manifold comes at air distributer but is blocked by piston of air distributer.
* Also 1, 7 bar line comes on top of first piston & waits
* When air kick is given, the pistons move downwards.
* Now vent is blocked, as pistons move down & ~~cam~~ roller sits on negative end of cam
* Simultanously now air will go to start air v/v of respective unit & unit will get a kick.



* Once 12% MCR is reached, all roller will be pulled up & air distributer will be inactive.

If start air v/v leaking, so exhaust gas can enter the starting air manifold
So in that case, cutoff fuel supply to that unit. & finally replace the valve

How to check air start v/v leaking?
Open indicater cocks of all units & open up auto start v/v manually
Shut air to distributer.

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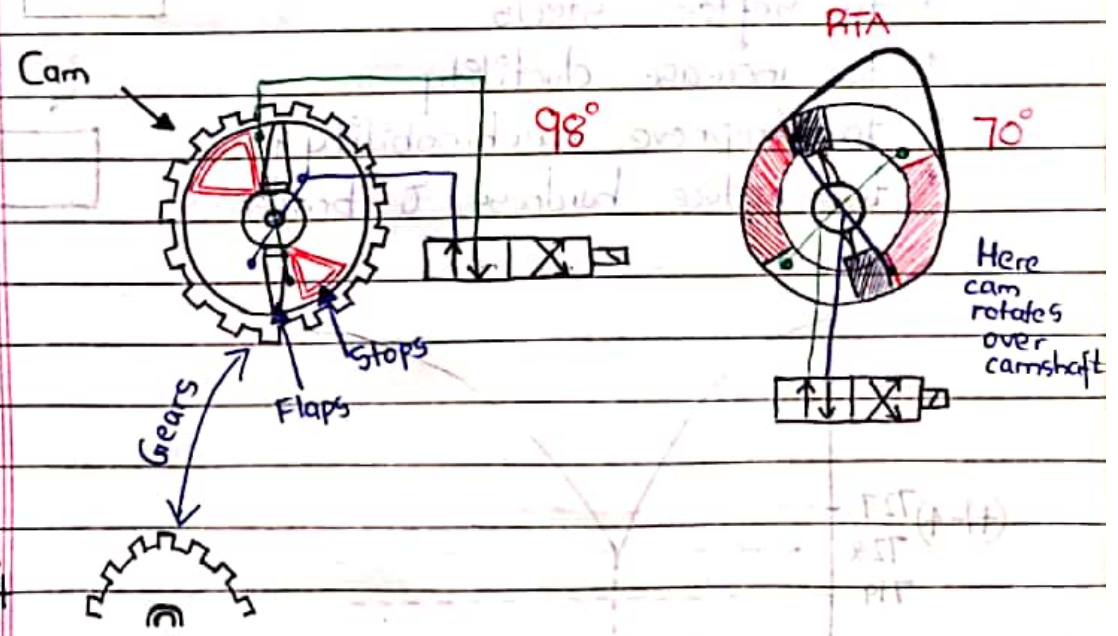
* Now all air goes upto to start air v/v of all units
* Start air v/v doesnt open as pilot air is shut.
* Now which ever unit is leaking, air will come out from that unit indicater cock.

