ON –LINE LECTURE

Course Code : FMPE-2.4.4

Course Title : Tractor and Automotive Engines

Topic : Fuel Properties and Fuel System

for

B. Tech Students of CAET Godhra

Semester: 4th

By

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Fuel Properties

- For satisfactory operation , diesel must satisfy following requirement

1. It must ignite readily and burn evenly.
2. It should have low viscosity- for atomization at nozzle holes.
3. It must have lubrication qualities.
4. It should have minimum foreign materials.

➢ Important fuel Properties

1. Heat value or Calorific value
2. Specific gravity
3. Volatility
4. Flash point
5. Fire point
6. Pour point
7. Viscosity
8. Octane number
9. Cetane number
10. Carbon residue
11. Sulphur content
12. Gum content

1. Heat value or Calorific value

- **It is the indicative of heat energy being produced by the fuel when it is burnt inside the cylinder/combustion chamber of an engine.**
- **It is expressed in J/kg of fuel and is measured in the device which is known as calorimeter.**
- **The impurities in the fuel leads to decrease in its heat value.**

2. Specific gravity

- **It is expressed as the ratio of the density of fuel to the density of water.**
- **The specific gravity affects the fuel atomization in the nozzles and spray penetration/injection in the engine cylinder/combustion chamber.**
- **Fuels which are relatively heavier have usually greater heat value.**
- **The specific gravity is measured by the hydrometer.**

3. Volatility

- **The readiness with which a liquid changes to a vapour is known as volatility of the liquid.**
- **It is the property of the fuel to get converted into vapours on burning at a specific temperature.**
- **The volatility is measured by means of distillation.**
- **In diesel fuel, volatility is indicated by 90% distillation temperature (temperature at which 90% of the fuel is distilled off).**
- **The lower this temperature, the higher the volatility of the diesel fuel.**
- **Lower volatility in fuels leads to increase in carbon deposits, smoke content and also wear of engine components.**

4. Flash point

- **It is the temperature at which the fuel must be heated to get flammable vapours and is driven off to ignite when brought into contact with the flame.**

5. Fire point

- **It is the higher temperature at which the vapours will continue to burn after being ignited.**
- **Generally, the fire point is 10^0 to 21^0 C higher than the flash point and it is the indicator of fire hazards.**
- **The lower the flash point, the greater is the fire hazard. In general, the flash point should be high enough to avoid producing flammable vapours.**

6. Pour point

- **It is the temperature at which the fuel becomes insoluble to prevent flow under specified conditions.**
- **A higher pour point implies that in cold weather the fuel will not flow easily through the filters and fuel system and also the atomization/spray characteristics are affected.**

7. Viscosity

- **It is the property of fluid/liquid that resists the force which makes the liquid/fluid to flow.**
- **It is measured by the instrument known as viscometer in which the time required by certain volume of fluid to flow is measured under stated conditions.**
- **It affects the spray pattern of fuel in the combustion chamber. Low viscosity produces a fine mist, whereas high viscosity leads to coarse atomization.**

8. Octane number

- It is a standard used for determining the knock characteristics of fuels (petrol).
- It refers to the percentage by volume of iso-octane (C8H18) in a mixture of iso-octane and normal heptane (C7H16).
- Fuel knock is prevented by the fuel's ability not to self ignite in the combustion process.

9. Cetane number

- The percentage of cetane in a mixture of cetane ($C_{16}H_{34}$) and α (alpha) methyl naphthalene ($C_{11}H_{16}$) is called cetane number.
- It is the measure of fuel property in which it is measured that how easily and fast the fuel (diesel) is ignited when reaches into the engine combustion chamber/cylinder.
- The commercial diesel fuels have got cetane varying from 30 to 60.

10. Carbon residue

- **Carbon residue refers to matter left after combustion in combustion chamber when the fuel is burnt in the engine combustion chamber/cylinder.**
- **It varies from 0.15 to 0.35% on weight basis and its permissible limit depends upon the engine characteristics.**
- **It should not exceed 0.22 to 0.25 % of the sample by weight.**

11. Gum content

- **Gum in the fuels is formed by the polymerization of some unsaturated hydrocarbons.**
- **To have good quality of fuel, the gum content should be minimum.**

