IC ENGINE

An engine is a device which transforms one form of energy into another usable form.

An engine in which combustion occurs inside the body of the engine itself, such an engine is knows as Internal Combustion Engine (IC Engine). Engines used in automobiles is an example of IC engine.

Basic Engine Components:

• Valves – These are just like doors of cylinder. If mass is to enter in or exit out, they open to facilitate the same. There are two types of valves –
a. Inlet/Intake – Used for entering air-fuel mixture (or air) inside the cylinder
b. Outlet/Exhaust – Used for exhausting combustion product from the cylinder

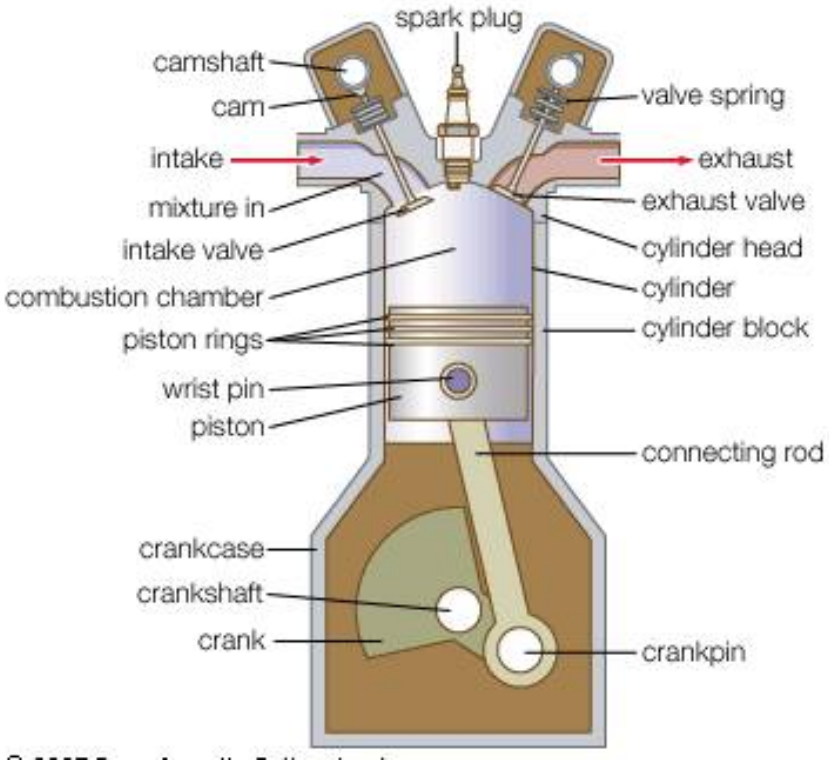
Valves are controlled by cam mechanism using camshafts.

• The rod connecting crank with piston is connecting rod

• Pay attention to the two pins mentioned in the image. One is crankpin and another is wrist pin. Wrist pin in also known as gudgeon pin

• Crankshaft – The reciprocating motion of the piston is converted to rotation of crankshaft which further drives wheel

There are more things to be discussed which will be discussed shortly.



Some important nomenclature:

1. Cylinder Bore (d) – Inner diameter of cylinder

2. Piston area (A) – Area of circle whose diameter is equal to the cylinder bore

3. Stroke (L) – Distance through which a working piston moves.

4. Top Dead Centre (TDC) – Farthest position of piston from crank

5. Bottom Dead Centre (BDC) – Closest position of piston from crank

6. Stroke volume/ Displacement volume / Swept volume / Working volume – This is the volume of cylinder swept between TDC and BDC by the piston.

