UNIT-II FUEL SYSTEM, SUPERCHARGING AND TURBOCHARGING

Air fuel ratio requirements of SI engines

In the SI engine, fuel is mixed with air, broken up into a mist, and partially vaporized. The compression ratio varies from 4:1 to 8:1, and the air–fuel mixture ratio varies from 10:1 to 20:1.

The air–fuel ratio determines whether a mixture is combustible at all, how much energy is being released, and how much unwanted pollutants are produced in the reaction. Typically a range of fuel to air ratios exists, outside of which ignition will not occur. These are known as the lower and upper explosive limits.

In an internal combustion engine or industrial furnace, the air–fuel ratio is an important measure for anti-pollution and performance-tuning reasons. If exactly enough air is provided to completely burn all of the fuel, the ratio is known as the stoichiometric mixture, often abbreviated to stoich. Ratios lower than stoichiometric (where the fuel is in excess) are considered "rich". Rich mixtures are less efficient, but may produce more power and burn cooler. Ratios higher than stoichiometric (where the air is in excess) are considered "lean". Lean mixtures are more efficient but may cause higher temperatures, which can lead to the formation of nitrogen oxides. Some engines are designed with features to allow lean-burn. For precise air–fuel ratio calculations, the oxygen content of combustion air should be specified because of different air density due to different altitude or intake air temperature, possible dilution by ambient water vapor, or enrichment by oxygen additions.

The stoichiometric mixture for a gasoline engine is the ideal ratio of air to fuel that burns all fuel with no excess air. For gasoline fuel, the stoichiometric air–fuel mixture is about 14.7:1[1] i.e. for every one gram of fuel, 14.7 grams of air are required. For pure octane fuel, the oxidation reaction is:

$25\ O_2 + 2\ C_8H_{18} \rightarrow 16\ CO_2 + 18\ H_2O + \text{energy}$

Any mixture greater than 14.7:1 is considered a lean mixture; any less than 14.7:1 is a rich mixture – given perfect (ideal) "test" fuel (gasoline consisting of solely n-heptane and iso-octane).

The spark-ignition automobile engines run on a mixture of gasoline and air. The amount of mixture the engine can take in depends upon following major factors:
(i) Engine displacement.
(ii) Maximum revolution per minute (rpm) of engine. (Hi) Carburettor air flow capacity.
(iu) Volumetric efficiency of engine.

Air-fuel Ratios

The air-fuel ratio is the proportions by weight of air and gasoline mixed by the carburettor as required for combustion by the engine. This ratio is extremely important for an engine because there are limits to how rich (with more fuel) or how lean (with less fuel) it can be, and still remain fully combustible for efficient firing. The mixtures with which the engine can operate range from 8:1 to 18.5:1 i.e. from 8 kg of air/kg of fuel to 18.5 kg of air/kg of fuel. Richer or leaner air-fuel ratio limit causes the engine to misfire, or simply refuse to run at all.