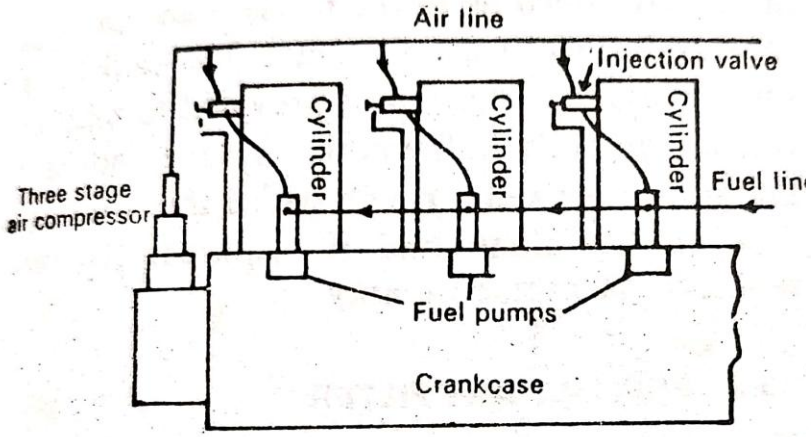
12. Sulphur content

- **The presence of sulphur in high quantity in the fuel is not desirable as it increases the wear of engine components specifically, the piston rings and the cylinder walls.**
- **It also causes the formation of hard coatings on the piston and oil sludge in the engine crankcase.**
- **The sulphur in fuel after burning combines with the water to form corrosive acids which further damages the finished surfaces.**
- **Sulphur content varies from 0.5 to 2% on weight basis.**
- **It should not exceed 1% of the sample by weight.**

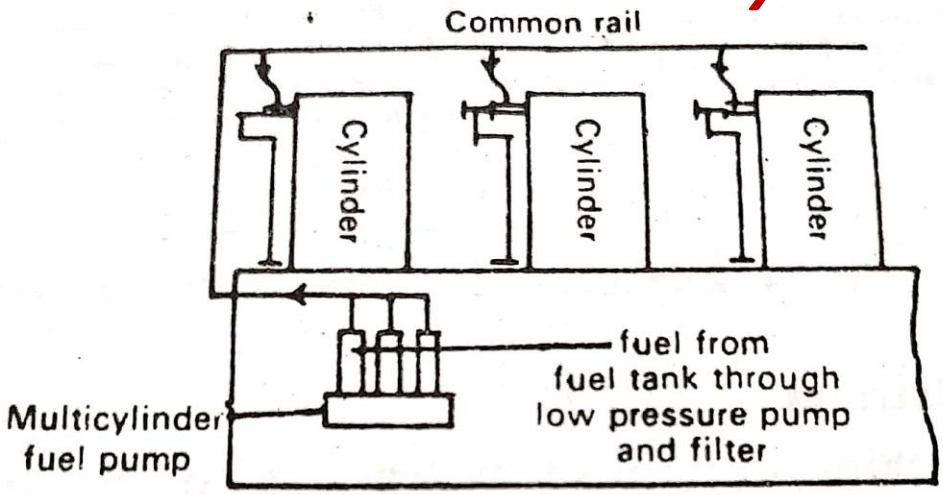
➢ System of fuel Injection

- **Two Types** 1. Air injection system
  2. Airless or solid injection system
- **Airless or solid injection system is again classified as** 1. Common Rail system
  2. Jerk pump or timed pump system
  3. Distributor system