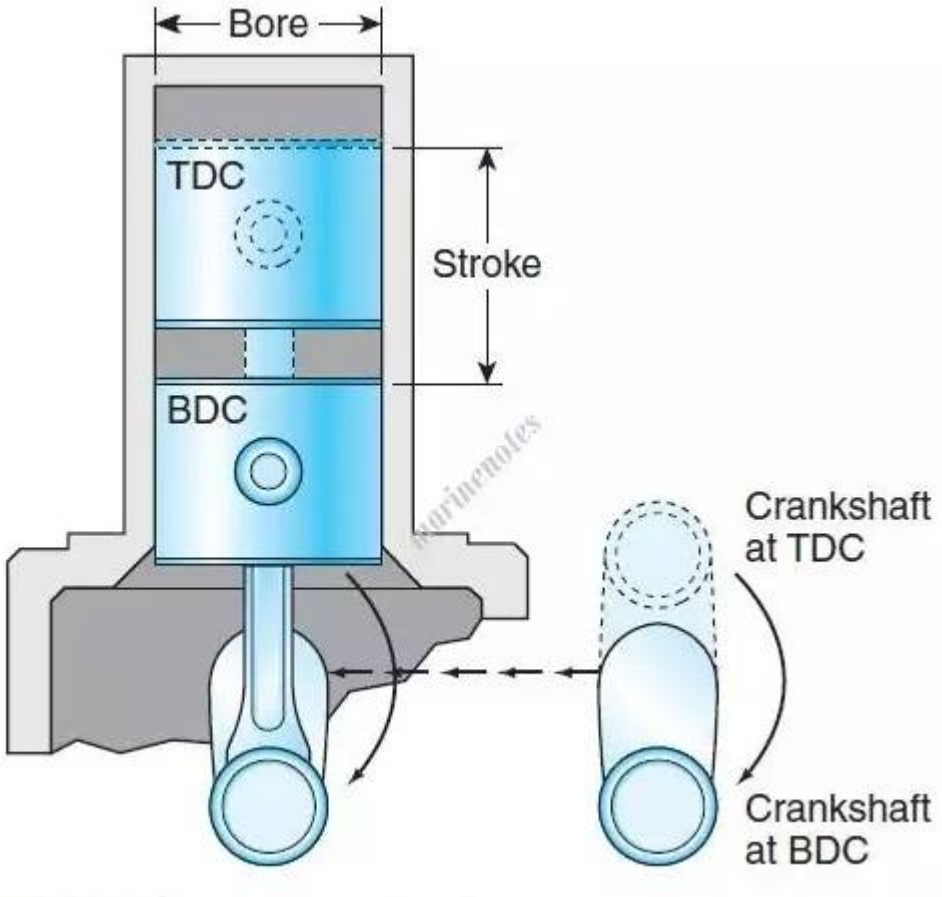
7. Cubic capacity of engine – It is the maximum volume that the engine can sweep. It is equal to
(swept volume by one cylinder * number of cylinders). You might have heard that a bike is of 150 cc. This is nothing by Cubic Capacity of engine which is telling that the engine can sweep 150 cm^3 of volume in one stroke.

8. Clearance volume – I am sure till now all of you are aware of it. It is the volume of cylinder above TDC.

9. Compression Ratio = Total Cylinder Volume /Clearance volume = (Vs + Vc) / Vc = 1 + (Vs/Vc)

Doubt : sir cubic capacity me clearance vol included hai?

Ans: No. Only swept volume



Stroke to bore ratio (L/d ratio):

- If d < L, engine is an 'under-squared' engine
- If d > L, engine is an 'over-squared' engine
- If d = L, engine is a 'square' engine

You might get a term like this in numerical where you have to realize that this is actually talking about the ratio of L to d.

Doubt: what is physical meaning of these terms undersquared / oversquared/squared engine

Ans : the shape of combustion chamber. When it looks like square, when bigger than a square and when small than a square for a given stroke.

...so its all about shape of certain type of engine...

There are many divisions of IC engine.
First division is on the basis of stroke which gives us 2- and 4- stroke engines
Second on the basis of combustion method which gives us SI and CI engines.

We will see two small videos to cover these concepts.