REVERSING

* Here dont change the timing
* We only change the sequence

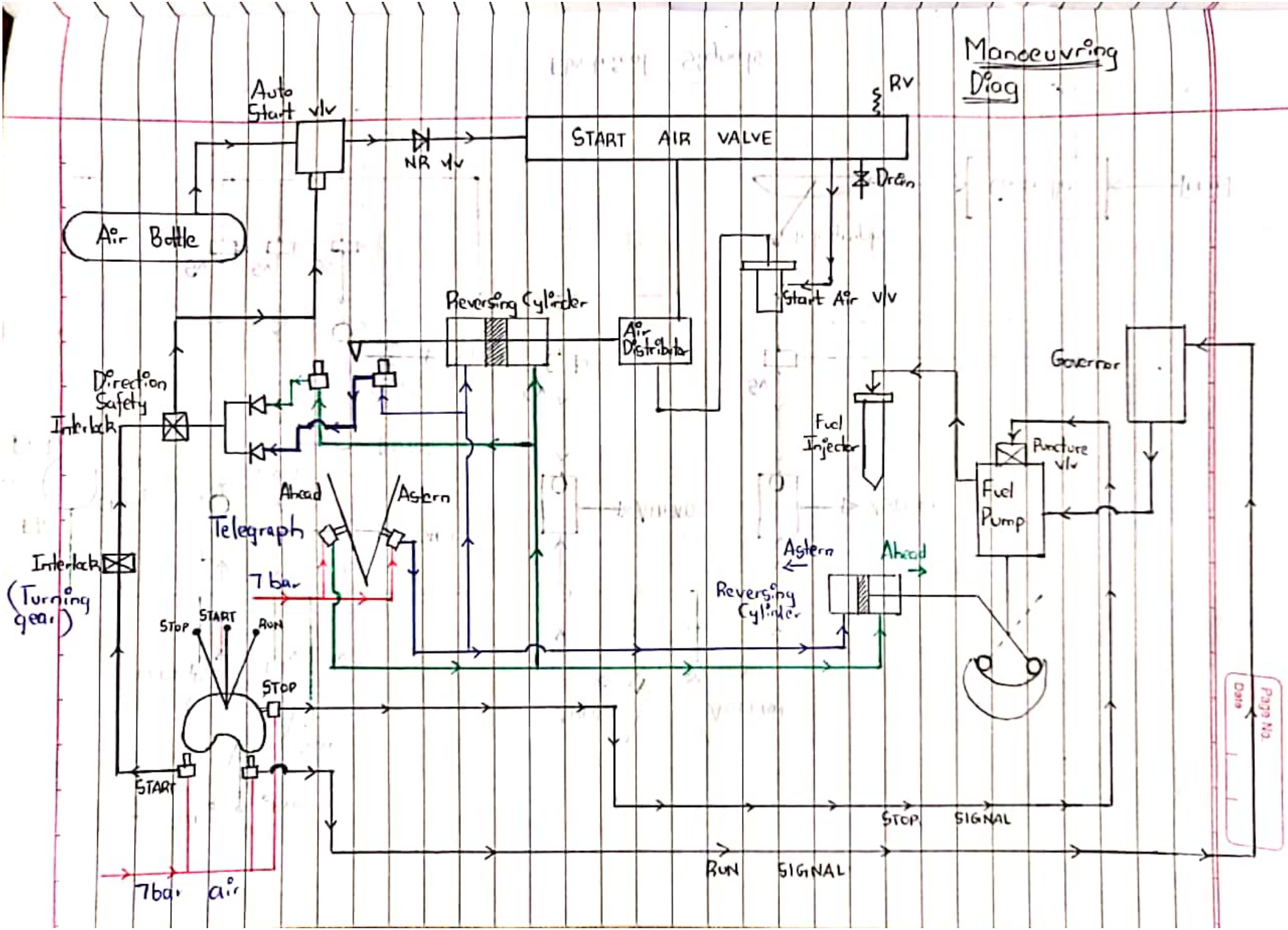
4 methods

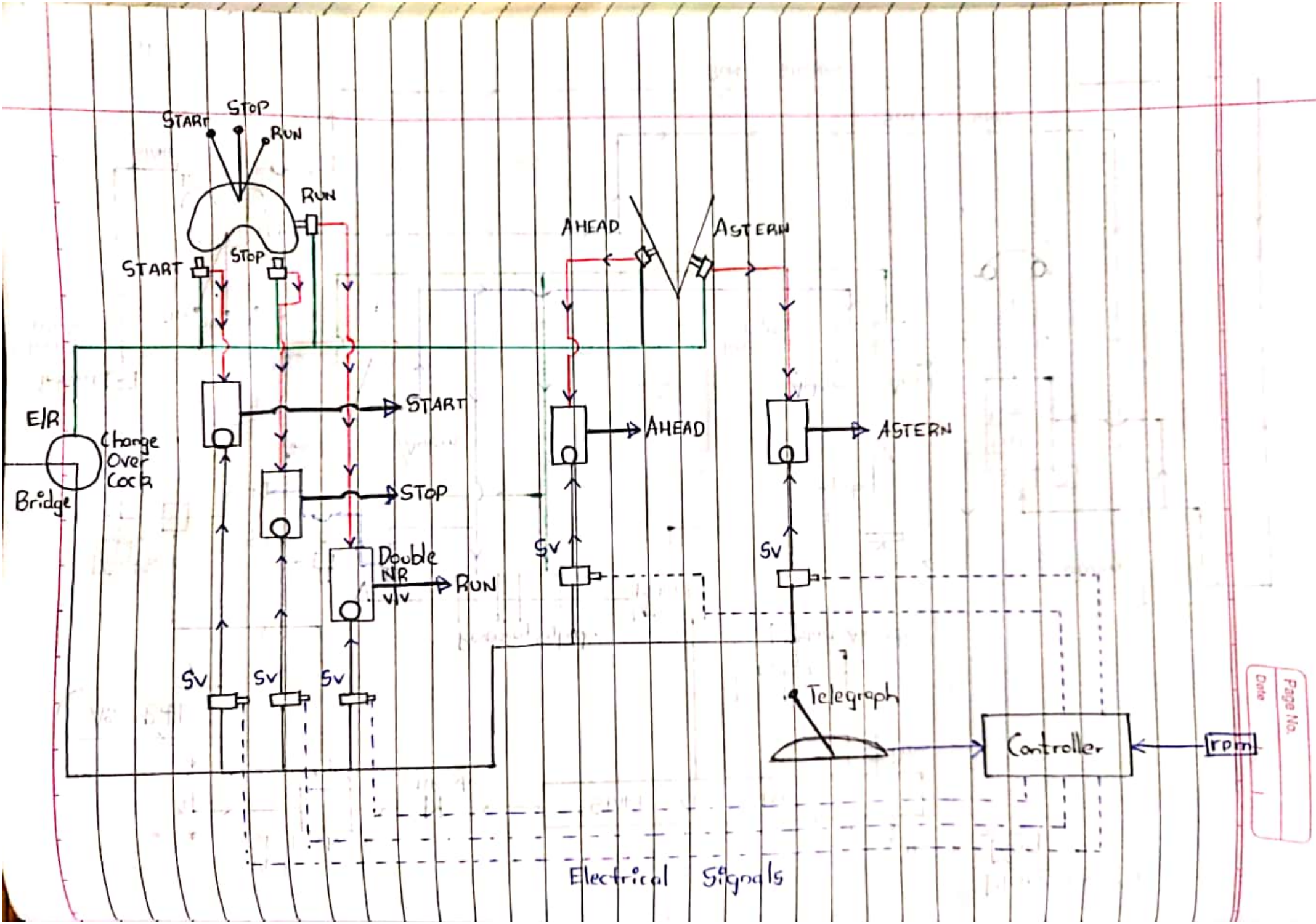
RAD RLA ① Lost motion clutch (No crankshaft turning, Only camshaft turning)



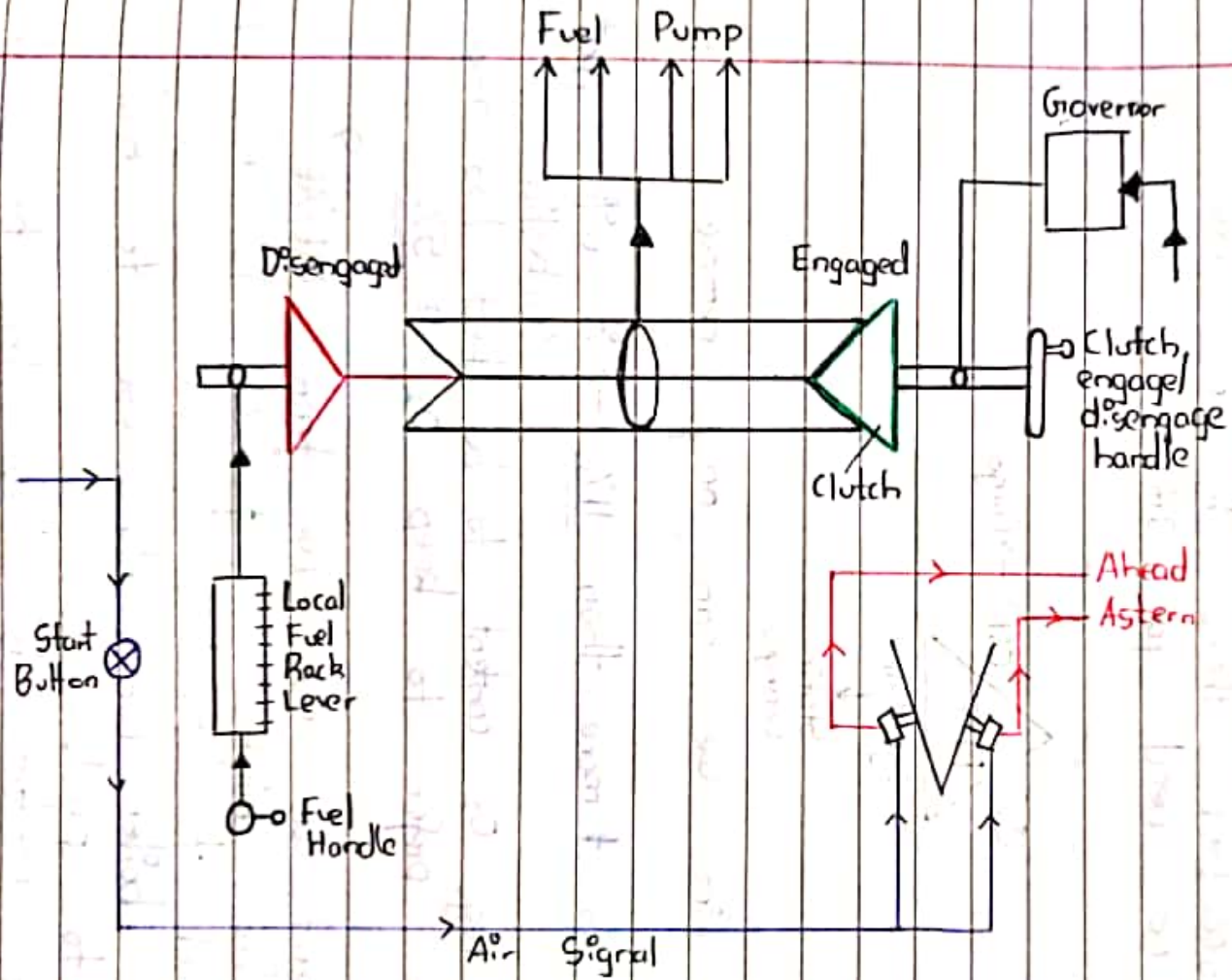
BTW ② Using seperate ahead & astern cams
RTA ③ Cams moving with help of hyd servo mota
BTW ④ Same ahead & astern cams but camshaft shifting axially, so that roller positions itself.

Manoeuvring Diag





Emergency Manoeuvring.



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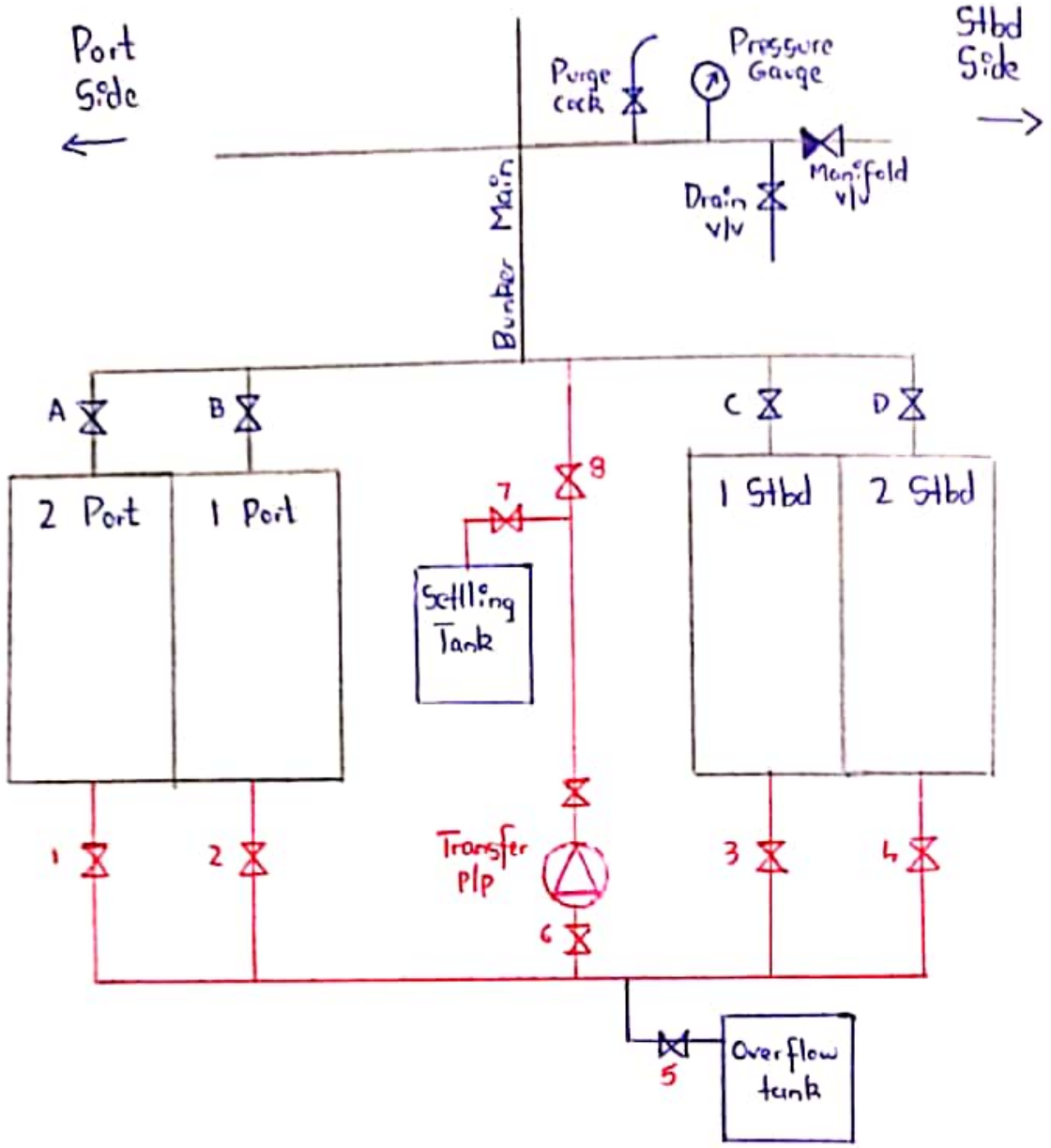
Bunker line pressure test