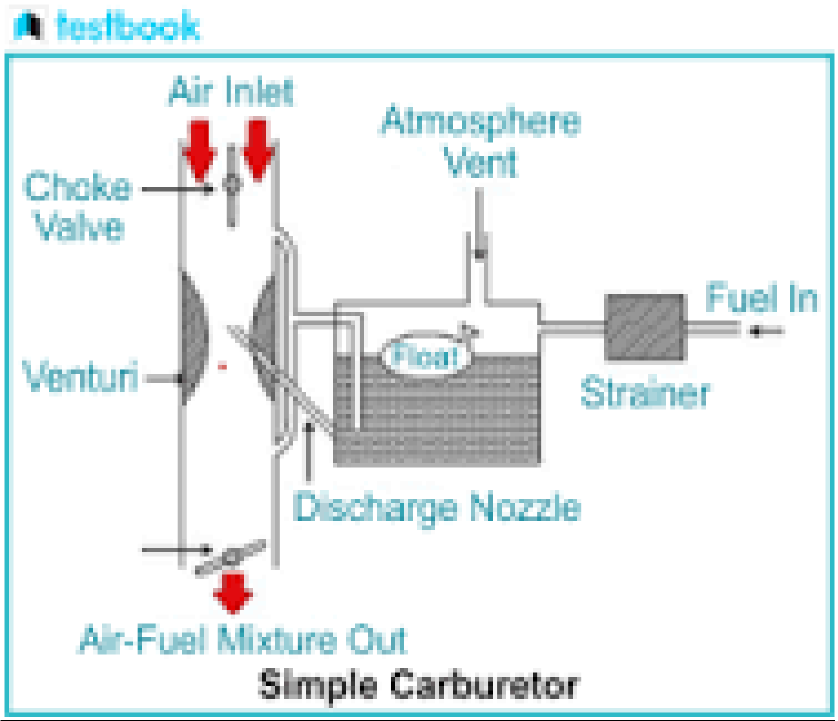
Stoichiometric Air-Fuel Ratio

The ideal mixture or ratio at which all the fuels blend with all of the oxygen in the air and be completely burned is called the stoichiometric ratio, a chemically perfect combination. In theory, an air fuel ratio of about 14.7:1 i.e. 14.7 kg of air/kg of gasoline produce this ratio, but the exact ratio at which perfect mixture and complete combustion take place depends on the molecular structure of gasoline, which can vary somewhat.

Engine Air-fuel Ratios

An automobile SI engine, as indicated above, works with the air-fuel mixture ranging from 8:1 to 18.5:1. But the ideal ratio would be one that provides both the maximum power and the best economy, while producing the least emissions. But such a ratio does not exist because the fuel requirements of an engine vary widely depending upon temperature, load, and speed conditions. The best fuel economy is obtained with a 15:1 to 16:1 ratio, while maximum power output is achieved with a 12.5:1 to 13.5:1 ratio. A rich mixture in the order of 11:1 is required for idle heavy load, and high-speed conditions. A lean mixture is required for normal cruising and light load conditions. Figure 9.36 represents the characteristic curves showing the effect of mixture ratio on efficiency and fuel consumption.

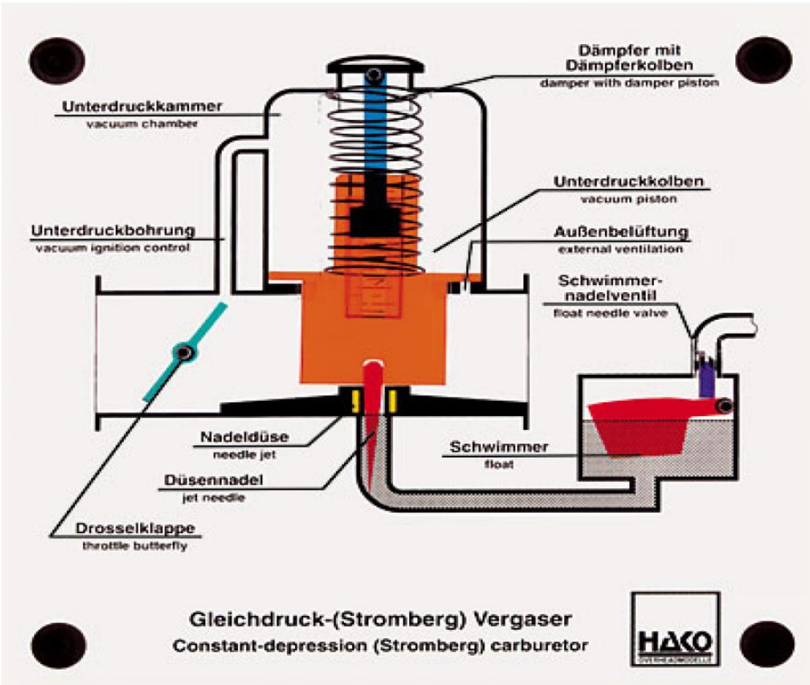
Working of a simple fixed venture carburettor :



The float chamber supplies fuel to the main nozzle through the main fuel jet. Air is drawn into the carburettor from the atmosphere through the choke valve and passes through the venturi, which reduces the cross-sectional area of the airflow and increases its velocity.

