ICE Fuel Metering

Dr. Md. Zahurul Haq

Professor
Department of Mechanical Engineering
Bangladesh University of Engineering & Technology (BUET)
Dhaka-1000, Bangladesh

zahurul@me.buet.ac.bd
http://teacher.buet.ac.bd/zahurul/

ME 401: Internal Combustion Engines

SIE: Requirements for Metering & Mixing

The (carburettor) system must supply continuously a mixture in proportions such that:

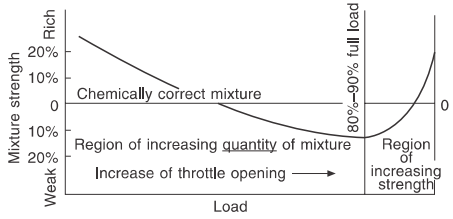
1. In all circumstances, it can be easily ignited by the spark.
2. The maximum possible amount of chemical energy can be extracted from it and converted by the engine into mechanical energy.
3. All fuels must be oxidized completely; i.e. without producing carbon-monoxide in the exhaust.

The actual Process of carburation comprises **three** phases:

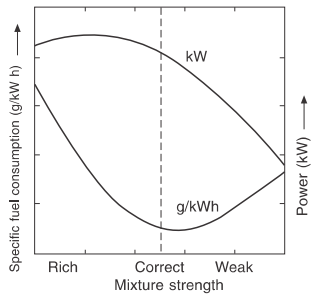
1. Metering the fuel through the jets in proportion to the air flowing into the engine.
2. Breaking up the liquid into fine droplets, or atomizing it, to assist evaporation.
3. Distributing the evaporating fuel uniformly into the air flow to form a homogeneous mixture.

Mixture Quality Requirements

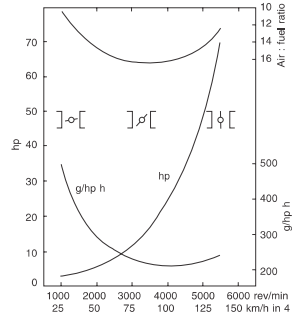
- A rich mixture is needed for starting, especially in cold conditions when a high proportion of the fuel condenses out on to the cold walls of the induction manifold.
- Enrichment of the mixture is needed for idling because of the fuel being consumed are so small.
- A slightly weak mixture for cruising, at part throttle, ensures that there is enough air to burn completely all the fuel.
- An extra supply of fuel for acceleration is essential because, when the throttle is suddenly opened, the flow or air increases more rapidly than that of the fuel.
- To obtain the maximum possible power output, the maximum possible quantity of fuel must be supplied to it, so the mixture must be enriched. However, it is achieved at the expense of higher brake specific fuel consumption.



e1013



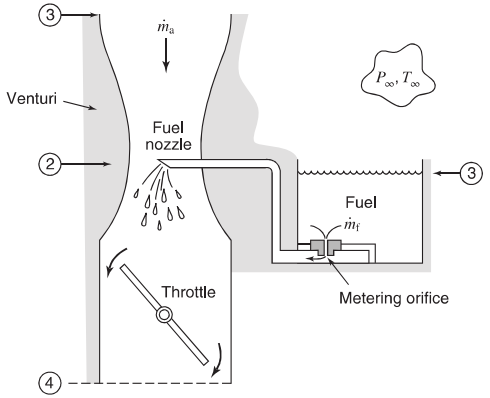
e1012



e1014

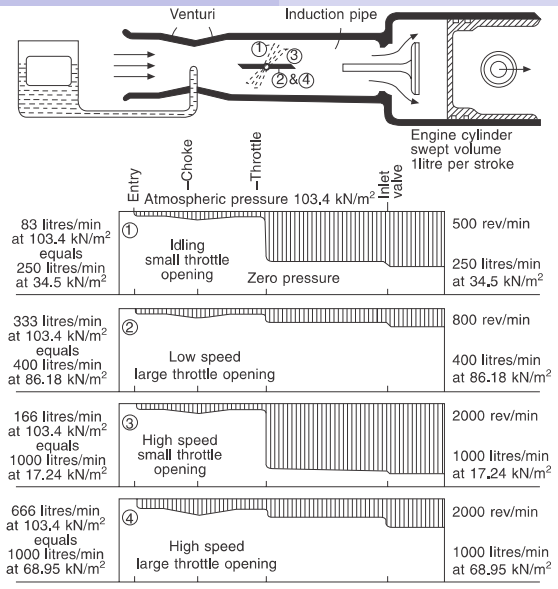
Throttling

- In SIE, torque and power output are regulated by varying the quantity of combustible mixture supplied to the cylinder which is regulated by means of a **throttle valve**.