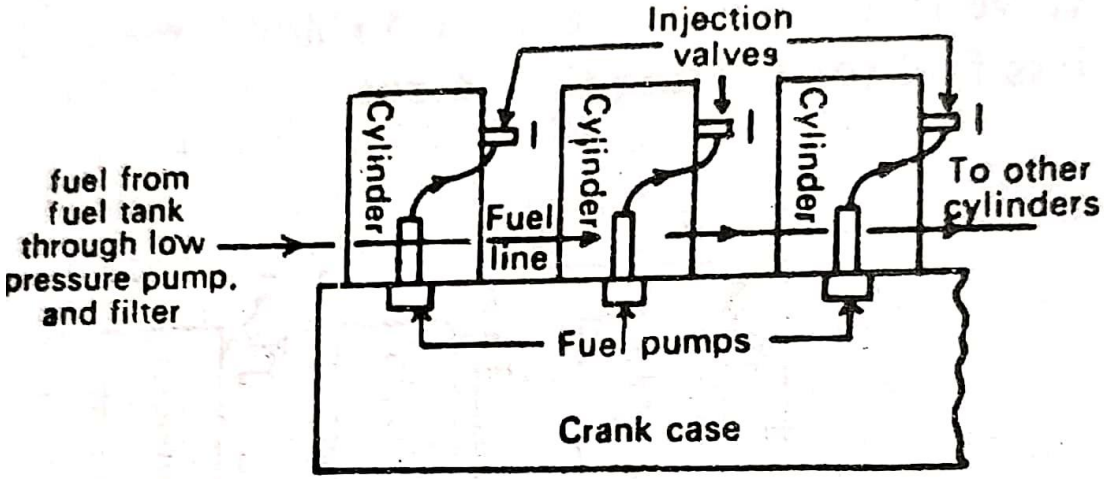
➢Systems of fuel Injection



Air injection system

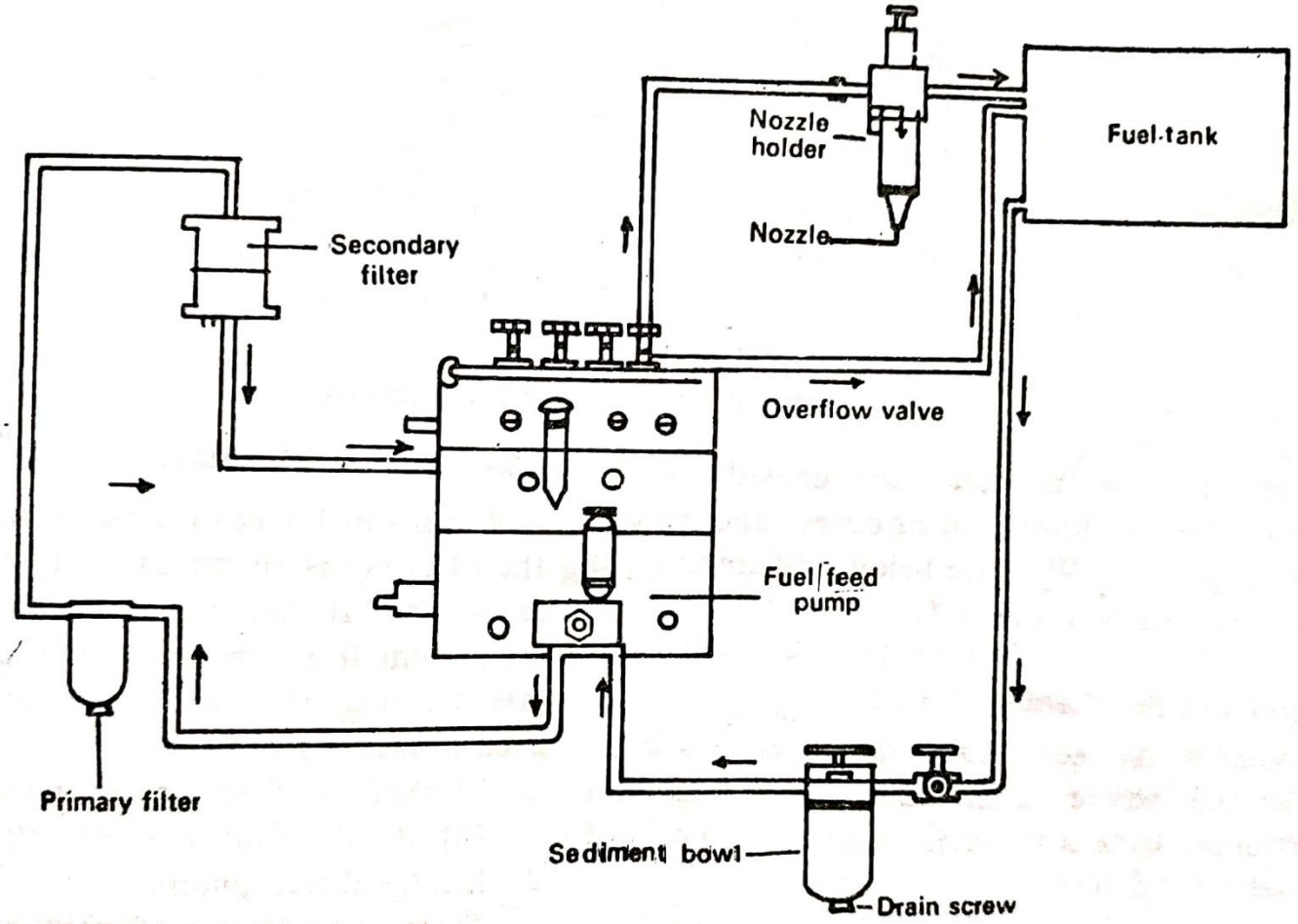


Solid injection – common rail system



Solid injection – individual pump system

Major parts of diesel fuel system (inline pump)



➢ Fuel Tank :

- **Fuel tank is usually made up of metal (MS Sheet) or fibre sheet having anti rust and better heat and shock resistant properties.**
- **Fuel tank should prevent fuel to get contaminated with dust, water or any other foreign material.**
- **It should have sufficient capacity to store the for about 10 hours.**
- **The tank cap is provided with pin hole to maintain atmospheric pressure inside the tank.**
- **At the bottom drain cock is provided as outlet of fuel.**

➢ Preliminary Filter :

- **Mounted anywhere between fuel tank and fuel feed pump**
- **It is also called sediment bowl assembly.**
- **It consist of glass bulb with a wire guage filter.**
- **Function is to prevent dust and foreign materials from reaching the filter.**

➢ Fuel Oil Filter

- Fuel filters are provided to remove the impurities (water or dust) from the fuel while flowing from tank to reach fuel injection pump.
- It consist of bowl, filter element, head or cover and rubber gasket.
- Two stage system: Primary Fuel Filter and secondary filter

✓ Primary Fuel Filter :

- It is usually made of wire mesh.
- It is used for removing water and the coarse particles of dust. It is attached to the fuel feed pump.