1. Watch this 3 minute video to see how four stroke engine works. Very lucidly explained:
https://www.youtube.com/watch?v=UjcIJJnpprs

2. Watch this 4 minute video to understand the difference between the CI and SI engines.: https://www.youtube.com/watch?v=bZUoLo5t7kg

You might have noticed that out of 4 strokes, 2 strokes are unproductive in 4-stroke engines: suction and exhaust. So a 2-stroke engine, cut down these strokes and merge them with the other two.

Hence, there is a power stroke in each cycle.

Theoretically, power developed by them is twice than that of 4 stroke for same speed of crankshaft

The total energy liberated by combustion of a substance is known as its calorific value (CV).

Higher the calorific value, more will be the energy released on combustion of the substance. Clearly, the chemicals used for combustion (petrol and diesel) have to have high CV.

First Law analysis of Engine Cycles:

• The heat liberated from combustion cannot be totally utilized for driving the piston as there will be some losses through:

1. engine exhaust
2. to coolant
3. due to radiation

• Due to these losses, are the energy liberated cannot be used in driving the piston. Right?

The energy of combustion which piston receives after some losses is known as INDICATED POWER.

• The power with which the piston moves will not be completely transferred to crankshaft because there will be friction between various pins and mechanicals parts. So, this will also cause some of the piston energy to lose. The sum of all such mechanical power losses is known as FRICTIONAL POWER.

• The energy with which crankshaft rotates now is INDICATED POWER – FRICTIONAL POWER. This is known as BRAKE POWER.

I am sure you have done Brake Power test in college laboratories where a rope was used around a rotating shaft to determine brake power.

Keep in mind that ANY power rating given on a machine is its brake power. This concept will be used in numericals.

$$\text{B.P.} = \frac{2\pi NT}{60 \times 1000} \text{ kW}$$

Indicated power can be expressed as

imep is the mean effective pressure acting on the piston acting on piston due to gas pressure.

Note the variation as N and N/2 for two and four stroke engines.

$$ip = \frac{(imep)LAnK}{60 \times 1000}$$

where, ip = indicated power (kW)
imep = indicated mean effective pressure (kN/m^2)
L = length of stroke (m)
A = cross-sectional area of piston (m^2)
n = number of power strokes
n=N/2 for four strokes, and n=N for two-strokes
N = crankshaft speed (revolutions per minute)
and K = number of cylinders

In 4 stroke, power is produced in 2 cycles.
in 2 stroke, in each cycle.

So, N/2 and N

The ratio of B.P. to I.P. is called *mechanical efficiency*

$$\textit{Mechanical efficiency},\ \eta_{mech.} = \frac{B.P.}{I.P.}$$

Specific Fuel Consumption (sfc)–

Mass flow rate of fuel being consumed divided by power.

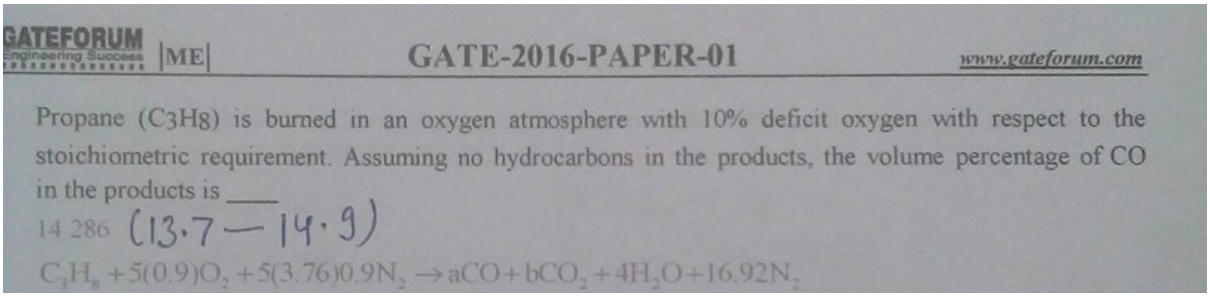
Depending upon which power it is: Brake power or Indicated power, sfc can be Brake Specific Fuel Consumption (bsfc) or Indicated Specific Fuel Consumption (isfc)

sfc tells how much fuel is being burned per unit time to produce a given power. A lesser value of sfc is desirable.