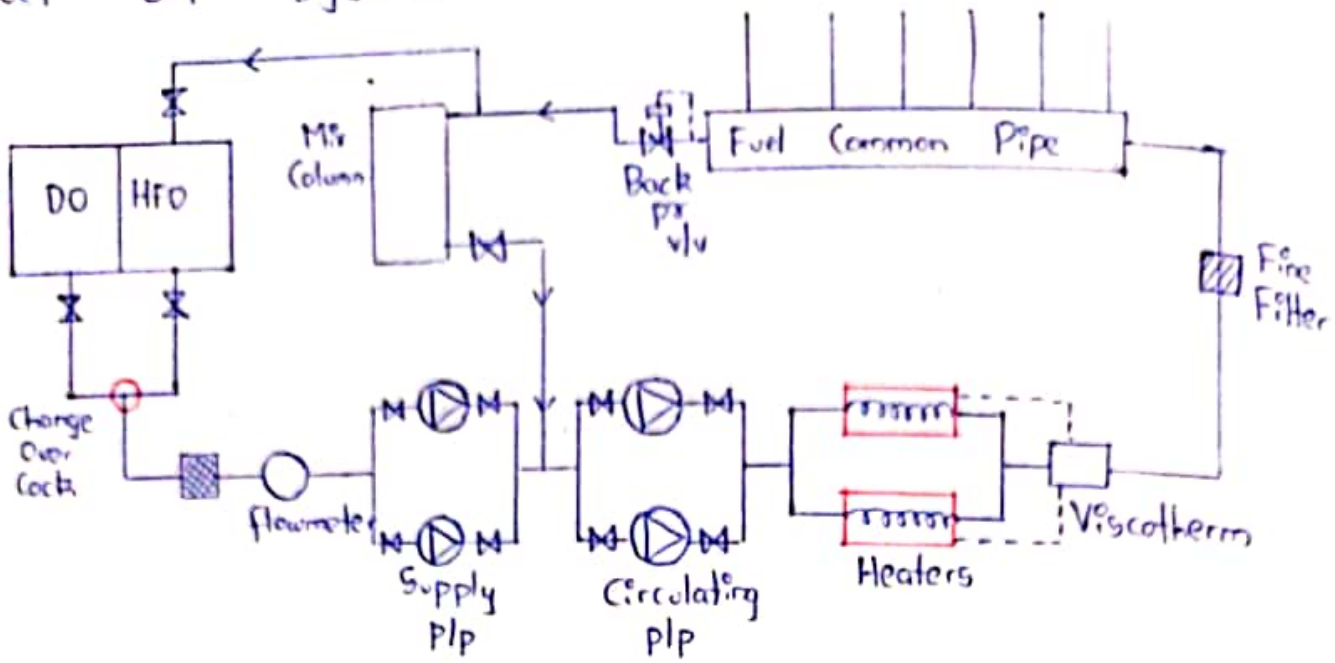
CLYDE

- We have to test bunker line with the same fuel instead of air
- Testing bunker line with air is considered ineffective

① Inform bridge
② Prepare & keep ready flange for connection of hydraulic pump to pump oil in line
③ Flange can be connected either to bunker flange or to drain valve.
④ Ensure manifold pr gauge is not faulty & well calibrated.
⑤ Ensure you have adequate man power with proper communication
⑥ Close the deck scupper plugs.
⑦ Keep SOPEP equipment ready.
⑧ Try out eme stop for pump
⑨ Set line from 1 tank to same tank
⑩ Valves ① ③ ④ ⑤ & ⑦ to be closed
⑪ Valves ② ⑥ ⑧ to be open
⑫ 1 person at manifold
1 person to check for leaks
1 person near pump
⑬ Shut the drain v/v & open purge cock
⑭ Start pump & push out all air in line till oil comes from cock.
⑮ Now stop pump close v/v B along with already closed valves A, C, D
Close v/v ②
⑯ Connect hyd p/p & fill DO in pump & start rising pr.
We have to raise to 1.5 times normal wking pressure (approx 5 bar)
⑰ Pressurize & hold this pr for 10 min
Pr should not drop more than 1% in an hr
⑱ Once successful, drain oil back to tank
⑲ Mention has to be done in ORB & pr test & date to be stenciled on manifold.

CLYDE

Fuel Oil System



* Mixing column helps in gradual change over
* Sudden change in fuel could damage plunger & barallel.
* Before change over make sure correct fuel temp is achieved

* Backpr v/v mainly comes into operation when starting & stopping engine.
* When stopped, backpr v/v fully opens sending max oil in recirculation
* When engine started, backpr v/v starts closing sending max oil to pumps.

CLYDE

Before Bunkering :

① Proper calculation to be done to ensure the bunker is sufficient for voyage & can be filled in tanks.

② Safety meeting in which
- ↳ which tanks to be filled
- ↳ proper sequence
- ↳ eme procedures
- ↳ responsibilities of individuals.

CLYDE

③ Pre bunker checklists have to be filled.

④ Scupper & drains to be plugged.

⑤ Ensure overflow tank is kept empty

⑥ Adequate lighting at bunker manifold & sounding pipe.

⑦ No smoking signs

⑧ Communication, signs & signals to stop operation to be understood by all.

⑨ Opposite side bunker manifold valves are closed.

⑩ Vessels draft & trim to be recorded.

⑪ All SOPEP equipment to be kept ready.

⑫ Bunker suppliers paperwork to be checked & pumping rate to be agreed

⑬ The bunker hose & supply connected to be checked

⑭ Bunker line valves are checked

⑮ Drip tray below manifold v/v

During Bunkering

① At start, pumping rate to be slow to check if oil coming to correct tank
② Check sounding of bunker tanks & neighbouring tanks to ensure oil goes to right tank.
③ Increase pumping rate.
④ Check manifold pr at all times
⑤ Take continous sample with sampling cock at manifold.
⑥ Topping up also to be done at slower rate
⑦ Max tank can be filled is 90%
⑧ Close sounding pipe while air blowing.

After Bunkering.

① Take final sounding of tank.
② 4 samples are taken during bunkering.
   ① kept onboard
   ① given to bunker barge
   ① for analysis
   ① for port state or IMO
③ Chief engineer signs bunker ~~BN~~ (BDN) & amt received
④ Hose is disconnected
⑤ Entry to be made in ORB.

BDN

* It is a std document req acc to annex VI
* It contains details like
  1. Ship name & IMO no.
  2. Name & address
  3. Product name
  4. Quantity
  5. Quality (grade)
  6. Density
  7. Sulphur content
  8. Samples of oil taken
  9. Port & date of delivery.

CLYDE

On what conditions can bunker be rejected?