✓ Secondary Fuel Filter :

- It is usually made fine pores material like cloth and paper.
- It is used for removing the fine particles and abrasive material in the fuel.

➢ Fuel feed pump

- The fuel comes from the fuel tank to the fuel feed pump which makes it to reach fuel injection pump after traveling through primary and secondary fuel filters.
- It is also known as transfer pump or lift pump.
- It maintain the fuel pressure in the system at sufficiently high level.
- The types used in tractor are :

  1. Mechanical feed pump : It include Diaphragm type, Gear type, Vane type and

     Plunger type

  2. Electrical type: it include vacuum and pressure type

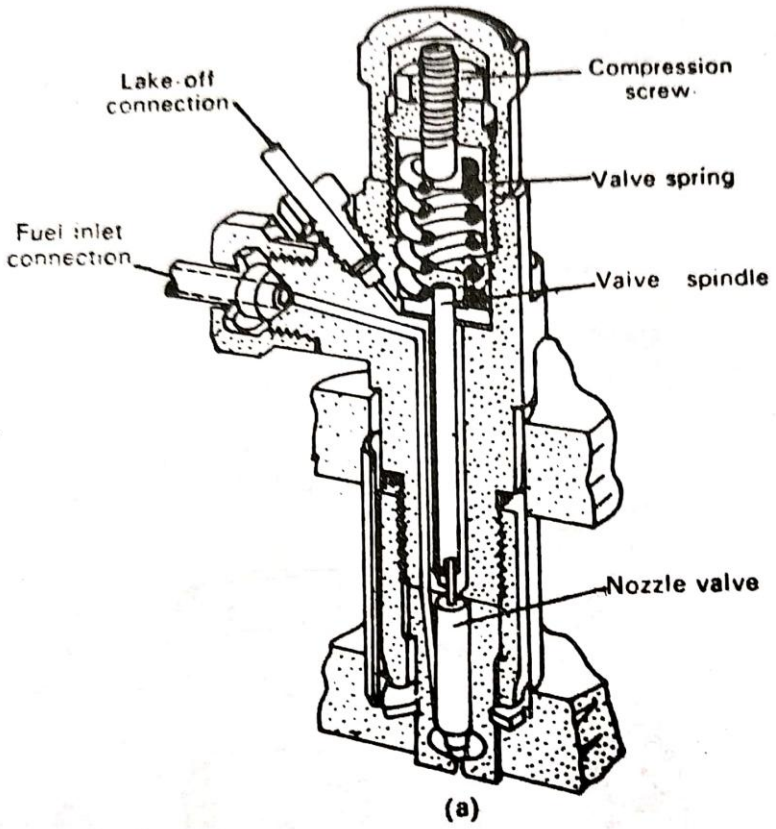
➢ **The hand priming device:** the function of the pump is to to feed the fuel from the tank to the filter or FI pump before starting the engine or to bleed the air of the system.

➢ Fuel Injection Pump

- **The fuel injection pump is used to deliver an accurate and metered quantity of fuel under high pressure, at the correct instant (time) and in the correct sequence (as per firing order) , to the injector fitted on each engine cylinder.**
- **The injection pressures generally varies in the range from 7 to 30 MPa and can be exceptional high as 200 MPa.**
- **The fuel injection pump is driven by timing gears and is controlled by the operator through hand or foot accelerator in a tractor.**
- **These fuel injection pumps are designed and manufactured with high precision as these are used for metering very low volume of fuel and very high frequency of injection**
- **The fuel injection pumps are generally of jerk pump type. However, in many cases, distributor type pumps are also used.**

➢ Injector

- It is the device by which fuel is injected into the combustion chamber.
- It is also known as atomizer or sprayer
- The fuel passes from FI pump to the Injector through delivery valve and pipe.
- At the end of the injector there is nozzle through which the fuel is sprayed in the form of a mist into the cylinder.
- The main parts of the injector are Nozzle, cap nut, spindle, holder body, compression spring, adjusting screw, leak off pipe and fuel inlet.