(mass flow rate * CV) gives total power being produced by burning fuel. It is the total energy available in the beginning. Hoe much efficiently this energy is getting utilized further tells us the thermal efficiency.

Indicated thermal efficiency = IP / mass flow rate*CV

Brake thermal efficiency = BP / mass flow rate*CV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Propane (C_3H_8) is burned in an oxygen atmosphere with 10% deficit oxygen with respect to the stoichiometric requirement. Assuming no hydrocarbons in the products, the volume percentage of CO in the products is ___

14 286 (13.7 — 14.9)

$C_3H_8 + 5(0.9)O_2 + 5(3.76)0.9N_2 \rightarrow aCO + bCO_2 + 4H_2O + 16.92N_2$

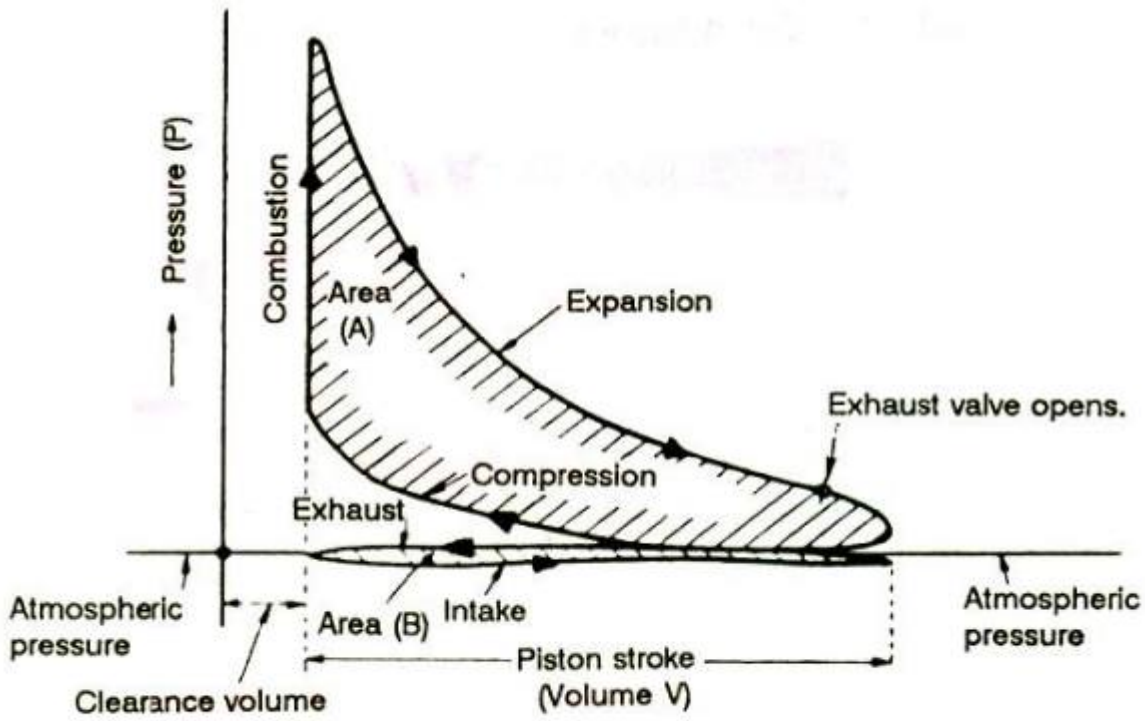
Bacis combustion equation ka idea rkhna hoga ki kya kya products form hote h

Fir toh bs number of atoms count krne hh

Relative Efficiency = Actual thermal efficiency / Air-standard efficiency

• Mean Effective Pressure (MEP) = The pressure on the piston inside the cylinder is continuously changing with the different strokes. MEP is the mean value of that pressure.