- if sulphur content not acc to standards
- if quantity less
- if fuel not acc to grade we ordered (ISO 8217)

Properties of fuel oil

Density @ 15°C
Viscosity
Flash pt
Pour pt
Sulphur content
Carbon content
Ash content
CCAI

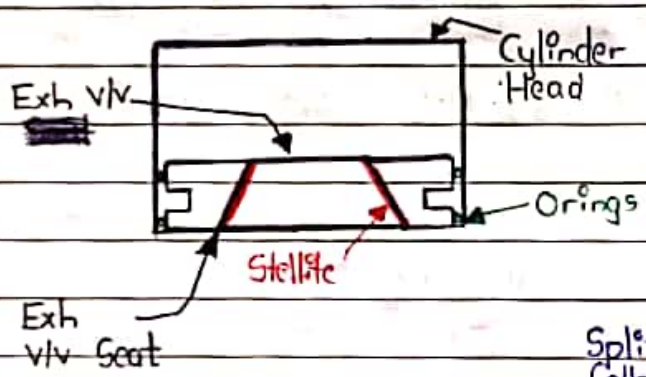
* CCAI is calculated based on DENSITY & VISCOSITY
* More CCAI, more inferior is ignition quality of fuel
* CCAI helps in ignition delay

** Exhaust Valve **

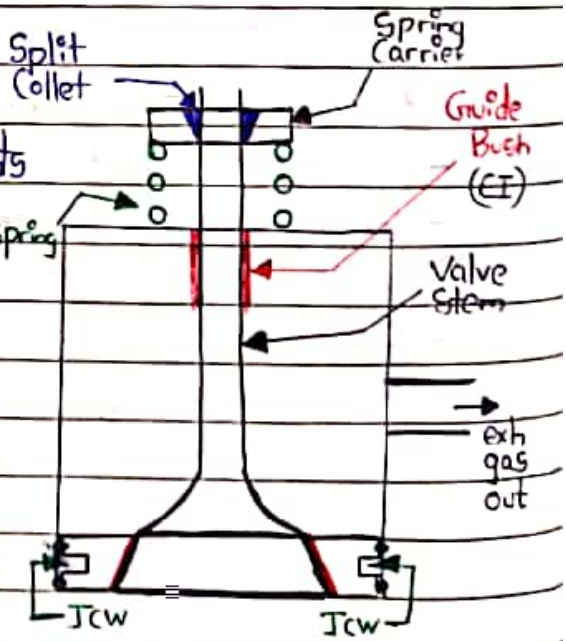
* exhaust v/v → Nimonic alloy (Nickel based alloy) resistance to high temp corrosion

* inlet v/v → Stainless steel

* Exh v/v seat made of Chromium Md Steel coated with STELLITE (Cobalt based alloy) resistance to high temp corrosion



* Exh v/v seat is done by JCW itself
* Exh v/v is press fit in cyl head



* Split collet holds v/v & prevents v/v from falling down
* Exh v/v opens inside the cylinder. WHY ?

↳ Exh v/v closes upwards as gas pr will cause positive closing & maintain good seal.

↳ Opening inwards, opening mechanism becomes simple.

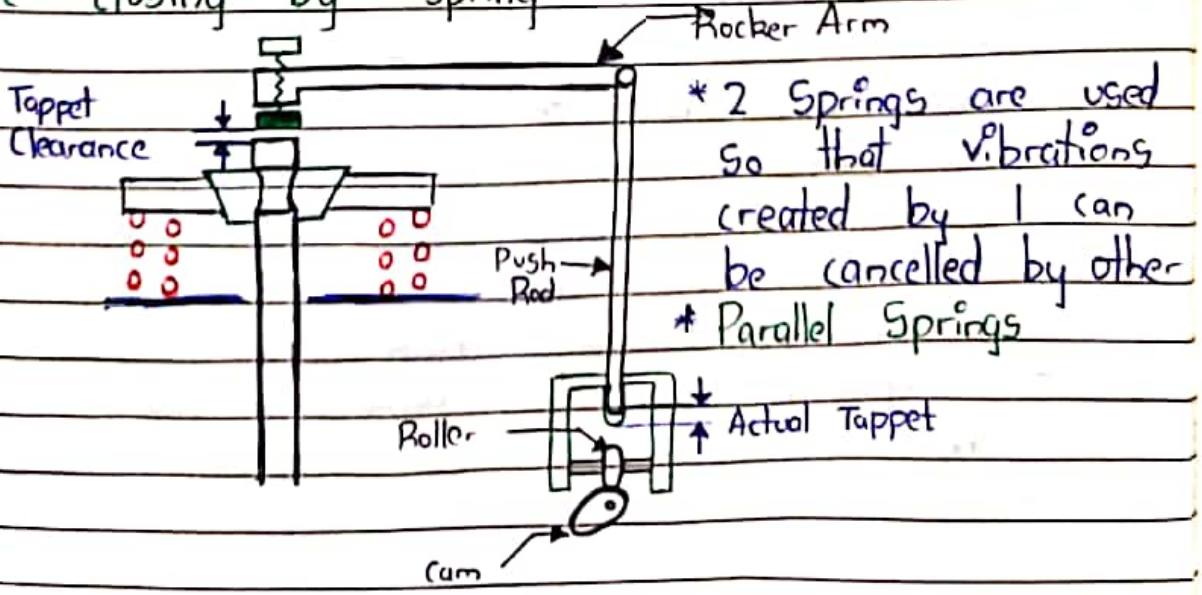
- Engines have more power developed
- More fresh air needed
- More exhaust gases generated

- So exh gas need to be removed fast & air inlet also needs to enter fast as it is a high speed engine

- Hence it is necessary to have 2 inlets & 2 exhaust for better & faster exchange of gases.

Advantages
- ↳ Better combustion & good thermal efficiency
- ↳ 2 small v/v's : so smaller area to sit & hence better sealing
- ↳ Valves can be rotated easily due to light wt
- ↳ Time between overhaul will increase
- ↳ Scavenge efficiency will increase

Valve opening by rocker arm
Valve closing by spring



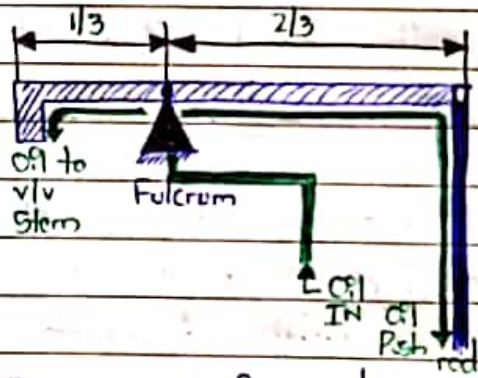
* 2 Springs are used so that vibrations created by 1 can be cancelled by other
* Parallel Springs

Q Why is clearance given at top?

- Because when v/v gets heated up during running, this allowance will take care of expansion due to heat

- If this allowance not given, expansion will happen down, & v/v will not close

- Actually the tappet is at pushrod but since we can't measure it there, we take above v/v



* This arrangement is given to provide easier opening & less mech effort
* Force x ⊥ dist

* But some engines have fulcrum in center
* This less effort, will increase life of roller, cam & pushrod

Q How is lubrication done?

- Oil line comes to the fulcrum PIN from there 1 lines goes to cool v/v steam & other line goes to cool push rod
- Return goes to crankcase
- Sometimes separate rockerarm gear pump is there

Tappet clearance to be taken when:
- engine stopped
- exh v/v is closed

But how to know exh v/v is closed.
① Open camcase door
② Check that roller should be on base circle of cam
③ This means exh v/v is closed
④ Check push rod is free.

CLYDE

- now put feeler gauge & check
- exh v/v tappet is more than air inlet v/v

Another method
① Take piston to TDC
② Now in 4 stroke, piston comes 2 times to TDC
③ So how to know if firing TDC or exhaust TDC
④ Check pushrod of both valves, it should be loose.
⑤ This means both valves are closed.

Another method
① Just after compression & when fuel about to inject both valves will be closed
② So on fuel plp body check from window 1 mark on sleeve moving up & down 1 mark on body
③ So turn engine & when both marking coincide means fuel injection begins
④ Now check tappet

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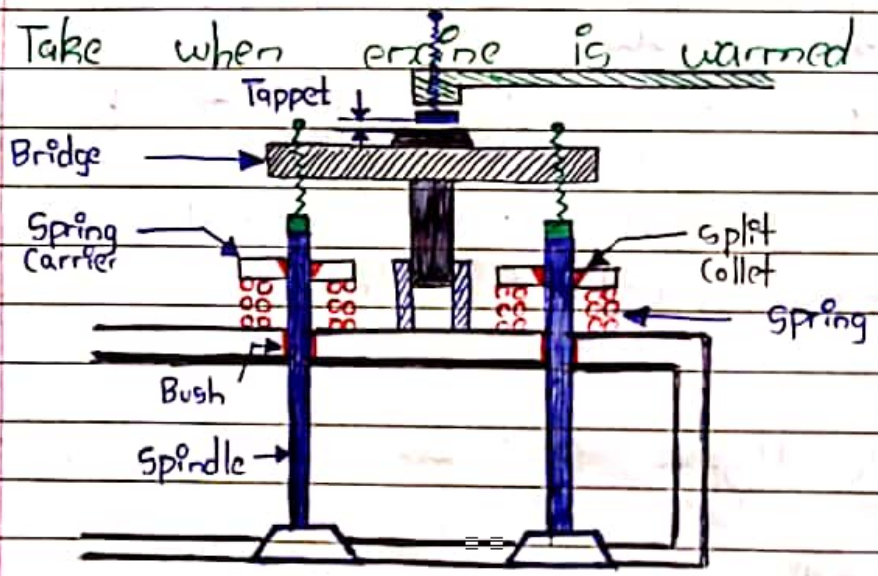
DO NOT TAKE Tappet

- when engine just stopped
- when engine completely cold

- Take when engine is warmed up by ICW



- Here both valves to open & close together.
- So tappet adjustment both for both spindles to have 0 clearance

* If TAPPET too low
vlv will open early
all compression will be lost & power affected

* If TAPPET too high
vlv will open late
blowdown effect wont happen & fresh air won't be able to enter & power affected.