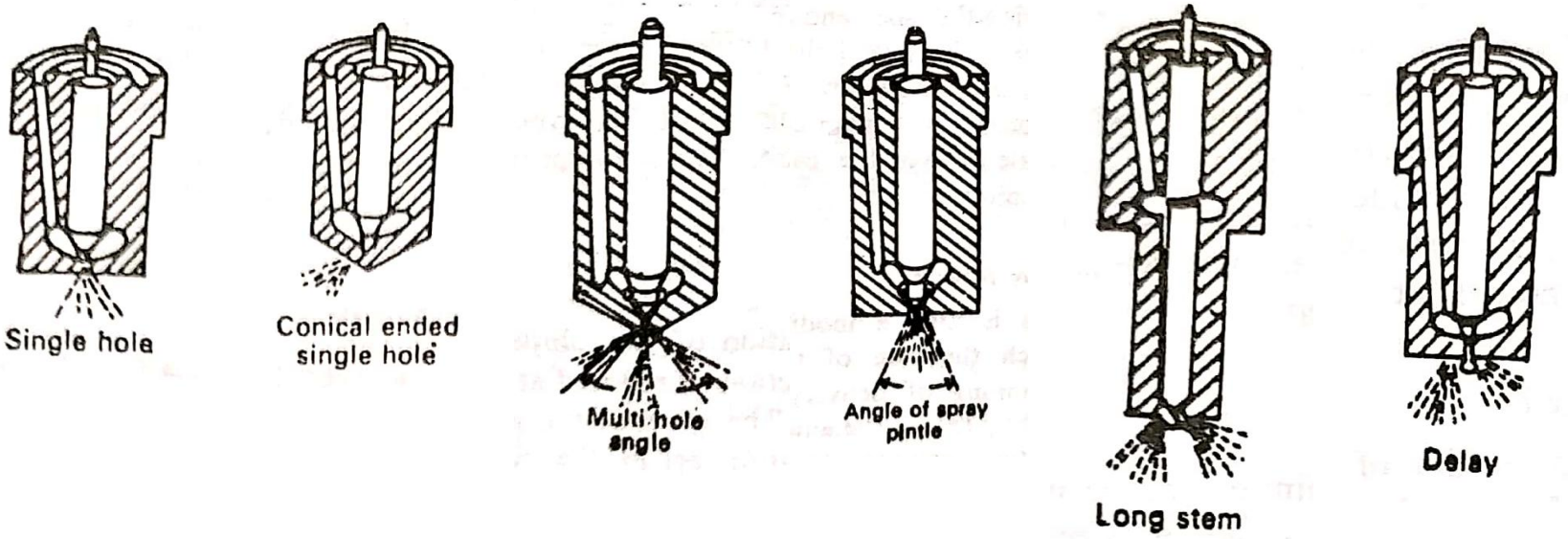


➢ Fuel nozzles

- These are also known as injectors, atomizers or fuel valves.
- Nozzles are used to inject the fuel in the combustion chamber/cylinder in a desired atomized form and in exact quantity on exact time.
- It convert the pressure energy of the fuel to the kinetic energy by passing it through the orifice of the nozzle outlet.
- Generally, replaceable nozzles are provided with screw caps to ease the change of nozzle whenever required.
- The nozzle body and nozzle tip (needle) is made from high grade steel which can withstand at high temperature in combustion chamber.
- **Operation of fuel Nozzle:**
- A spring-loaded spindle is used to keep the nozzle valve pressed against its seat in the nozzle body.
- As the fuel is supplied by fuel injection pump with sufficient pressure to lift the nozzle valve against the spring force, then a spray of atomized fuel is fed into the combustion chamber.
- The fuel spray continues till the nozzle valve closes back on its seat.
- The pressure at which the nozzle valve opens is adjusted by a screw provided at the top of nozzle.

➢ Types of Nozzle:

1. **Hole type: single hole, multi hole and long stem**
2. **Pintle type nozzles: Pintle and delay type and**
3. **Circumferential or disc type.**



- **Hole type nozzles are the most commonly used in engines having open type combustion chambers, whereas pintle type nozzles are common in engines with pre-combustion chambers and some special swirl chambers.**
- **The pintle type nozzles carry an extension, which produces a hollow cone type spray. Such nozzles have the advantage of being self-cleaning.**
- **The opening pressure of hole type nozzles varies from 17 to 34 MPa, whereas that of pintle type nozzles varies from 7 to 15 MPa.**

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➢ Carburetor

- **Carburetor is the device which works on Bernoulli's Principle and is used in petrol engines to controls the amount of atomized fuel and air in the air fuel mixture to be supplied to engine combustion chamber.**
- **Carburetor is provided with the throat in which the air stream flows. The velocity of air is more in the throat as compared to velocity at the entrance and this high velocity reduces the pressure inside the throat which makes the fuel to enter in the throat due to pressure difference and gets mixed with the air stream.**
- **Under all conditions, the engine carburetor must perform the following:**

