Module – II

Carburetion

***Carburetion:**

The process of preparing a combustible fuel-air mixture outside engine cylinder in SI engine is known as carburetion.

Important factors which affect the process of carburetion are given below;

-time available for the mixture preparation i.e. atomisation, mixing and the vaporisation
-Temperature of the incoming air
-quality of the fuel supply
-design of combustion chamber and induction system

***Mixture requirements for steady state operation:**

Three main areas of steady state operation of automotive engine which require different air fuel ratio are discussed below,

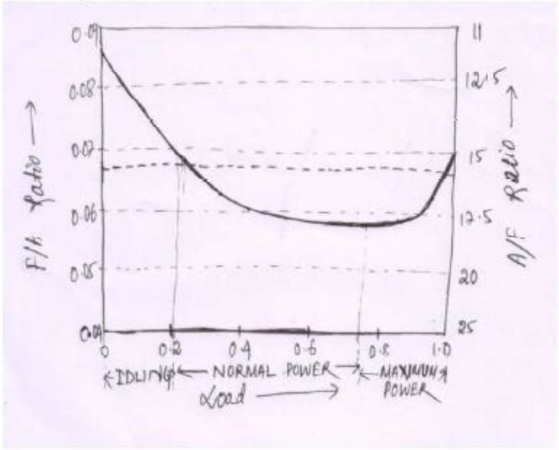

Fig. 13. Main areas of automotive engine operation

(a) Idling and low load:

-from no load to about 20% of rated power
-No load running mode is called idling condition
-very low suction pressure give rise to back flow of exhaust gases and air leakage
-increases the amount of residual gases and hence increase the dilution effects
-Rich mixture i.e. F/A ratio 0.08 or A/F ratio 12.5:1 provide smooth operation of the engine

(b) Normal power range or cruising range:

-from about 20% to 75% of rated power
-dilution by residual gases as well as leakage decreases, hence fuel economy is important consideration in this case
-maximum fuel economy occurs at A/F ratio of 17:1 to 16.7:1
-mixture ratios for best economy are very near to the mixture ratios for minimum emissions

(c) Maximum power range:

-from about 75% to 100% of rated power
-mixture requirements for the maximum power is a rich mixture, of A/F about 14:1 or F/A 0.07

-Rich mixture also prevents the overheating of exhaust valve at high load and inhibits detonation
-in multi-cylinder engine the A/F ratio are slightly lower

***Mixture requirements for transient operation:**

-Carburettor has to provide mixture for transient conditions under which speed, load, temperature, or pressure change rapidly
-evaporation of fuel may be incomplete in the transient condition, quantity of fuel may be increasing and decreasing

(a) Starting and warm up requirements:
-engine speed and temperature are low during the starting of the engine from cold
-during starting very rich mixture about 5 to 10 times the normal amount of petrol is sulpplied i.e. F/A ratio 0.3 to 0.7 or A/F ratio 3:1 to 1.5:1
-mixture ratio is progressively made leaner to avoid too rich evaporated fuel-air ratio during warm up condition
-too high volatility may form vapour bubbles in the carburettor and fuel lines particularly when engine temperatures are high
-too low volatility may cause the petrol to condense on the cylinder walls, diluting and removing the lubricating oil film

(b) Acceleration requirements:
- Acceleration refer to an increase in engine speed resulting from the opening of the throttle
-acceleration pump is used to provide additional fuel

***Simple Carburettor:**
-provide air-fuel mixture for all operating conditions
-Carburettor depression is pressure differential in the float chamber and venture throat which causes discharge of fuel into the air stream
-flow is controlled by small hole of fuel passage
-pressure at the throat at the fully open throttle condition lies between 4 and 5 cm of Hg and seldom exceeds 8 cm Hg
-petrol engine is quantity governed
-Drawback of simple carburettor is that it provides too rich and too lean mixture due to vacuum created at the throat is too high and too small which is undesirable