T549

- The power output of an engine is controlled by regulating the amount of charge. The smaller the degree of throttle opening, the greater is the depression induced in the cylinders. Because of the fall in volumetric efficiency with speed, maximum torque is obtained at a speed lower than that at which maximum power is developed.
- Four important conditions are:
  1. Low speed, small throttle opening (engine idling).
  2. Low speed, large throttle opening (at the beginning of acceleration, or when the engine is labouring during the ascent of a hill).
  3. High speed, small throttle opening (descending a hill).
  4. High speed, large throttle opening (fast motoring on level ground).

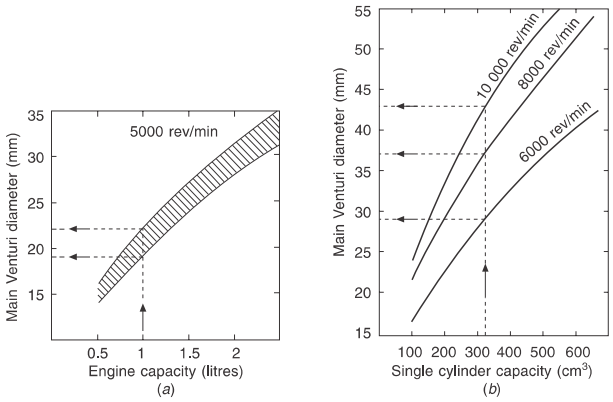


e1011

Carburation System

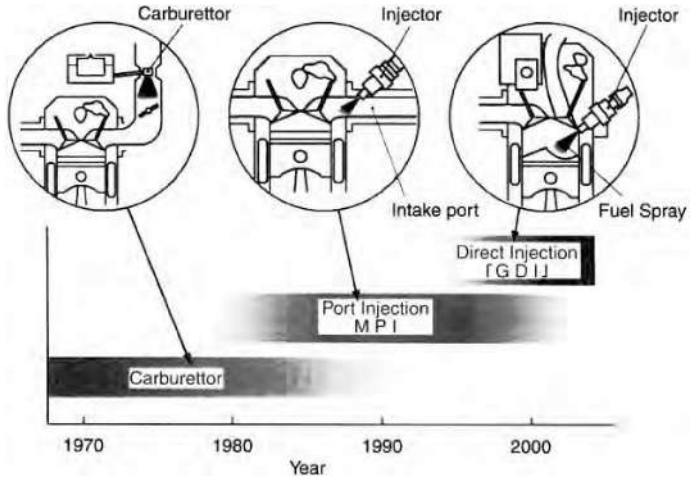
- The carburettor uses the venturi principle: the inlet air Hows through a necked-down area (venturi). where the flow increases in speed and decreases in pressure.
- The pressure drop at the venturi increases with engine speed and with throttle position, thus causing fuel flow from the reservoir to the venturi to increase as engine speed and throttle position increase.
- Carburation system consists of the following subsystems:
  - Inlet system to maintain a constant level of fuel in the reservoir.
  - Metering system to maintain the desired air-fuel ratio.
  - Accelerator-pump system to provide extra fuel during acceleration.
  - Power enrichment system to provide extra fuel during periods of high demand.
  - Choke system to provide a rich mixture for start and cold-engine operation.

Venturi Diameter



e1015

Weber charts for the selection of venturi diameter (a) for engines having between one and six cylinders, and (b) for sports car engines having one carburettor per cylinder.

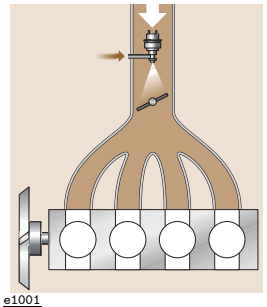


e697

Fuel Injection

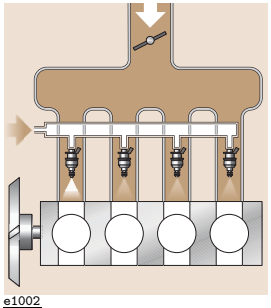
Fuel injection system can be divided into two basis types:

1. manifold: (a) throttle body & (b) port
2. gasoline direct injection (GDI)