• Indicator diagram – It is the graph between pressure inside the cylinder and its volume. Shown in the image attached.



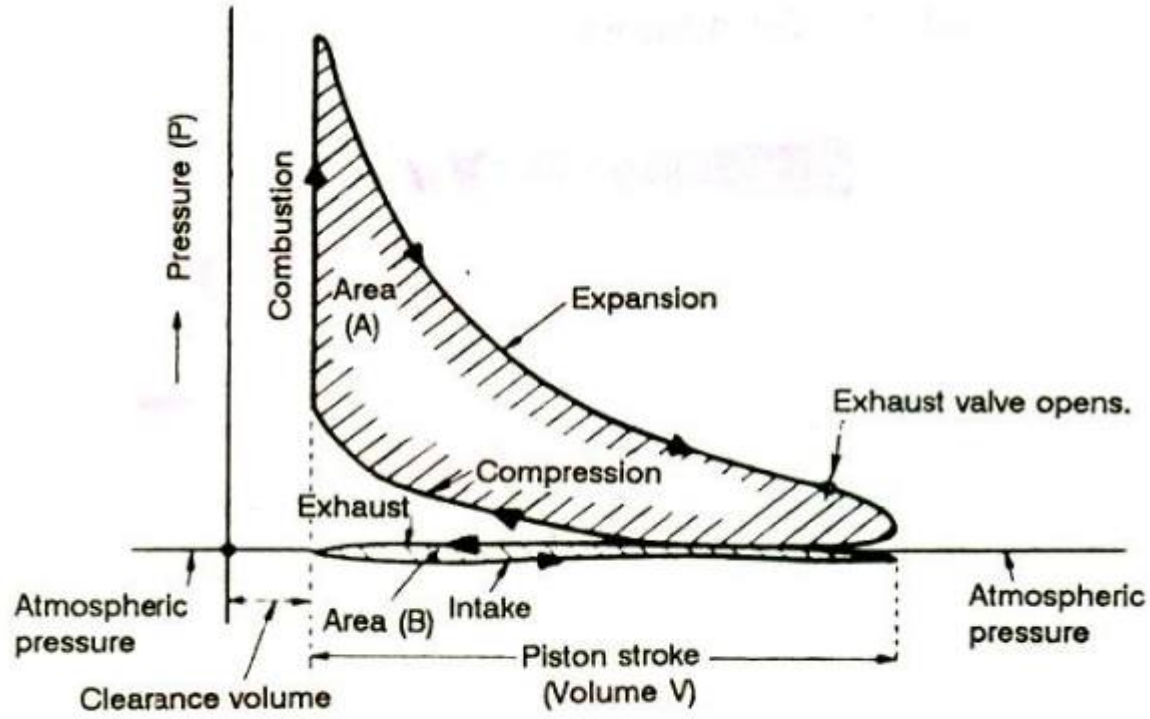
Aise fig.ka workdone kaise niklega

Ye actual cycle h. Work done ideal cycle se nikalte h. Which is Otto or Diesel. Revision kr rhe ho na?

• MEP = Area of indicator diagram / Length of the indicator diagram

• Note that area of pv is work and length of dia is the stroke volume.

• Engines of different cylinder dimensions, power and speed are compared in the basis of Mean Effective Pressure only.



Mean piston speed = 2LN
where L = stroke and N is speed in rpm

• Specific Power Output = Brake power/Piston area. It tells how effective the piston is in absorbing and forwarding power.

Ye kaunsa formulae hai . Mean speed ka unit kya hoga is formular k according

length ki jo unit ho divided by minute agar rpm me h toh

rps me toh length ki unit / sec

Fuel-Air Ratio: Relative proportion in which fuel and air are mixed is very important. It determines how the combustion will occur.

We know that combustion is governed by a chemical reaction. A mixture of fuel and air that contains just enough air for complete combustion of all the fuel in the mixture is called a chemically correct or stoichiometric fuel-air ratio. I am sure you have studied stoichiometry in class 11th.