Constant vacuum carburettor

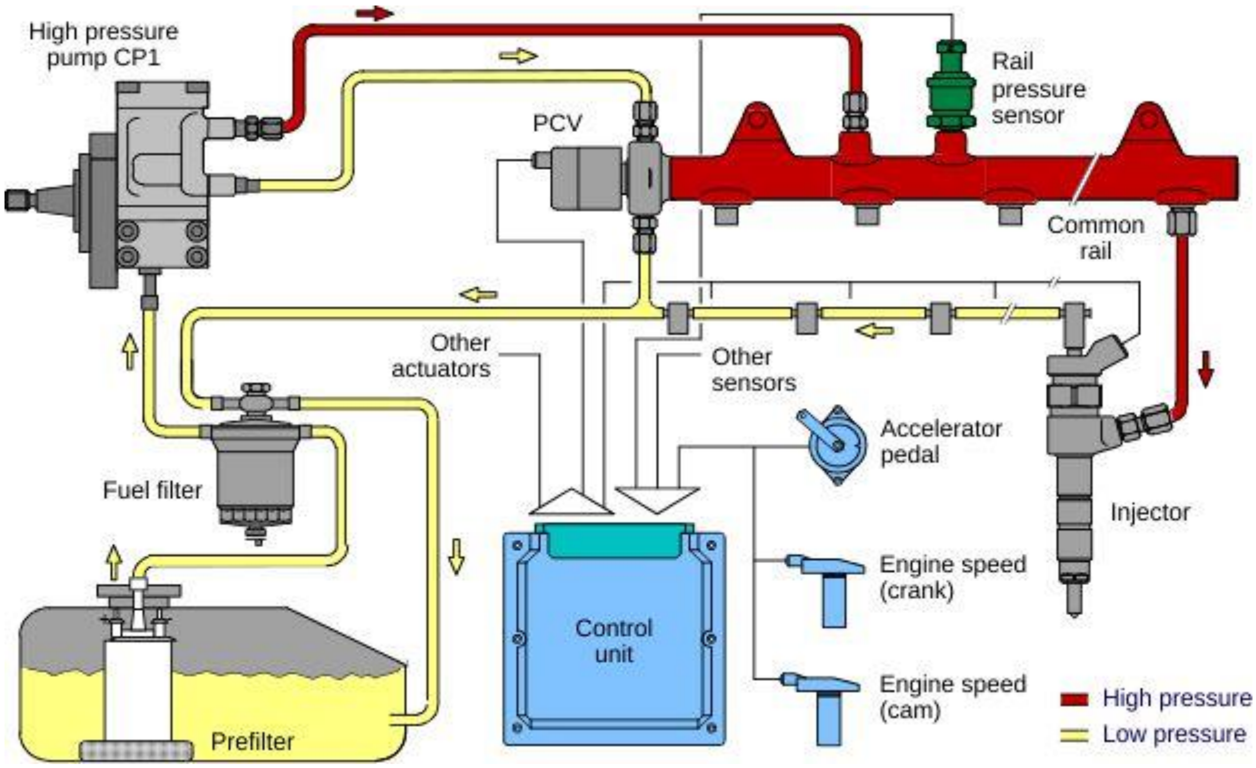
A constant vacuum carburetor which is also called as a variable choke carburetor, is a carburetor where the areas of fuel and air flow are different according to the requirement of the engine. However, in the process, the maintained vacuum is always the same.



<u>Diesel fuel injection systems :</u>

There are four primary systems for injecting fuel:

- Individual pump and injector for each cylinder.
- Combined pump and injector for each cylinder (unit injector type)
- One pump serving injectors for several cylinders (distributor type)
- Pumps in a common housing with injectors for each cylinder (common rail system)



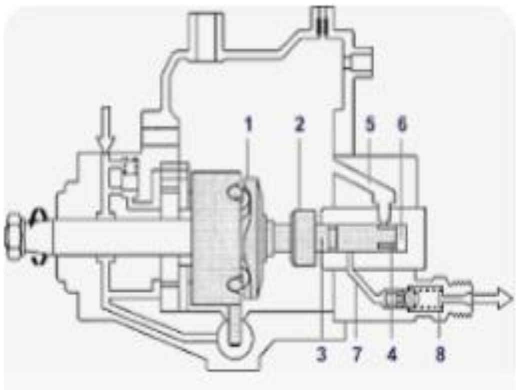
Jerk pumps

a fuel-injection pump in an oil engine which supplies impulsively an accurately metered charge to the nozzle at the time of the opening of the inlet valve

The jerk type fuel pump works by drawing fuel from a feed line or fuel tank, then delivering it to the engine cylinders via the engine's fuel injectors. The pump is driven by the engine camshaft i.e. it is a cam driven pump, which is connected via gears or a chain to the engine crankshaft via the flywheel.