→ air inlet vlv slightly bigger than exhaust vlv
→ now-a-days both equal size

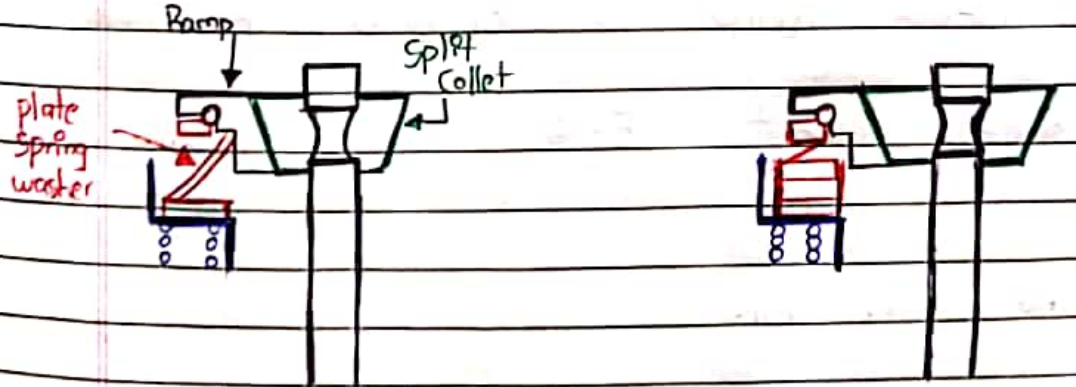
Exh vlv will have E written on it
Exh vlv will have bluish stellite coating

* If you take out cover of cyl head & you observe exh gases coming out
* This is clearly indicating bush worn out
* The bush is press fit
* Sometimes over bush, a lip seal is there to not allow lube oil to enter.

- Now here v/v rotates at time of CLOSING
① to give self cleaning effect & increase life of v/v & v/v seat.
② uniform distribution of heat over v/v & v/v seat

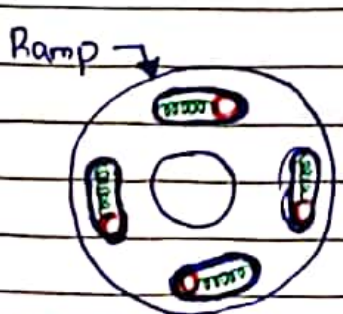
CLYDE

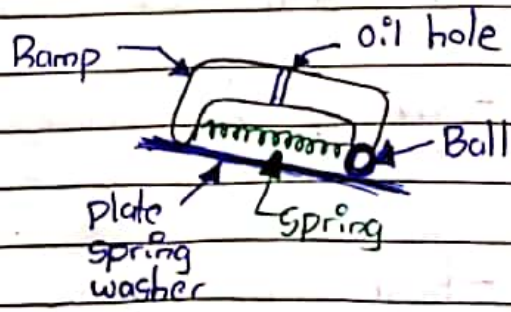
This job is done by ROTOCAP



v/v Closed

v/v OPEN





* These springs won't allow the balls to go inwards → The cause ball to be in contact with ramp

- When vlv is open, that time the plate spring washer gets compressed
- As soon as the vlv closes, the spring expands
- This energy will be released to balls
- But since balls cannot move, the entire ramp moves
- This causes exh vlv to rotate over vlv seat.

- Inlet vlv doesn't need but they have rotocap too

- After overhauling, hit with rubber hammer on vlv steam to check for rotation of vlv
- Put a chalk mark to observe the rotation

* vlv rotates about 5~8°

CLYDE

2 Stroke Exh Valve

- vlv spindle - nimonic alloy
- vlv seat - cr md steel

- vlv spindle moves in guide bush made of CI or brass

- Bush is press fit

- Exh valve cage & valve seat is cooled by JCW

- Air spring piston is clamped to spindle by a split collet
- This piston has teflon rings which act like piston rings to give sealing effect
- Spring air enters at bottom via non-return valve at 7bar

-

- Hyd piston will be pushed down by lube oil pr & causes exh vlv to open inside cylinder

- Exh goses passes over rotary vanes causing v/v to rotate at time of OPENING

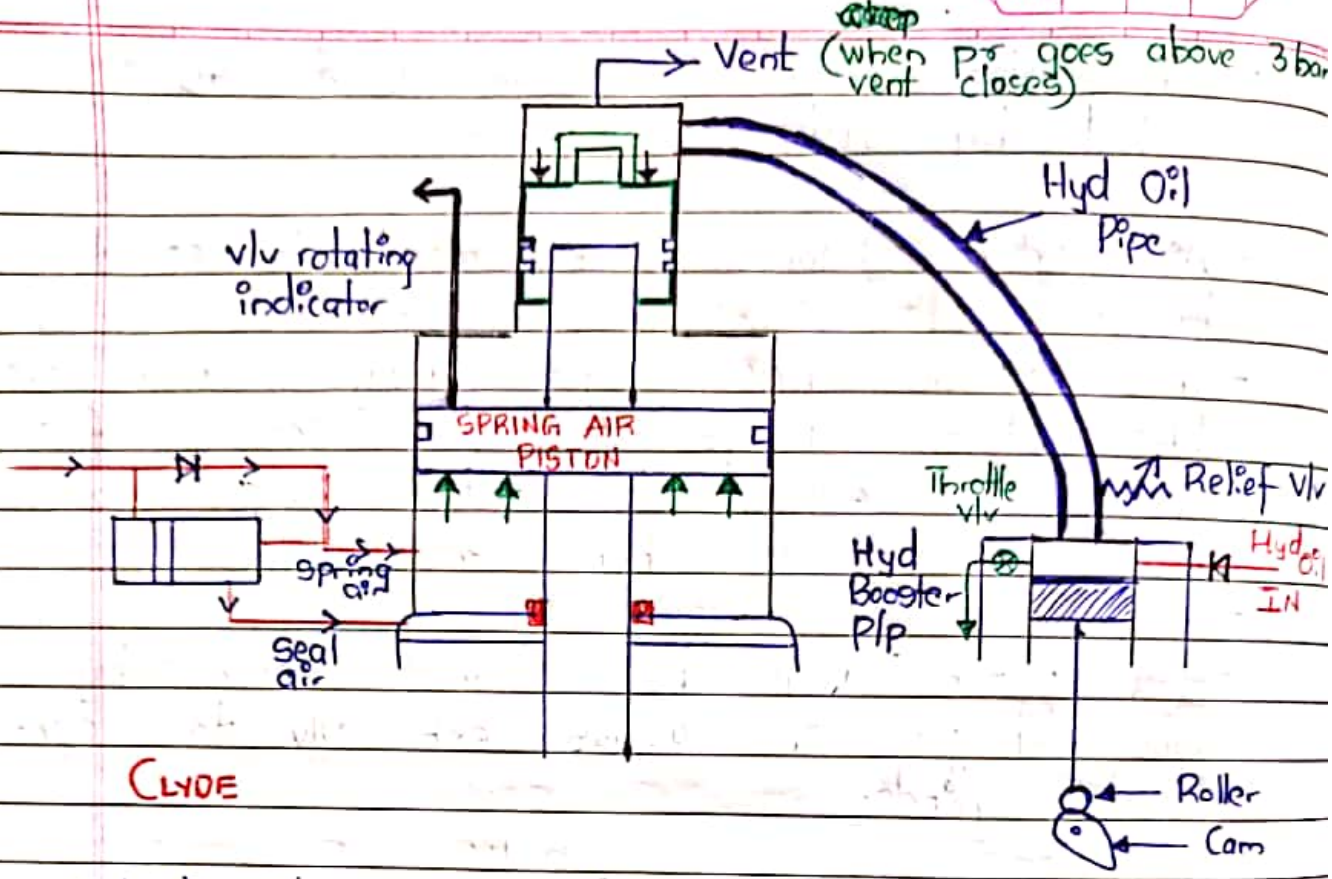
- Gas deflector prevents exh gas to go inside bush

- Exh vlv seat is removable as it is fitted by 2 grub screws from valve body.
- Seat is coated with stellite coating

- Vent vlv provided to remove any vapours or air

* Valve Opens by hyd oil pr
* Valve closes by spring air

- Control air pr of 7 bar acts all time only sometimes pr will increase or decrease



CLYDE

* Hyd oil comes from LO p/p. but MC engines separate camshaft LO p/p & tank
* When roller on base circle of cam, oil will enter & venting will take place
* When roller on rise of cam, plunger will go up, oil will get compressed.
* Now when pr goes above 3 bar, automatic the vent will shut
* This pr will now act over the hydraulic piston & cause v/v to open

* At same time, when v/v was closed, 7 bar air enters below Spring Air Piston.
* Now as v/v opens, this air gets compressed

* When again roller comes to base circle

of cam, the hyd oil pr reduces, So now the compressed air expands & closes the valve.