A mixture having more fuel (or less air) than stoichiometric ratio is Rich Mixture.
A mixture having less fuel (or more air) than stoichiometric ratio is Lean Mixture.

For most hydrocarbon fuels, stoichiometric air : fuel ratio is around 15:1.

Be very cautious whether Fuel-Air ratio or Air-Fuel ratio is asked. Air-Fuel ratio will be reciprocal of Fuel- Air.

15:1 stoichiometric ratio hai? .yes

Air fuel ratio is always <1

>1

More air is req

Equivalence Ratio ϕ :

• The equivalence ratio is defined as the ratio of the actual fuel/air ratio to the stoichiometric fuel/air ratio.

• Note that it is Fuel-air ratio not air-Fuel.

The volumetric efficiency of SI is _____ (more/less) than CI.

compression ratio is more in CI so vol eff of SI should be more??????

It was pressure ratio not compression ratio. Compression Ratio is high since it has to reach that T with spark. SI is doing that with spark.
ANS . LESS

Reason is that in volumetric efficiency it is the volume of just AIR which is considered. In CI, there is only air being sucked. Bu in SI, there is fuel too with air

Volumetric efficiency last event me kraya toh h.
Total air in / Total swept volume

Actual/ Swept vol

Swept toh fixed h.
Actual kitni air enter hui wo numerator me h

Agr fuel b aa rha air k sath utne h volume me toh air kam aygi na

Low speed require rich mixture since at low speeds, the exhaust gases after combustion are not pushed effectively and they mix with fresh charge (air fuel mixture) coming from inlet. The presence of these exhaust gases obstruct the contact of fuel and air particles which is necessary for combustion. So, poor combustion occurs. To balance this, more fuel is added and mixture is made rich.

You might have noticed that in the speedometers, there is a range of speed shown with ‘economy’ written on it. Range centered at 40 kmph. This is because least fuel is consumed in that range. That is cruising range.

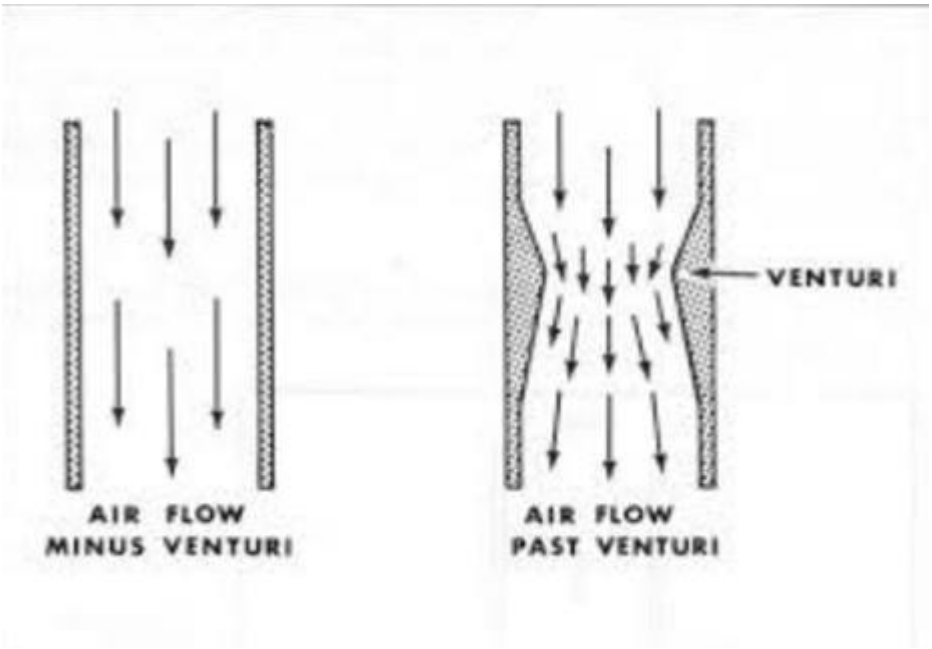
reason kya hai least fuel k liye?

sab kehte hai greater the speed less the fuel consumption

Power Range consumes rich mixture. Kabhi petrol kam ho petrol pump na mil rha ho toh 40 ki speed me chalana, sbse door tk ja paoge

Carburetor works on the principle of Ventri

If area along a flow decreases, speed increases. If speed increases, pressure decreases. So if there is a pipe connected to the section where are is minimum, it will such fluid on the other end of the pipe.