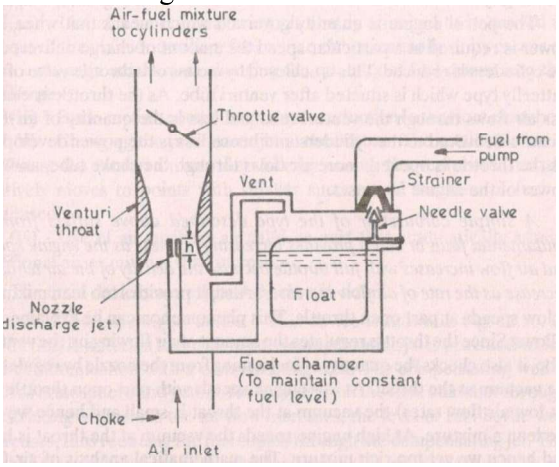

Fig. 14. A simple carburettor

***Complete Carburettor:**

Additional systems used with simple carburettor can help the engine to operate at all conditions, which are given below,

(i) Main metering system:

-provide constant fuel-air ratio at wide range of speeds and loads.
-mainly based upon the best economy at full throttle (A/F ratio about 15.6:1)
The different metering systems are,

Compensating jet device:-Addition to the main jet, a compensating jet is provided to provide the leanness effect

Emulsion tube or air bleeding device:
-mixture correction is done by air bleeding alone
-in this arrangement main metering jet is fitted about 25 mm below the petrol level which is called as submerged jet

Back suction control or pressure reduction method:
-in this arrangement large vent line connects the carburettor entrance with the top of the float chamber and another small orifice line is connected with the top of the float chambers with venture throat
-it creates pressure differences according to engine operating conditions

Auxiliary valve carburettor:
-Valve spring of auxiliary valve lift the valve during increase of engine load which increases the vacuum at venture
-Allows more admittance more additional air and the mixture is not over rich

Auxiliary port carburettor:
-opening of butterfly allows more air inductance which decreases quantity of fuel drawn
-used in aircraft carburettors

(ii) Idling system:
-Idling jet is added for the idling and low load operation which requires rich mixture sof about A/F ratio 12:1
-consists of small fuel line from the float chamber to a point of throttle side
-gradual opening of throttle may stop the idling jet

(iii) Power enrichment or economiser system:
-this system provides the richer mixture for maximum power range of operation
-It has meter rod economiser of large orifice opening to the main jet as the throttle is opened beyond a certain point
-rod is tapered or stepped

(iv) Acceleration pump system:
-Engine acceleration condition or rapid increase in engine speed may open the throttle rapidly which will not able to provide rich mixture
-acceleration pump of spring loaded plunger is used for fuel supply

(v) Choke:
-Rich mixture is required during cold starting period, at low crancking speed and before the engine warmed up condition
-butterfly type valve or choke is used between the entrance to the carburettor and venture throat to meet the requirement
-spring loaded by-pass choke is used in higher speeds

***Carburettor types:**

(i) Open choke:Zenith, solex and carter
Constant vacuum type: S.U. carburettor

(ii) updraught type
Horizontal or downdraught: mixture is assisted by gravity in its oassage to the engine induction

(a) Solex carburettor:
-provide ease of starting, good performance, and reliability
-used in Fiat and standard cars and Willey jeep
-Bi-starter is used for cold starting
-well of emulsion system is used for idling and slow running condition
-diaphragm type acceleration pump is used for increasing speed case

(b) Carter carburettor:
-downdraft type carburettor used in jeep
-has triple venture diffusing type choke in which smallest lies above the level float chamber, other two below the petrol level, one below other
-multiple venturies result in better formation of the mixture at very low speeds causing steady and smooth operation at very low and high engine speed
-mechanical metering method is used
-choke valve is provided in the air circuit for cold starting
-plunger type acceleration pump is used

(c) S.U. carburettor:
-constant air-fuel ratio is maintained due to vacuum depression
-has only one jet
-no separate idling jet or acceleration pump
-constant high velocity air across the jet may avoid the use of idling jet
-jet lever arrangement provides the rich mixture in cold starting
-used in many British cars and Hindustan ambassador car