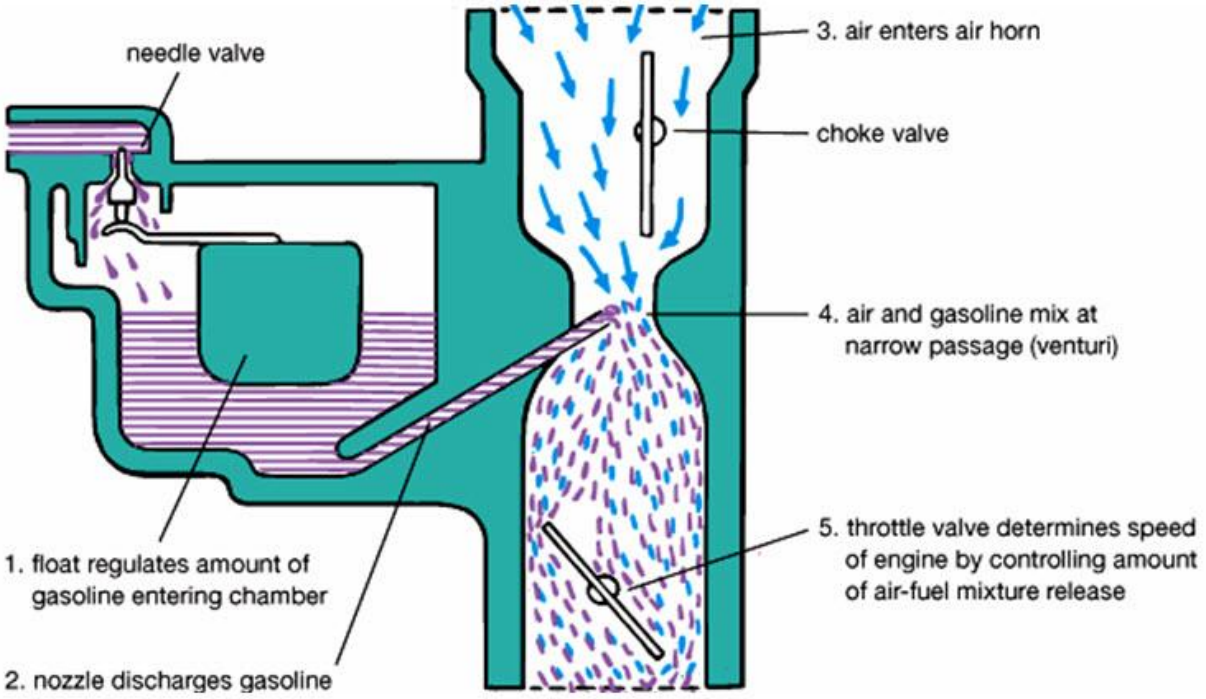
  1. Regulate the airflow in the engine

  2. Supply the required amount of fuel to maintain the level of fuel/air mixture

  3. Prepare the exact fuel and air mixture

➢ Following are the components of carburetor :

- Float chamber and float
- Venturi
- Nozzle
- Throttle valve
- Fuel jet
- Choke



- **Carburetor can be of following three types on the basis of direction of air-fuel mixture is supplied :**

  i) Up-Drought

  ii) Down-Drought

  iii) Horizontal

- **Out of above mentioned types of carburetors, down-drought is the most commonly used type due to following advantages :**

  i) Fuel flows dues to gravity which helps the engine under load to run smoothly at lower speed

  ii) Volumetric efficiency can be enhanced and it is easy to access

➢ Engine Detonation

- **Engine detonation is an engine refers to inappropriate combustion of fuel in the combustion chamber/cylinder of the engine.**
- **To get maximum power from the engine it is required that proper of air fuel mixture or fuel is supplied to the engine and ignited at proper time.**
- **Sometimes, where preignition of fuel can happen in the engines, it is also observed that whole of the fuel or air fuel mixture is not burnt at once.**
- **Due to this, a pressure wave is set up in the combustion chamber which travels to and fro and hits to the cylinder walls.**
- **This disturbance in the cylinder forces the walls at the frequency of gases which produces a very peculiar sound which is known as engine detonation or knocking.**
- **Engine detonation can also be illustrated as it can also occur due to sudden and instantaneous ignition of the unburnt charge when the temperature and pressure is so high and sufficient to ignite the fuel or air fuel mixture.**