* When v/v opens that time also spring air & sealing air is at same pressure & when v/v closes that time spring air & sealing air is at same pressure.

CLYDE

- This is to prevent leakage

Throttle V/v :

- provided either at hyd piston or pump
- all expanded oil can be removed
- if this oil is not removed, v/v wont be able to close.

* This cannot be done by vent v/v as vent v/v will shot

* Thus we call this as virtual tappet

* If throttle v/v open too much, v/v will bang when it closes

* Relief v/v also provided incase if plunger goes up & v/v doesn't open → hyd oil side

* In case if exhaust gases enter air piston if bush is damaged air pr will rise too much. Hence relief v/v → air piston side

- When v/v closes, v/v bangs against seat & we call this Knocking.

- Sometimes, you have a damping piston so that closing is gradual & Knocking is avoided

Q Do not start LO p/p before keeping Spring air open

Why?

- Pr will develop pushing exh v/v down
- Spring air piston will also come down thus blocking air inlet passage.

* So turn engine & let piston push v/v on top

Variable Exhaust Closing

* Fitted in SULZER, we bleed out some oil by SV & drain oil to close v/v as pr drops

- We want to close exh v/v early so that we do not loose air
- Every 10° earlier closing will increase compression pr by 4 bar.

* SV located at actuator itself

* MAN B&W also has incorporated this, but it is called Eco CAM

* Here SV located at hyd oil piston side

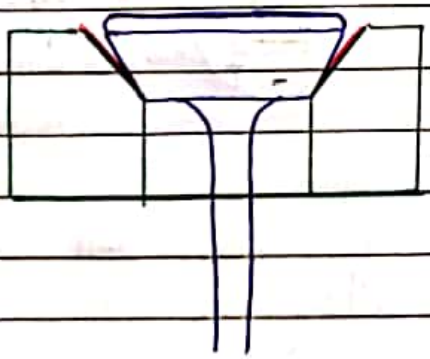
* Effective bet^n 10~60% load

SULZER variable exh closing (above 60% load)
MAN B&W eco cam (10~60% load)

CLYDE

- Valve & v/v seat are at different angles when v/v is cold but while running due to expansion proper contact bet^n v/v & v/v seat

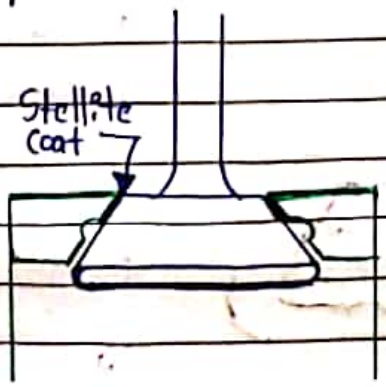
PLAIN SEAT



* 5~10° difference in angle bet^n v/v & v/v seat

3 types of seats available

CHAMBER SEAT



* compressed air gets trapped in the space are cools the seat increasing life

latest technology is

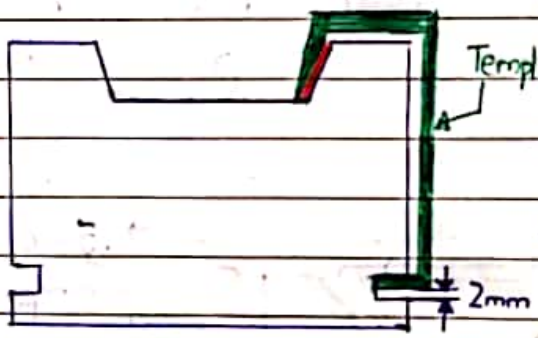
W - SEAT

* Here we have pt contact
* Throw away seat after fixed hrs

* This seat is induction hardened
* Here no stellite coating

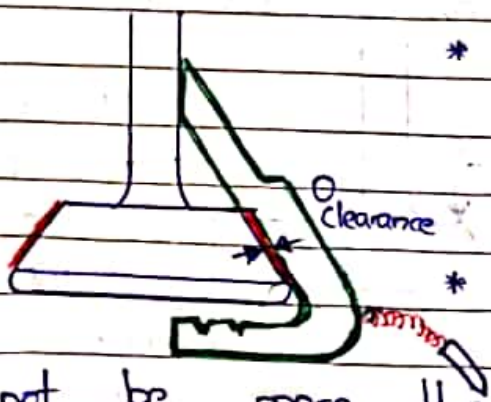
CLYDE

MAINTENANCE



* To check burn out of exh v/v seat, a template is provided
* When seat is new 2mm allowance will be there

* When you start grinding seat, all stellite coat will go & 0mm allowance will be obtained
* Now send for reconditioning.



* when spindle is new, template will touch v/v & clearance will be 0
* As you grind, gap starts to form

* Gap to not be more than 2mm

CLYDE

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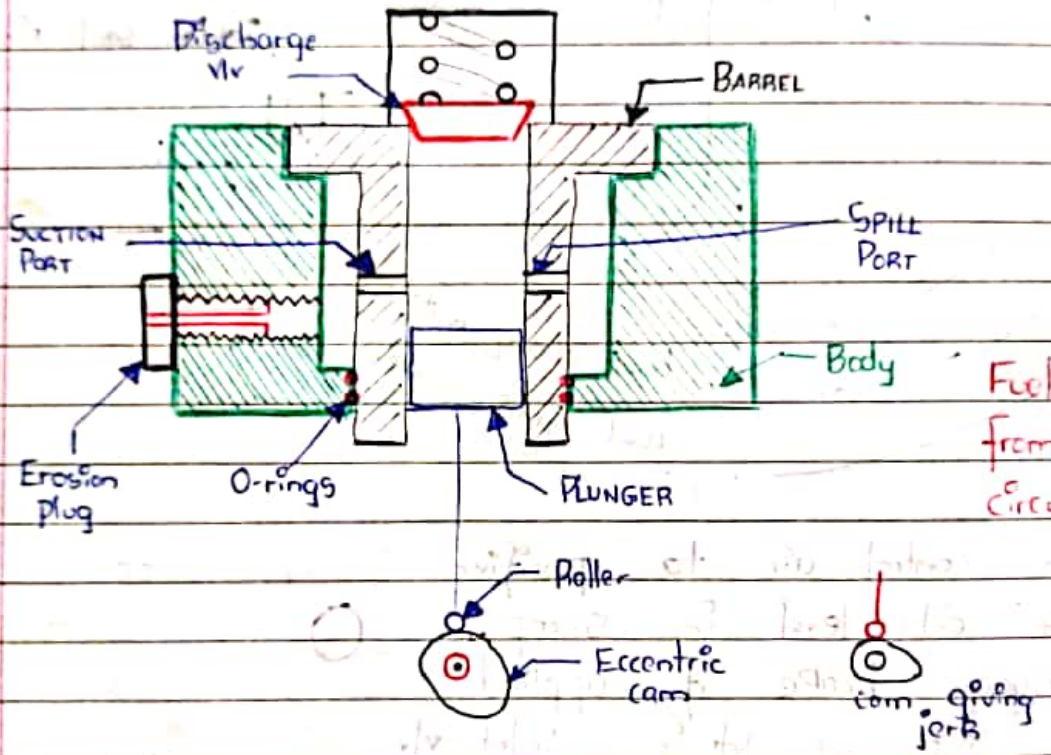
Fuel Pump (+ve disp pump)

Objectives :-

* To increase fuel pr to injection value
* To time fuel injection w r t governor
* To meter fuel injection (quantity)

Jerk Pump



* It consists of a plunger & barrel made of nitride steel, v hard & well polished
* Clearance bet" plunger & barrel about 2~3μ
* Plunger moves up & down with help of roller on eccentric cam (center of rotation & its own geometric center dont coincide)
* In normal condition, spring holds delivery vlv in closed position
* Now when plunger is at bottom, it uncovers the suction port, so oil will enter. now some oil also spills from spill port
* As plunger moves up, at 1 time it will shut top edge of spill port & oil totally stops to ente

* As oil is incompressible, pr will start to build up sufficiently to lift fuel injector against spring pr & inject fuel.
* This pr develops v gradually & pr develops, injector injects. Now as soon as injection begins, pr drops & injection stops.
* But now plunger is still moving up. So again pr builds & injection happens
* Now we dont want this pulse type injection
* Once injection starts, we want continous injection
* We don't want pr to drop as soon as injector opens till it completes injection.
So rate of fall of pr due to injection should be compensated by rate of rise of pr due to the plunger
* Hence we accelerate the plunger movement by giving a Jerk
* This will cause rate of rise of pr by plunger to compensate with rate of fall of pr due to injection & hence fuel injector will remain open till end of injection
* All fuel pumps use jerk type principle

When fuel rack is 0 such that effective delivery stroke is 0 is called 0 setting of fuel pump