Drawbacks of modern carburettor:
-improper mixture proportion in multi-cylinder engine
-loss of volumetric efficiency due to obstruction of flow of mixture from choke tubes, jets, throttle valve etc.
-wear of carburettor parts
-Freezing at low temperature
-surging when carburettor is tilted or during acrobatics in aircraft
-backfiring in fuel pipe line

Petrol injection:
-to avoid above problem of modern carburettor, petrol injection is used like in diesel engine
-petrol injected during the suction stroke in the intake manifold at low pressure
-injection timing is not much critical as like in diesel engine
-continuous injection and timed injection methods are used

Continuous injection:
-fuel is sprayed at low pressure continuously into the air supply
-amount of fuel is governed by air throttle opening
-in supercharged engine, fuel injected in the form of multiple spray into the suction side of the centrifugal compressor
--provide efficient atomisation of fuel and uniform mixture strength to all cylinder
-higher volumetric efficiency
-one fuel injection pump and one injector

Timed injection system:
-similar to high speed diesel engine
-components are fuel feed or lift pump, fuel pump and distributor unit, fuel injection nozzles and mixture controls
-mixture controls are automatic for all engine operating conditions

(i) Multiple plunger jerk pump system:
-pump with separate plunger and high injection nozzle pressure for each cylinder
-100 to 300 bar pressure
-measured quantity of fuel for definite time and over definite period is delivered

(ii) Low pressure single pump and distributor system:
-single plunger or gear pump supply fuel at low pressure to a rotating distributor
-pressure about 3.5 to 7 bar

(a) Lucas petrol injection system:
-firstly used in racing car
-single distributor system with novel metering device
-line pressure is maintained at 7 bar
-metering distributor and control unit distributes the required amount of fuel at correct time and interval
-has shuttle arrangements for metering unit
-in aircraft engine two injectors and spark plug provided for direct injection of fuel in combustion chamber

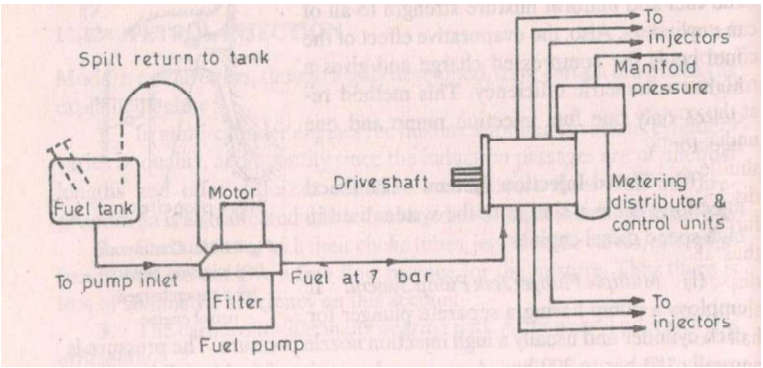

Fig. 15. Lucas petrol injection system for 6-cylinder petrol engine

(b) Electronic fuel injection

Fuel delivery system:

-electrically driven fuel pump draws fuel from tanks to distribute
-fuel and manifold pressure kept constant by pressure regulator

Air induction system:

-air flow meter generate voltage signal according to air flow
-cold start magnetic injection valve give good fuel atomisation and also provide extra fuel during warm up condition

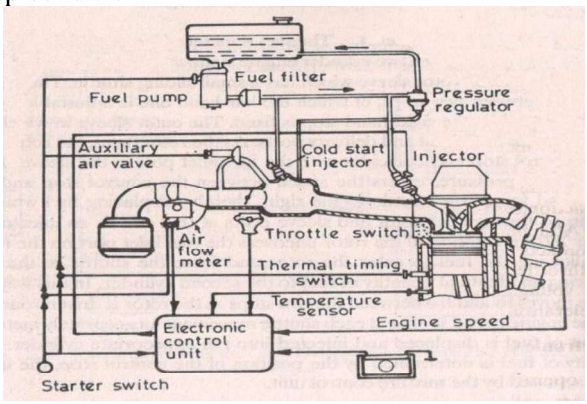

Fig. 16. Electronic fuel injection system- L-Jetronic with air flow meter

Electronic control unit (ECU):