Distributor pumps

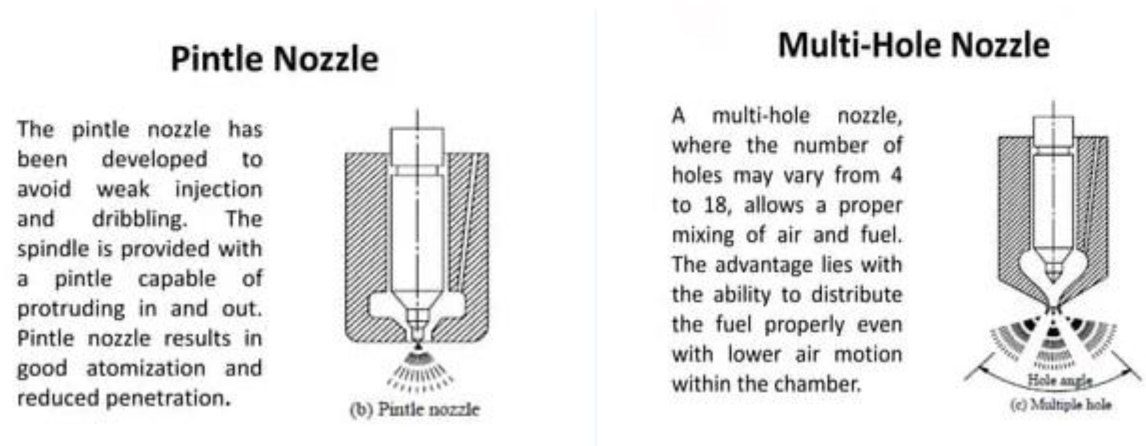
Distributor/Rotary Pump System. The distributor pump performs the same function as the in-line injection pump. It allows a precisely metered amount of fuel to be injected into the combustion chamber at the right time for efficient combustion.



pintle and multihole nozzles

The throttling pintle nozzle is commonly used in indirect-injected engines. One important characteristic of this type of nozzle is the pintle and its effect on the rate of fuel injection.

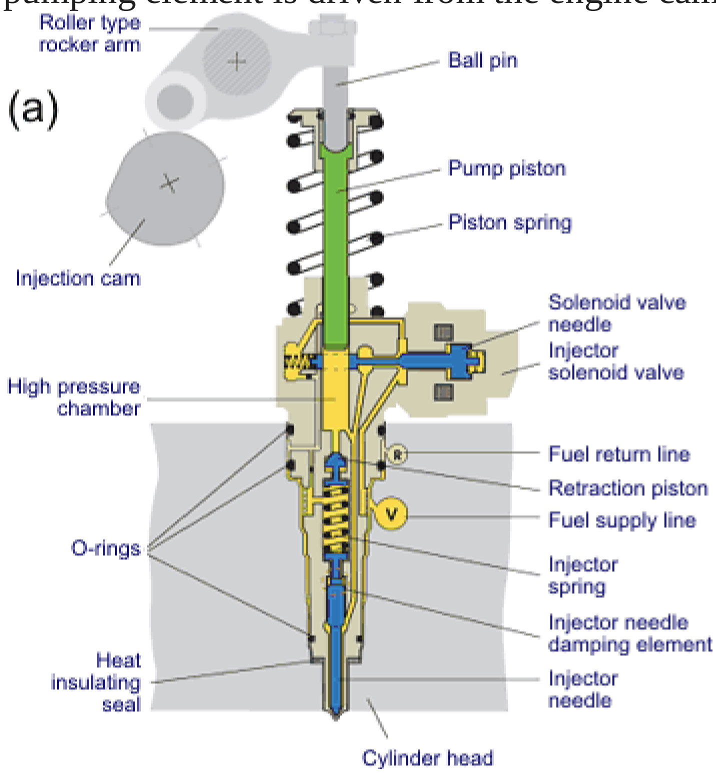
It provides a spray operating at low injection pressures of 8-10MPa. The spray cone angle is generally 60 degree. The main advantage of this nozzle is that it avoids weak injection and dribbling. It prevents the carbon deposition on the nozzle hole.