Higher load, higher EDS
Lower load, lower EDS

Bosch or Helix control PLP

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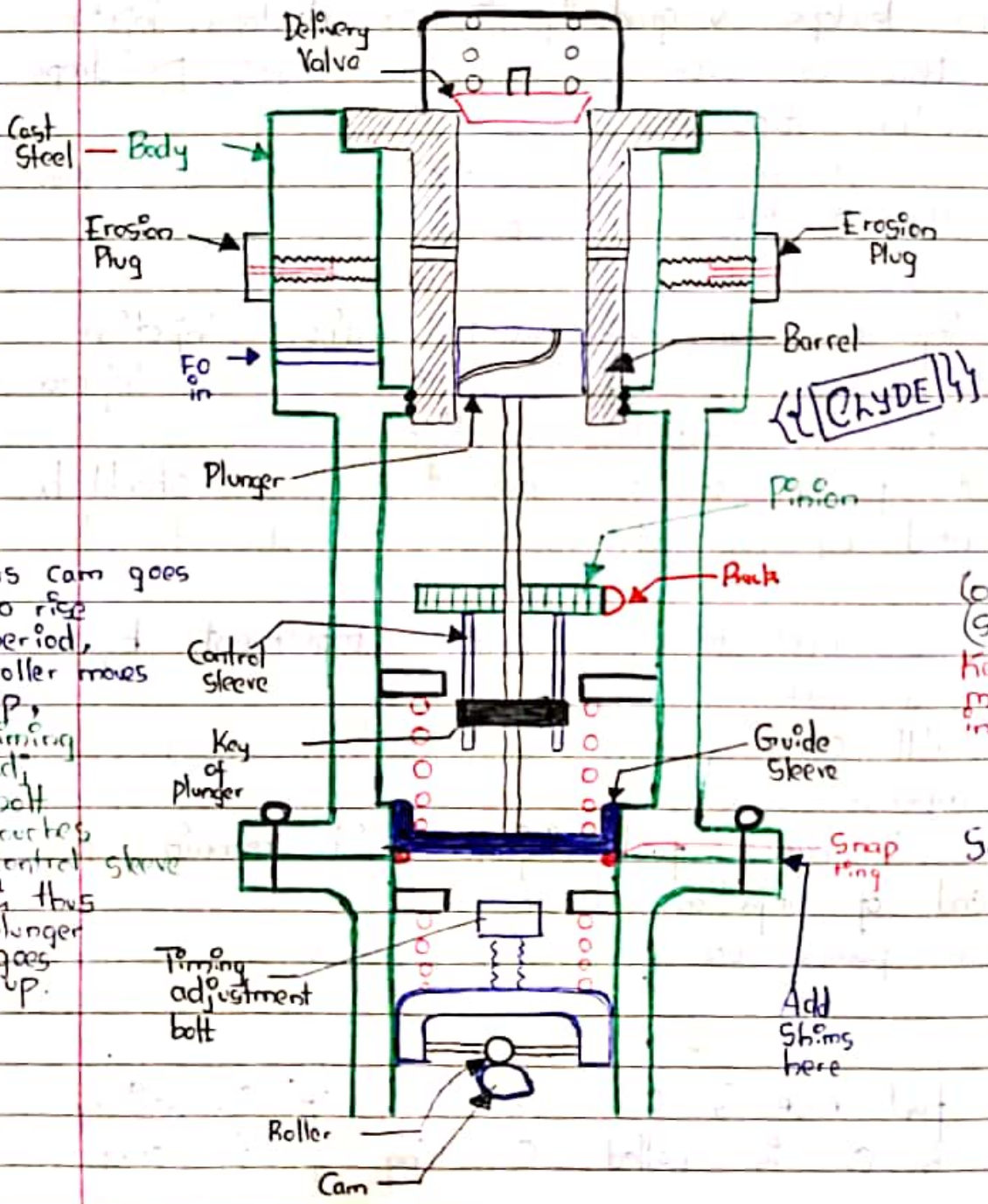
* Fuel pump plunger has helix cut on its surface
* Now plunger is at its bottom most position



As cam goes to rise period, roller moves up, timing adj. bolt pushes control sleeve & thus plunger goes up.

(Control Sleeve (Stationary)
Key of plunger moving up & down in control sleeve

So Pinion rotates
↓
Plunger key rotates
↓
Angle of plunger changes in barrel

* Oil enters & goes on top of plunger. delivery v/v will now be closed
* Now as plunger moves up, timing bolt also moves up with help of cam & roller arrangement

CLYDE

Injection pr - 500~900 bar

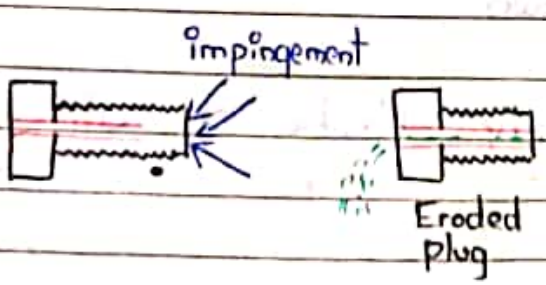
- It will touch guide sleeve & plunger will now start moving up.
- Guide sleeve & plunger are connected to each other
- As plunger moves up & down, key of plunger also moves up & down wrt control sleeve
- As it moves up, a time will come where Top edge of plunger closes top edge of suction port & spill port

Now no more spilling action
This is BEGINING OF INJECTION (constant)

- Now as plunger goes up, a time will come where top of plunger connects spill port via helix cut

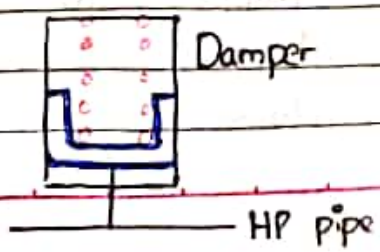
This is END OF INJECTION

- Bet^n BEGINING OF INJECTION & END OF INJECTION is called EFFECTIVE DELIVERY STROKE (depends on load)
- When injection ends, HP oil 1000bar oil comes down to 10 bar, & gradually fuel plp body will get holed
- Hence we use erosion plugs



Erosion plug can be replaced but not fuel pump body.

Also due to sudden change in pr, HP fuel pipe will vibrate enormously, so a damper is provided on suction pipe.



* Here beginning of injection is fixed i.e as soon as plunger covers spill port
* But end of injection depends on direction of helix which can be varied.

* With respect to load, governor will move rack Rack will rotate Pinion As Pinion rotates, control sleeve also rotates & plunger will rotate in barrel & position its helix to spill port.

* As load increases, END OF INJECTION will be more late allowing more fuel to get injected

* Now we can position rack such that, effective delivery stroke will be 0
i.e BEGINING OF INJECTION = END OF INJECTION
THIS IS 0 SETTING OF FUEL P/P

* Snap ring provided such that guide sleeve does not come down

* Effective delivery stroke of all units must be approx equal → we can check this by position of rack

* Now when delivery v/v shuts, HP oil gets trapped in line bet" fuel p/p & injector Now this pr will act on injector & cause secondary injection ← We don't want

Secondary Injection
Cavitation
Side thrust
} drawbacks

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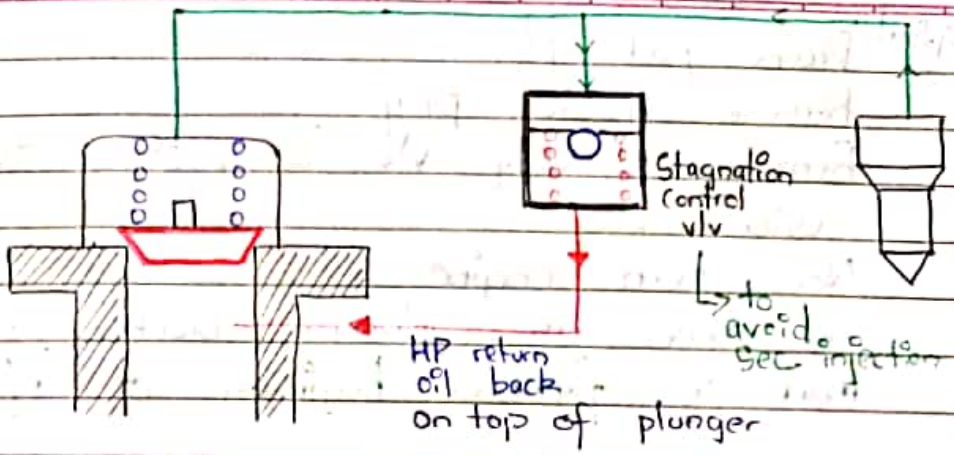

Here secondary injection will be avoid by opening of v/v & sending oil back to spill

Stagnation control v/v → Wartsila engines

Now when delivery v/v closed & piston goes down, it will create vaccum inside causing Cavitation. causing damage

— × — × — × —

To check timing, we can only check BEGINING OF INJECTION as end will vary acc to load.