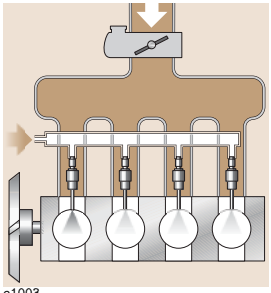
e1001

Throttle body injection



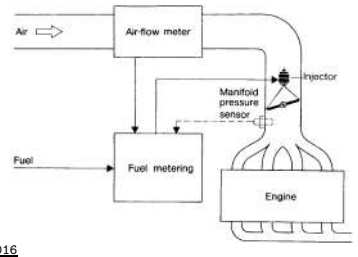
e1002

Port injection

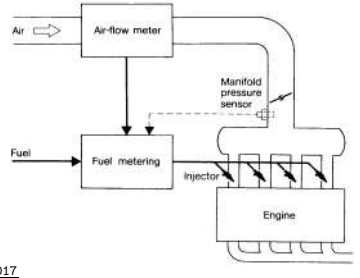


e1003

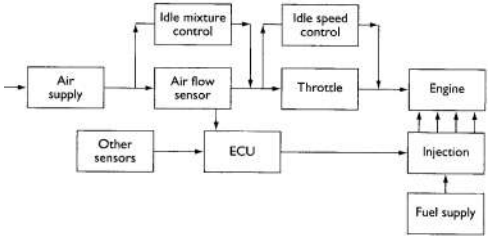
Gasoline direct injection



e1016



e1017



e1018

Objectives of CIE Injection System

- Meter the quantity of fuel demanded by the speed of, and the load on, the engine.
- Distribute the metered fuel equally among the cylinders.
- Inject the fuel at the correct time in the cycle.
- Inject the fuel at thee correct rate.
- Inject the fuel with the spray pattern and atomization demanded by the design of the combustion chamber.
- Begin and end the injection sharply without dribbling or after-injections.

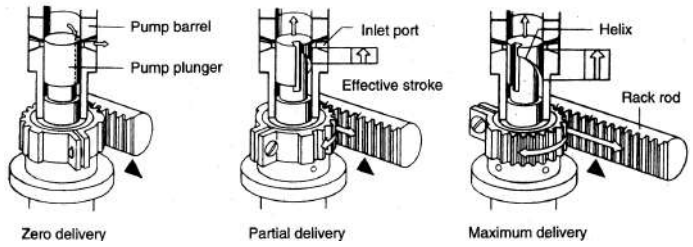
CI Injection Systems

1. **Individual Pump Systems**: a separate metering and compression pump for each cylinder.
2. **Distribution Systems**: a single pump for compressing the fuel (which may also meter), plus a dividing device for distributing the fuel to the cylinders (which may also meter).
3. **Common Rail Systems**: a single pump for compressing the fuel, plus a metering element for each cylinder.

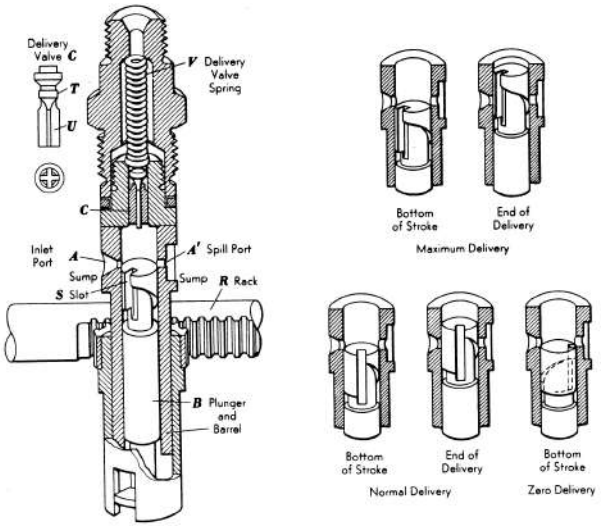
While in pre-chamber engines, injection pressures of approx. 400 bar are sufficient, for direct injection they have to be between 1200 and 2000 bar.

Fuel Delivery Control

In cam-operated injection systems, pressure increase and fuel metering are coupled mechanically. The cam moves the tappet of the injection pump, which for its part "compresses" the fuel volume. The resulting climbing pressure opens a valve and thus releases the feeding pipe for the injection nozzle. The return line is opened via a trimming edge, and so the fuel pressure falls, the valve closes, and injection is over.