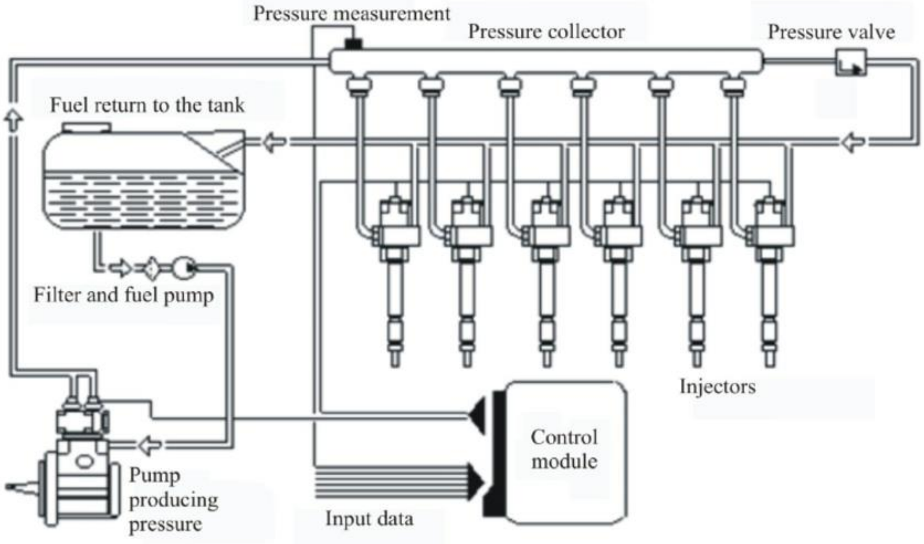
Unit injector

A unit injector (UI) is a high-pressure integrated direct fuel injection system for diesel engines, combining the injector nozzle and the injection pump in a single component. The plunger pump used is usually driven by a shared camshaft. In a unit injector, the device is usually lubricated and cooled by the fuel itself.

High-pressure injection delivers power and fuel consumption benefits over earlier lower-pressure fuel injection by injecting fuel as a larger number of smaller droplets, giving a much higher ratio of surface area to volume. This provides improved vaporization from the surface of the fuel droplets and so more efficient combining of atmospheric oxygen with vaporized fuel, delivering more complete and cleaner combustion.
Unit injectors incorporate the pumping element and the injector in one assembly. In this device—sometimes also called the "pump-nozzle" unit—fuel lines between the pump and the injector are simply replaced by drillings in the UI body. The pumping element is driven from the engine camshaft.



Common Rail Direct Injection system



A high-pressure pump pressurises the fuel. A pressure regulating valve is attached to the high-pressure pump which gets input from ECU. The ECU receives signals from the throttle position sensor, temperature sensor, speed sensor and manifold pressure sensor.

Solenoid or piezoelectric valves make possible fine electronic control over the fuel-injection time and quantity, and the higher pressure that the common rail technology makes available provides better fuel atomisation. To lower engine noise, the engine's electronic control unit can inject a small amount of diesel just before the main injection event ("pilot" injection), thus reducing its explosiveness and vibration, as well as optimising injection timing and quantity for variations in fuel quality, cold starting, and so on. Some advanced common rail fuel systems perform as many as five injections per stroke.

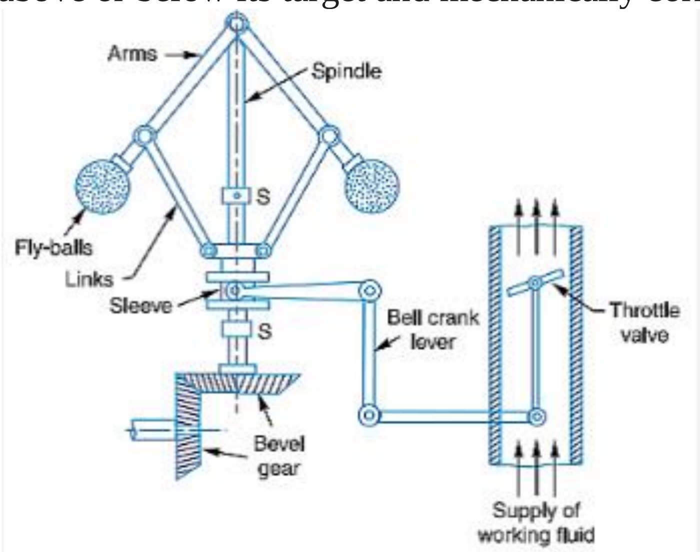
Common rail engines require a very short to no heating-up time, depending on the ambient temperature, and produce lower engine noise and emissions than older systems.
The main advantages of the common rail direct fuel injection can be summarised in reduction of exhaust and noise emissions, better fuel efficiency and improved overall engine performance. The system consists of a high-pressure pump, injectors, a rail, and an electronic control unit.

The common rail is a long metal cylinder. It receives the fuel from the pump and distributes it to the injectors under extremely high pressure. The increase in the fuel pressure is a result of the latest engines' design. Both diesel and gasoline engines tend to become smaller and lighter for better fuel efficiency and improved performance which increases the fuel pressure and sets entirely new standards for the manufacturing of a high-quality common rail.

First, the geometrical accuracy of the component is of critical importance. Precise design contributes to better common rail performance. Even a minimal size or shape fluctuation could lead to failures. Defining the right parameters in the design phase is essential, but what really matters is strictly following them during the manufacturing process.

<u>Description of a simple diesel engine governor.</u>

The governor on a mechanical unit works by using a series of springs to try to control the amount of fuel injected to maintain the speed at a fixed level. The governor isn't aware of the actual speed of the engine, it is only aware of if it is above or below its target and mechanically corrects accordingly.



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.