. wo wala last line samajh nahi aaya?

Suppose that there is a pipe connected to the throat. On the other end of pipe, there is fuel, so fuel will get sucked into the throat since pressure at throat is less. Got it?

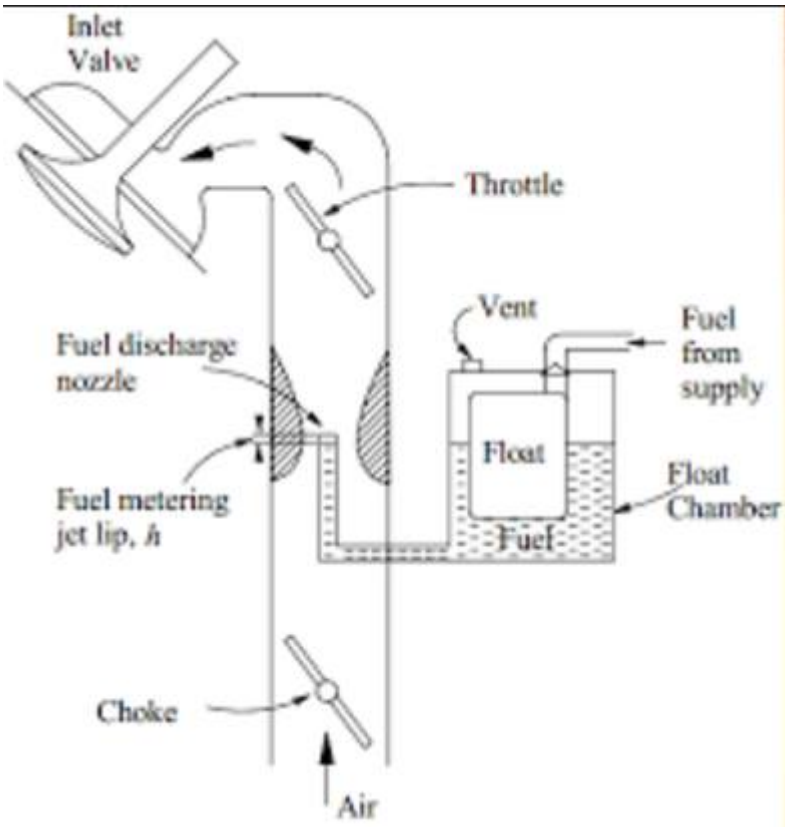
FM concept? Yes

The fuel will be sucked by the smallest area (throat) and it will mix with incoming air.

There is one disadvantage with this. Higher the speed, more will be the suction, richer will be the mixture. Means as the speed will keep on increasing, mixture will keep getting richer. But I may want a different mixture. For example, while driving on hills, I need a richer mixture at comparatively lower speeds. What to do then?

This is done using valves.

See next post



When choke valve is closed, it means it is obstructing the flow (see image in #12).

When it is open, it is parallel to the flow and not obstructing.