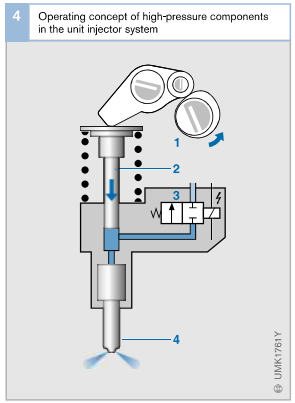


e1005



e1022

Unit Injection (UIS) & Unit Pump System (UPS)



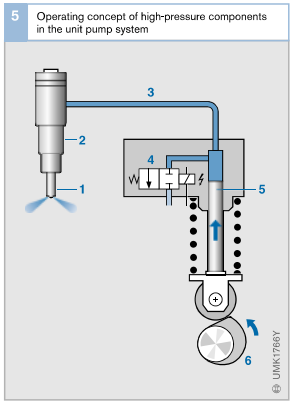


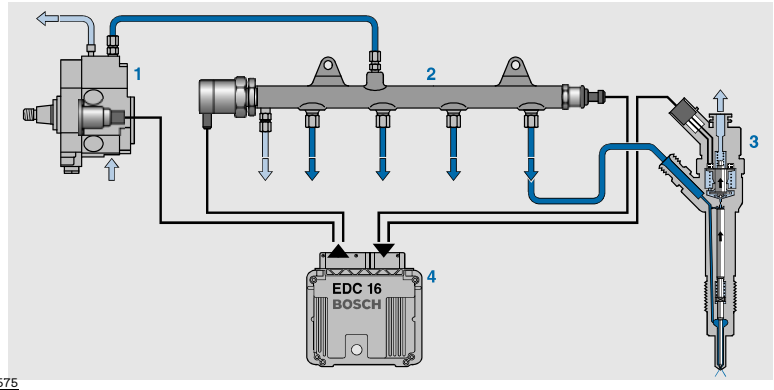
Fig. 4
1 Drive cam
2 Pump plunger
3 High-pressure solenoid valve
4 Injection nozzle

Fig. 5
1 Injection nozzle
2 Nozzle-and-holder assembly
3 High-pressure fuel line
4 High-pressure solenoid valve
5 Pump plunger
6 Drive cam

T574

- In UIS, fuel-injection pump and injection nozzle form a single unit.
- In UPS, the nozzle-and-holder assembly (2) and the fuel-injection pump are linked by a short high-pressure line (3).

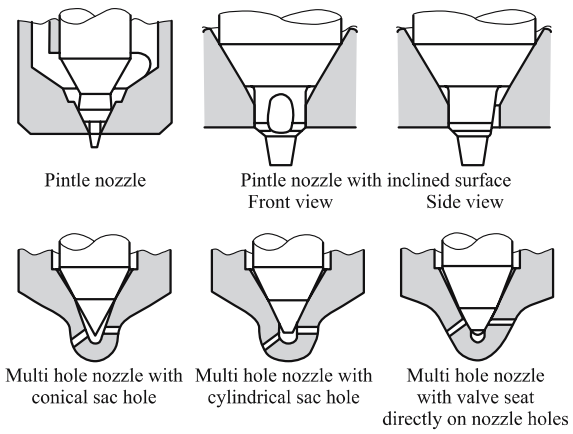
Common Rail System



T575

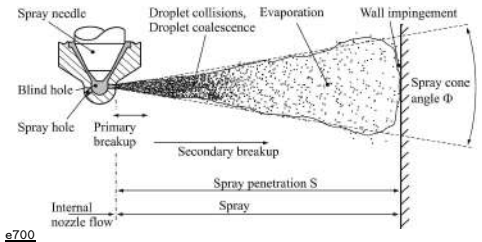
1. High-pressure pump, 2. Fuel rail, 3. Injection nozzle, 4. EDC electronic control unit

Injection Nozzles

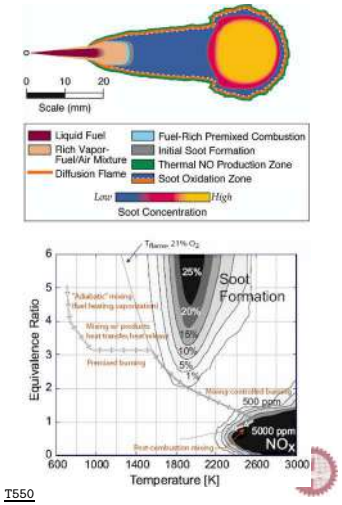


e1009

Fuel Spray & Combustion



e700



T550