-sensors for manifold pressure, engine speed and temperature at intake manifold
-sensor measures operating data from locations and transmitted electrically to ECU

Injection timing:

-injected twice for every revolution of crank shaft
-triggering of injectors

***Diesel injection system:**

Requirements of diesel injection system:

-fuel must introduce precisely defined period of cycle
-amounts metered very accurately
-rate of injection meet desired heat release pattern
-quantities of fuel meet changing speed and load condition
-good atomisation of fuel
-good spray pattern for rapid mixing of fuel and air
-no dribbling and after injection of fuel i.e. sharp injection
-injection timing suits the speed and load requirements
-distribution of fuel in multi-cylinder should uniform
-weight, size and cost of fuel injection system should be less

Types of diesel injection system:

(a) Air injection system:

-fuel supplied through camshaft driven fuel pump
-fuel valve is also connected with high pressure airline to inject into cylinder
-multi-stage compressor which supply air at a pressure of about 60 to 70 bar

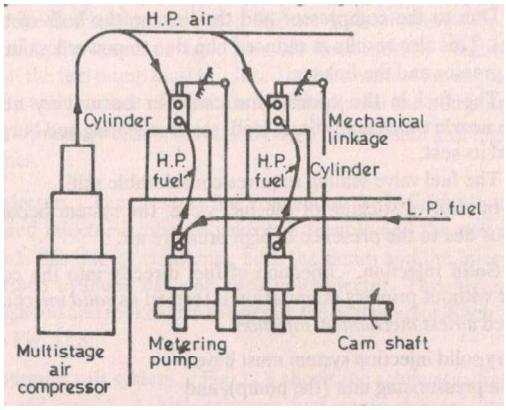

Fig. 17. Air injection system

-blast air sweeps the fuel along with it
-good atomisation results in good mixture formation and hence high mean effective pressure
-heavy and viscous fuels are used
-fuel pump require small pressure
-but it is complicated due to compressor arrangement and expensive
-bulky engine and low bhp
-overheating and burning of valve seat

(b) Solid injection system:

-Fuel directly injected to combustion chamber without primary atomisation termed as solid injection.
-Also known as airless mechanical injection
-2 units-pressurise and atomising unit
3 different types which are described below,

(i) Individual pump and injector or jerk pump system:

-separate metering and compression pump is used for each cylinder
-reciprocating fuel pump is used to meter and set the injection pressure of the fuel
-heavy gear arrangements which gives jerking noise, hence name is given is jerk pump
-jerk pump is used for medium and high speed diesel engines

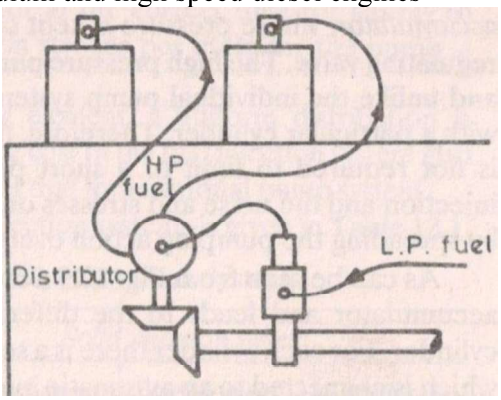

Fig. 18. Individual pump and injector or jerk pump system

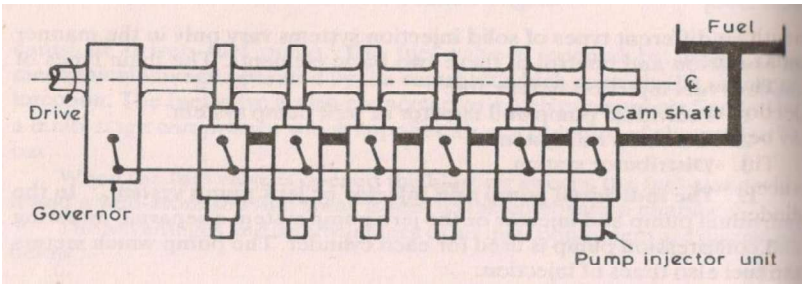

Fig. 19. Unit injector

(ii) Common rail system:

-high pressure fuel pump delivers fuel to an accumulator whose pressure is constant
-plunger type of pump is used
-driving mechanism is not stressed with high pressure hence noise is reduced
-common rail or pipe is connected in between accumulator and distributing elements
-separate metering and timing elements connected to automatic injector
-self-governing type

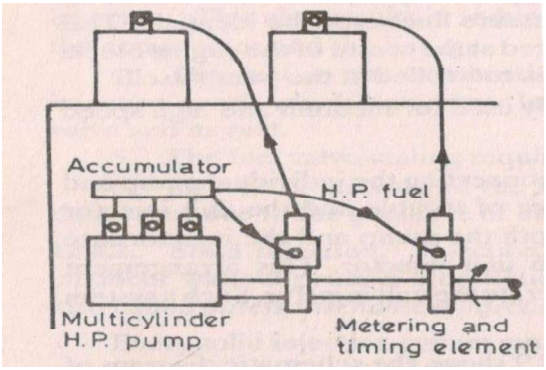

Fig. 20. Common rail system

(iii) Distributor system:

-fuel pump pressurises, meters and times the fuel supply to rotating distributor
-number of injection strokes per cycle for the pump equals to the number of cylinder
-One metering element which ensure uniform distribution

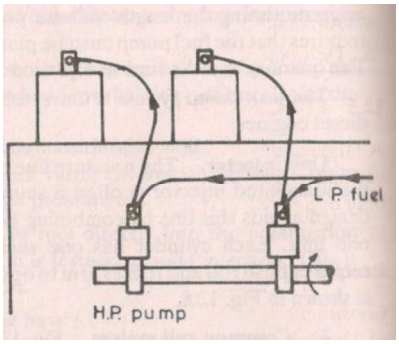

Fig. 21. Distributor system

*** Fuel Injectors**

3 main types of fuel injectors,

Blast injector:

-these are superseded by mechanically operated injectors used in air injection system

Mechanically operated injector:
-consist of a set of camshaft, cams and rocker gear and other cams for controlling the timing of the fuel injection
Automatic injector:
-consists of spring loaded needle valve and operated hydraulically by the pressure of fuel
-quanity of fuel is metered by the fuel pump

Types of nozzles:
(a) Depends on the type of combustion chamber,
Open combustion chamber:
-fuel seeks air
-air swirl is created due to inclined induction port
-multi-hole nozzle injects fuel at a pressure of about 200 to 300 bar to slow moving air
-provide good cold starting performance and improved thermal efficiency

Pre-combustion chamber:
-air velocity is very much high
-single hole nozzle with 65 to 100 bar injection pressure is used
-used in high speed engine due to rapid combustion
-external heating device for easy starting of the engine

(b) Open and closed type of nozzle,
Open type:
-consists of fuel orifices and open to burner
-cheap and less efficient
ex- opposed piston two-stroke Junkers diesel engine
Closed type: pressure drop is minimised compared to open type

(c) Different types of nozzle for different combustion chamber
(i) Single hole nozzle:
-used in open combustion chamber
-size of hole larger than 0.2 mm
-very high injection pressure required

(ii) Multi-hole nozzle:
-no. of hole varies from 4 to 18 and the size from 1.5 to 0.35 mm
-injection rate is not uniform

(iii) Pintle nozzle:
-a projection or pintle is provided in the nozzle to avoid weak injection and dribbling
-pintle may be cylindrical or conical shape
-cone angle varied from 0 to 60^{o}
-provide good atomisation and reduced penetration
-fuel pressures are lower than single and multi-hole nozzle

(iv) Pintaux nozzle:
-injected fuel in upstream of air
-development of pintle nozzle with auxiliary hole drilled in the nozzle body
-reduced delay period and increased thermal efficiency