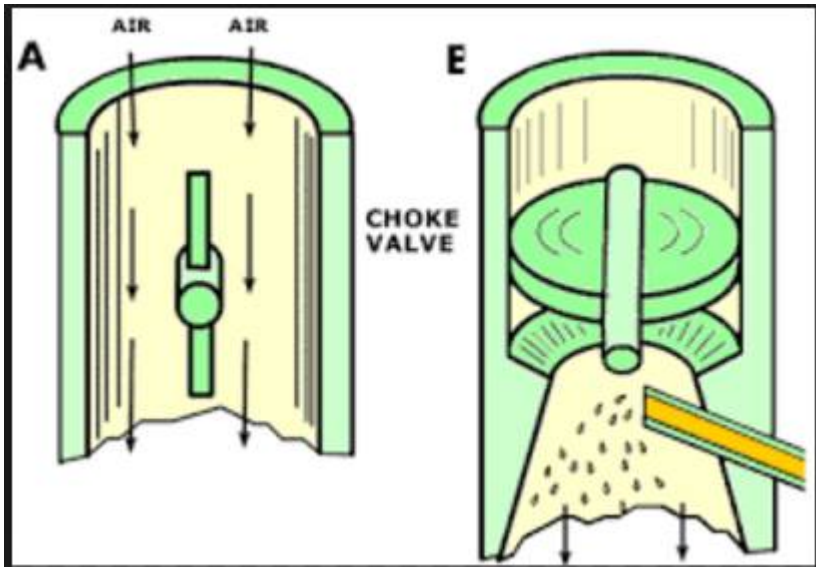
So if you close choke, large pressure drop will occurs (blunt body in a flow), so more fuel will be sucked at same speed. Remember you give choke when bike does not start in winter mornings?

Note that in general language you might say open the choke in winter morning, but what you are actually doing it that you are closing it. 😛:P

> choke close krne pe pressure drop kyu ho rha h sir?
>
> kyunki flow obstruct ho rha.

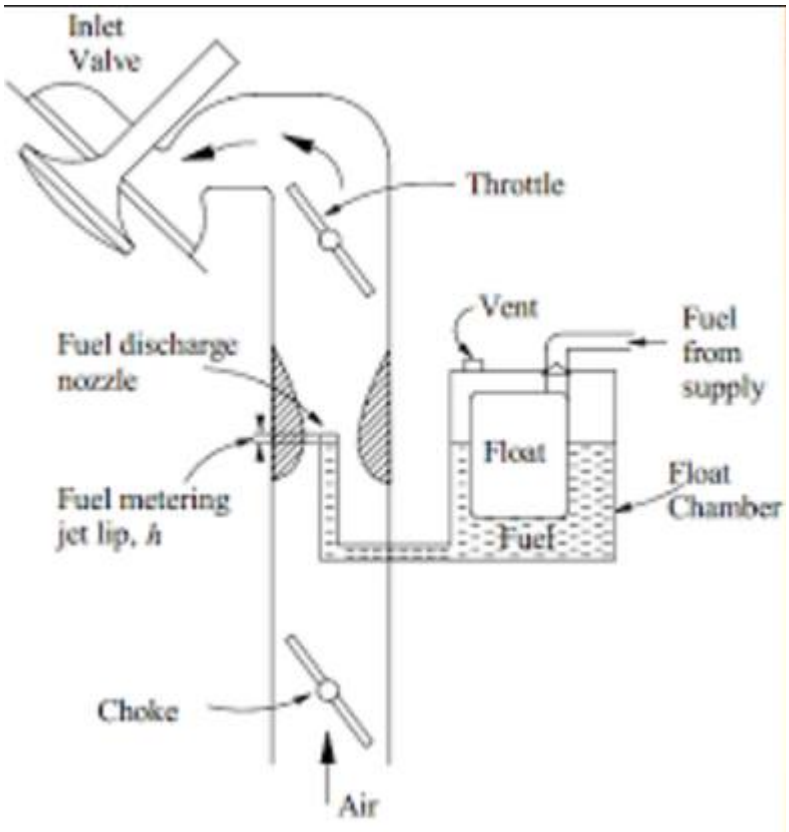
Left shows open choke valve, right shows closed.

Large the obstruction, more the pressure head loss. FM ka concept



> Flow kiska obstruct ho rha hai

air flowing towards inlet



Throttle valve is used to control how much mass enters the cylinder. It is controlled by Governors. Function of governor is to increase / decrease the amount of mixture entering the cylinder.