➢ The factors affecting engine detonation

1. Compression ratio: **Engine detonation increases with increase in compression ratio as it increases the gas temperature and pressure thus lowering the reaction time for charge to get ignited. Every engine is designed for a particular maximum compression ratio and any compression ratio beyond this, causes engine detonation.**

2. Engine size: **Engine detonation increases with increase in cylinder size (bore).**

3. Spark advance: **Retarded spark helps in lowering the detonation whereas over-advance in spark leads to more detonation as pressure gets higher than the normal maximum pressure.**

4. Design of combustion chamber: **The design which produces more turbulence in the combustion chamber, it helps in rapid combustion of the charge and hence decrease the chances to knock or detonate.**

5. Defective cooling system: If engine cooling system is not working properly due to fault in engine thermostat, water pump etc., it can also increase the engine detonation.

6. Engine speed: At higher engine speeds which may also lead to fall in volumetric efficiency, the engine detonation is decreased.

7. Valve timing: As the valve timing increases the volumetric efficiency which increases the air-fuel mixture intake and increase the cylinder pressure, the tendency to engine detonation is also increased.

8. Air, Fuel and Air-Fuel Mixture charge: The characteristics like Octane number, cetane number can cause engine detonation.

➢ Effects of detonation

1. Inefficient combustion.
2. Loss power.
3. Local overheating.
4. Mechanical engine failure.

➢ Prevention of Detonation

1. Anti-knock agents.
2. Cooling of the charge.
3. Reducing the time factor.

GOVERNOR

➢ NEED OF GOVERNOR :

- **If load on the engine increases, the resistance due to it will also increases. Consequently, the speed of engine tend to fall down. In case of decrease in the load on the engine, the speed will tend to increase.**
- **However, for all practical purposes, it is desirable that the engine should run at uniform speed.**
- **In diesel engines, to control the variation in engine speed, a device used is known as governor.**
- **Governor regulates the engine speed by varying the fuel flow as per the load conditions.**
- **So, Governor is a mechanical device which automatically maintains a uniform speed by regulating amount of fuel entering the combustion chamber.**

➢ Classification of Governor

- **The governors may be classified as:**

  (1) Mechanical governor

  (2) Pneumatic governor

  (3) Hydraulic governor

- **Mechanical governors may be further classified as:**

(a) Constant speed governor: this is mounted on the engine which are required to run at constant speed. e.g. a stationery engine used for an electricity generation plant.

(b) Variable speed governor: A governor capable of holding any speed between idling and maximum speed is called variable speed governor.