Method ①
Take out delivery v/v
Connect a pipe at delivery into a bucket
Give some fuel rack
Plunger should be at bottom of barrel.
Now free flow of oil will be in bucket
Turn engine.
Top end of plunger closed top end of suction & oil will stop coming in bucket.
Mark on flywheel as beginning of injection

Method ②
Drain fuel p/p
Remove erosion plug
Remove delivery v/v & put a torch & see from erosion plug
Now turn engine
As soon as plunger blocks all light, mark on flywheel beginning of injection

Method ③
If 2 erosion plugs
Remove both
Put torch from 1 side & see from other
Turn engine
As soon as plunger blocks all light, mark on flywheel beginning of injection

Method ④
Now fuel p/p body may have a cut mark & guide sleeve mark coincides, this is beginning of injection.

To change beginning of injection → due to wear down of roller, cam etc

- If we left timing adjustment bolt, beginning will be early
- If we do opposite, beginning will be late

OR

- If you remove shims, beginning will be early
- If you add shims, beginning will be late

When piston @ TDC, piston speed is 0.
So no use to inject At TDC.
When piston after TDC & injection is done
P_z will drop as rise in P_z will compensate with increase in vol & AFTER BURNING will happen.

→ as piston goes down

At 90°, piston speed will be max
so when piston goes to TDC, injection should happen as volume wont increase but p_z will increase P_{max} increases

But now, according to load, we also want to vary the beginning of injection
So earlier injection, will increase P_{max} & hence efficiency of engine
Altering timing - will reduce fuel consumption
- will increase thermal eff.
This is done by Variable Injection Timing

How to do this?

So the bottom of barrel will be threaded (Acme thread)
There is a sleeve which has inner threads & coincides with threads on barrel.
+ Outside of sleeve, there is a rack (VIT rack)
+ When VIT rack moves, sleeve moves & barrel goes up & down
+ When barrel is lowered, spill port will come down. means plunger will cover the spill port earlier than when barrel was at initial position.
Thus begining will be early

* When barrel is raised, spill port will also go up means plunger will cover spill port late than when barrel was at initial position. Thus begining will be late.

Overhaul Of Fuel Pump

① Remove pump from foundation, stop oil, roller to be on base circle of cam & remove foundation nuts.
② Remove FO HP pipe & take out fuel pump
③ Also disconnect fuel racks
④ Top discharge vlv can be removed easily
⑤ Now take plp to wkshop & invert it to remove all parts.
⑥ Give pr on guide sleeve by drill chuck. This will press it against spring & circlip can be removed
⑦ Now spring, pinion all will come from bottom
⑧ Use ultimate cleanliness to ensure plunger & barrel does not get dirt on its surface
⑨ Barrel is the only one that comes from top

Now put plunger in barrel & put your hand on top of barrel & pull plunger down, you'll feel vaccum on hand this shows plunger barrel clearances are satisfactory.

Clean all parts with diesel, blow with air & clean

Check is helix is worn.
Check condition of erosion plug.

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Q Crankcase Inspection :

* Check the oil for 3 things -
  colour - should not be black
  smell - should not smell of DO, HFO or ammonia
  slimyness
* Check for white metal particles
* Check for any bluish dark patches → Hotspot
* Check if the crank web slip has occured
* Check floating of con rod.
* Check for cranks in bedplate
* Check lock wires or washer for bottom end bolt
* Check crosshead guides & crosshead
* Check the wiremesh in crankcase
* Check the spring of cc relief door

Precautions prior to entry :
- carry out tool box meeting
- risk assessment
- lockout tagout
- signboards
- wear full body PPE
- ventilate & cool down by blower
- ensure lighting is adequate
- ensure LO priming plp off

* Check gear teeth & backlash

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Boiler alarms & trips :

low water level (A)
low low water level (A)(T)
High water level (A)
High high water level (A)(T)
Low feedwater pr (A)
Low fuel oil pr (A)
Low fuel oil temp (A)
High steam pr (A)(T)
Low air pr (A)(T)
Flame failure (A)(T)

Lo Tests onboard :

water content test (1~2%)
comparative viscosity test
TBN test (AE-30 ME-8 cyl oil 50~70)
insoluble content test
pH test (8~10)

① 5ml of oil sample mix with 15ml reagent containing paraffin.
Before closing lid, a sealed sachet of calcium hydride is kept
Close the lid of the digital test meter & shake well.

select correct range

value 1~2% max

② Test done by flowstick which is inclined & compared with fresh oil sample
Take both samples and ensure both are having same temperatures
Add 5ml to 1 reservoir (old oil)
Add 5ml to other reservoir (new oil)

When new oil reaches mid of scale check position of old oil.

If old oil has not reached the mid
↳ viscosity higher
If old oil has passed mid
↳ viscosity lower

③ 10ml of oil sample mix with 50ml reagent TBN.
Shake well
Wait till reading shows

④ Take same oil in beaker
Keep a filter paper on flat surface
Dip acetate rod in oil
First drop let it fall in beaker but let 2nd drop fall on paper.
Allow to dry for 24 hrs
Compare with new oil sample paper

Exhaust v/v

1. How to differentiate bet^n inlet v/v & exhaust v/v?
2. Material of inlet v/v & exh v/v?
3. Material of seat of exh v/v?
4. Why is 2 exh valves on engine?
5. How are valves held in place?
6. what is tappet clearance?
7. When tappet clearance has to be checked?
8. where tappet clearance is checked.
9. What happens if TC more & what are consequences?
10. What happens if TC less & what are consequences?
11. TC to be taken when exh v/v is closed. But how to know?
12. What happens if tappet = 0?
13. What are values for TC for exh v/v & inlet v/v?
14. How does exh v/v rotate? & why? & when?
15. Explain mechanism for v/v to rotate?
16. In 2 stroke, how does the v/v open & close?
17. When & how does v/v rotate?
18. What are the maintenance carried out on exh valve?
19. Valve Maintenance?

Fuel Pump

① Objectives of fuel pump?
② 4 definations
- ↳ Begining of injection
- ↳ End of injection
- ↳ Total stroke
- ↳ Effective stroke

③ Describe Jerk Pump?
④ what is Jerk pump principle?
⑤ what do you mean by o setting of fuel p/p?
⑥ What is material of plunger & barrel?
⑦ What is clearance bet^n plunger & barrel?
⑨ Use of erosion plugs?
⑨ Use of vibration damper?
⑩ Problems with fuel pumps?
⑪ How to check begining of fuel injection?
⑫ How fuel pump timing changes & how to rectify?
⑬ When is best time the inject fuel?
⑭ what is purpose of VIT?
⑮ What is super VIT? How super VIT is controlled? How does barrel move?

Fuel Valve

① What is job of fuel valve?
② Construction & working of 4 stroke injector.
③ How to remove injector from head?
④ Procedures & methods to do fuel injector testing? (4 tests)
⑤ Construction & working of 2 stroke injector.
⑥ What do you mean by O sac vol?
⑦ Explain common rail sys?
⑧ Advantages of common rail sys? & where it is used?
⑨ Fuel sys in electronic MAN & SULZER.

TURBOCHARGER :

1. Difference bet^n supercharger & turbocharger?
2. What is purpose of t/c?
3. Why is inlet to t/c 460°C but outlet 260°C?
4. What is material of turbine blades & how are they filled?
5. What is purpose of shroud ring?
6. What is material of blower?
7. What is purpose of diffuser & inducer?
8. Which bearings are used in turbine & blower?
9. What is Brinelling & where does it happen?
10. How to protect brinelling?
11. Types of t/c based on flow?
12. What is purpose of labyrinth seal? where it is located?
13. Explain t/c dry & wet washing? Why is it required?
14. How often t/c & blower cleaning to be carried out?
15. When does the entire t/c need overhauling?
16. How to know if labyrinth seal leaking?
17. What are 2 types of bearing system used on turbochargers?
18. What is t/c surging? How to know?
19. Reasons for t/c surging?
20. What are methods of turbocharging?

Bearing

① What is load carrying capacity of bearing?
② What is formula for oil film thickness?
③ Explain transient rpm? & internal friction?
④ Explain the different types of lubrication?
⑤ What do you mean by bubble pt?
⑥ What are different properties of bearing?
⑦ What do you mean by fatigue failure?
⑧ What are different types of loading?
⑨ What do you mean by wiping out of bearing?
⑩ Explain bearing geometry?
⑪ What are types of bearing material?
⑫ How are the layers in bearing?
⑬ What is thick shell & thin shell bearing?

General Q & A on fire? IMP

① What do you mean by cc explosion?
② What are causes of hotspots?
③ How to identify a crankcase explosion
④ Actions to be taken?
⑤ What do you mean by scavenge fire?
⑥ What are causes of scavenge fire?
⑦ Actions to be taken?
⑧ What is starting air line explosion?
⑨ How to prevent it?
⑩ Actions when START air v/v leaking?
⑪ Actions when bursting disc bursts → manoeuvring?
⑫ How to test start air v/v leaking?
⑬ SOLAS req for fitting cc relief v/v & OMD?