- **Tractor engines are fitted with variable speed governor.**

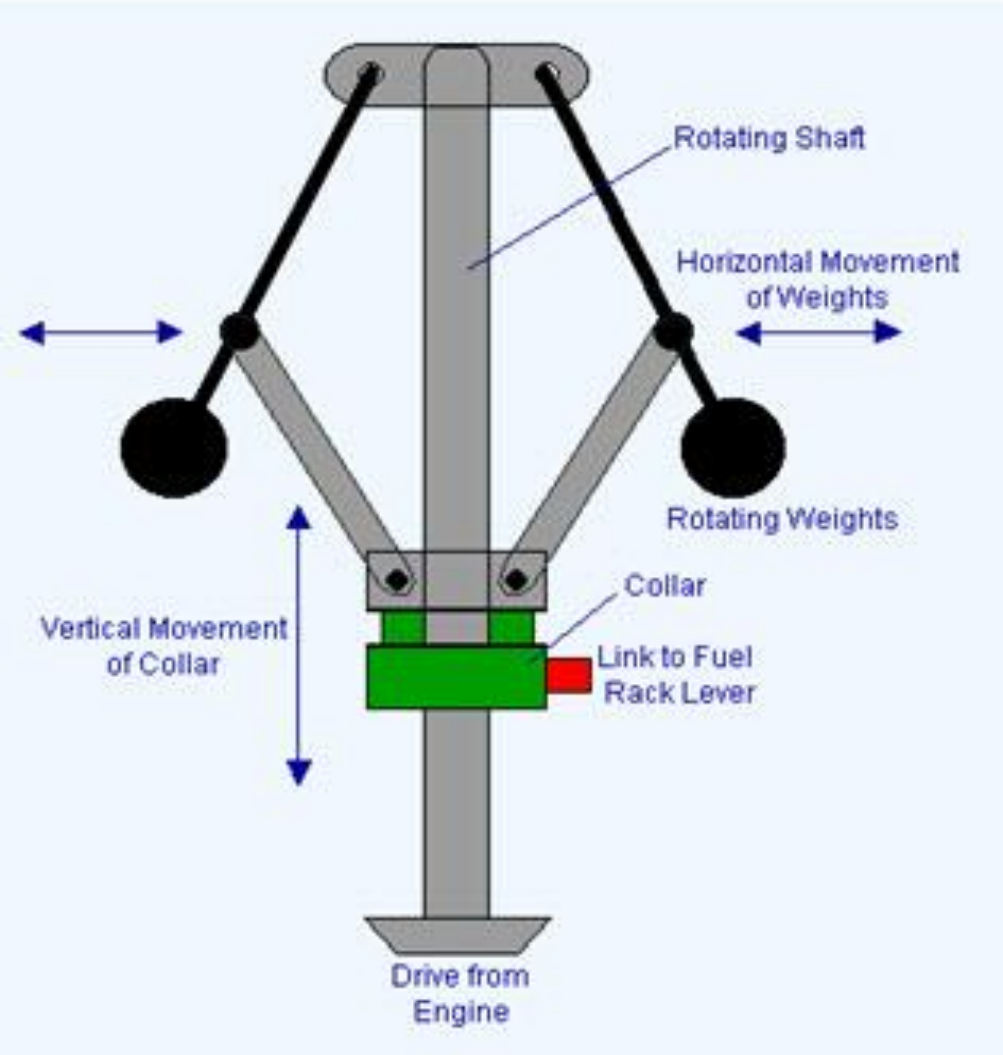
➢ Principle of Mechanical Governor

- The basic principle of working of governor is that the governor spring and flyweights are so selected that at any designed engine speed centrifugal force and spring force are in equilibrium.
- If the speed increases, the increasing centrifugal force of the flyweights acts through the system of levers to reduce the delivery of fuel which decrease the speed.
- When the speed decrease, the control rod moves to step up the fuel delivery rate to increase the speed to desired level.
- The governor maintains all speeds automatically including idling and minimum speed.
- Governors are often included in the design of the fuel injection pump.
- It is fitted directly to one end of the injection pump housing so that it operate the control rod of the injection pump.

➢ Working Mechanical governor

- The centrifugal/mechanical governor is most commonly used governor in tractors.
- Two spring-loaded centrifugal weights are mounted on the governor shaft having sliding collar which further actuates the throttle and the fuel supply.
- At low loads, as the engine speed tends to go high, the weights fly apart with the centrifugal force against the spring tension to actuate fuel injection pump to reduce the amount of fuel delivered and hence decreases the engine speed.
- At high loads, as the engine speed tends to become slower and weight comes to closer due to Spring tension. The contraction in the weights causes more amount of fuel supply through injection pump and hence increase in the engine speed.

➢ Working Mechanical governor



➢ Pneumatic governor

- A pneumatic governor consists of venturi unit and diaphragm unit which are connected by a vacuum pump.
- The venturi unit leads to the engine inlet manifold and the diaphragm unit is connected with the fuel injection pump.
- The position of the butterfly valve in the venturi unit is controlled by the accelerator pedal to control the amount of vacuum from the inlet manifold, to actuate the fuel pump through diaphragm unit and hence the amount of fuel injected.

➢ Hydraulic governor

- A hydraulic governor works on the principle of pressure change and receives the oil from the engine lubricating system which further act as controlling force to control the fuel supply and hence the engine speed.
- The loss of oil pressure cuts the supply of oil to the governor and cause the governor to shut down the engine.

- **The diesel engine governors should have following certain qualities or characteristics.**

1. Governor Regulation: Governor is fitted on engine to maintain uniform speed, in spite of this some variation in engine speed is observed at full load and no load condition.

The speed variation from no load to full load is known as "steady state regulation" or speed drop

$$\text{Speed drop} = (S1 - S2)/S2 * 100$$

Where, S1 = No load speed

S2 = Rated full load speed

2. Percentage regulation: It indicates the sensitivity of the governor. The percentage speed variation between no load and full load condition is known as Percentage regulation.

$$\text{Percent of regulation} : (S1 - S2)/S3 * 100$$

Where, S3 = (S1+S2)/2

3. Governor hunting:

- A new governor sometimes give trouble because of sticking parts or paint interfering with its operation.
- Due to this, the governor is become unstable, the speed will swing back and forth around the desired value which is known as hunting.
- The sudden rise in engine speed or drop of speed from the governor speed due to obstruction in free movement components is called as governor hunting.
- A governor with a high degree of precision or stability is known as a “dead deal” governor.

THANK YOU

Ref. and Courtesy:

1. Jain, S. C. and Rai, C. R. (2008) . *Farm Tractors- Maintenance and Repair*. (2nd reprint ed). Delhi: Standard Publishers Distributors.
2. Patil S. B. (2012). A text book of Farm Power. (First Ed). Kolhapur: Aditi Prakashan.
3. ICAR- e course material