Internal Combustion Engines

MIXTURE PREPERATION in CI ENGINES

Prof.Dr. Cem Soruşbay

Internal Combustion Engines

Mixture Preperation

- Introduction
- Atomization of fuel, sprays
- Fuel systems - in-line systems, distributor systems
- Common-rail systems, unit pump and unit injector systems

Fuel Atomization

In Diesel engines, fuel-air mixture is prepared as a result of fuel injection into the cylinder at the end of compression stroke (usually before TDC) during a limited time (crank angle) interval.

The purpouse of fuel injection is to provide good mixing of air and fuel in the limited time available, by increasing the surface area of the liquid fuel as a result of atomization

Dividing unit fuel volume into droplets of 100×10^{-6} [m] diameter would increase the total surface area by 10,000 times.

Liquid Atomization

Liquid atomization is effected by internal and external forces.

controlled by Reynolds number defining the balance between inertia effects and viscous effects

$$Re = \rho u D / \mu$$

Atomization at Low Speeds

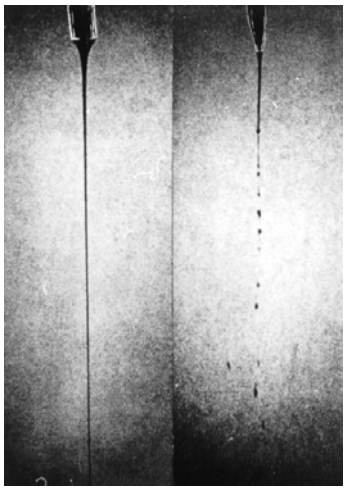
Rayleigh regime : internal effects are dominant

surface tension, fuel density, liquid column diameter

Any disturbance produces break-up of liquid column

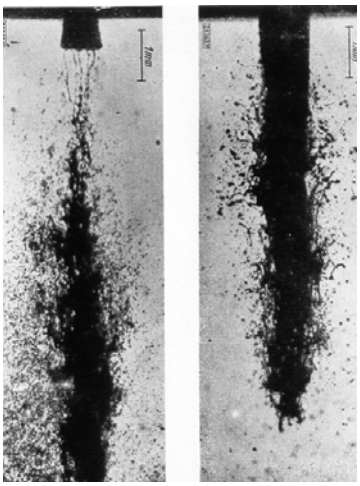
Weber : indicated the importance of viscous effects

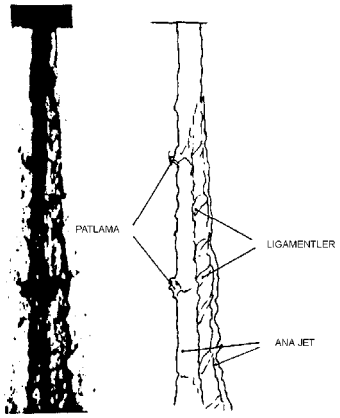
Heavy fuel, (left) 5000 cS
Diesel fuel (right) 6 cS



Atomization at High Speeds

Atomization at High Speeds

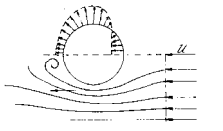


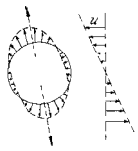


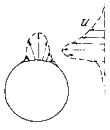
Secondary Atomization

Weber number

$$W_e = \frac{\rho_h u^2 D}{\sigma}$$







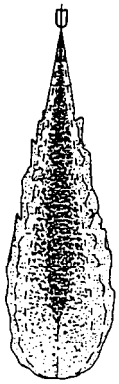
Spray Structure

In difusion flames, combustion is controlled by the mixing rate of the fuel and air.

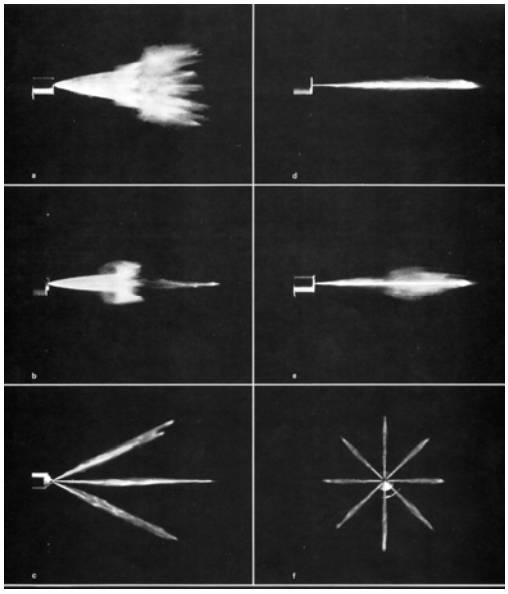
The local conditions in the combustion chamber such as the air-fuel ratio, temperature, pressure control the ignition of the fuel and the combustion process. Heat and mass transfer in the combustion chamber and the fluid flow (air flow) also effects this process.

Spray structure,

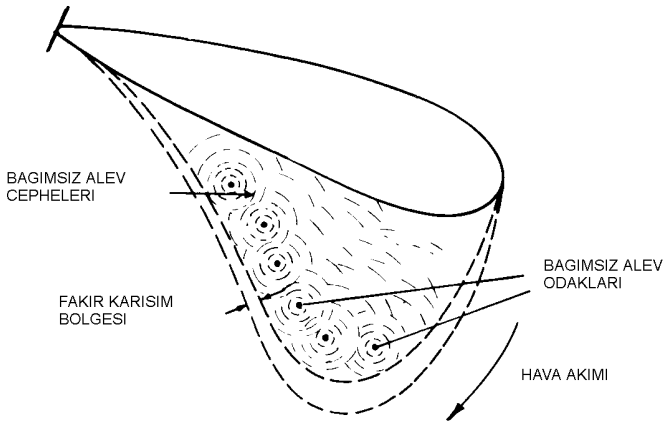
- core
- breakup length
- spray tip penetration



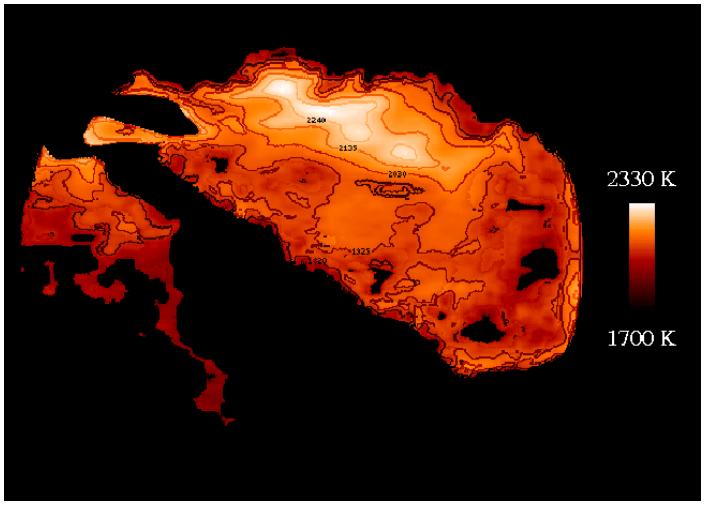
Fuel Sprays



Fuel Sprays

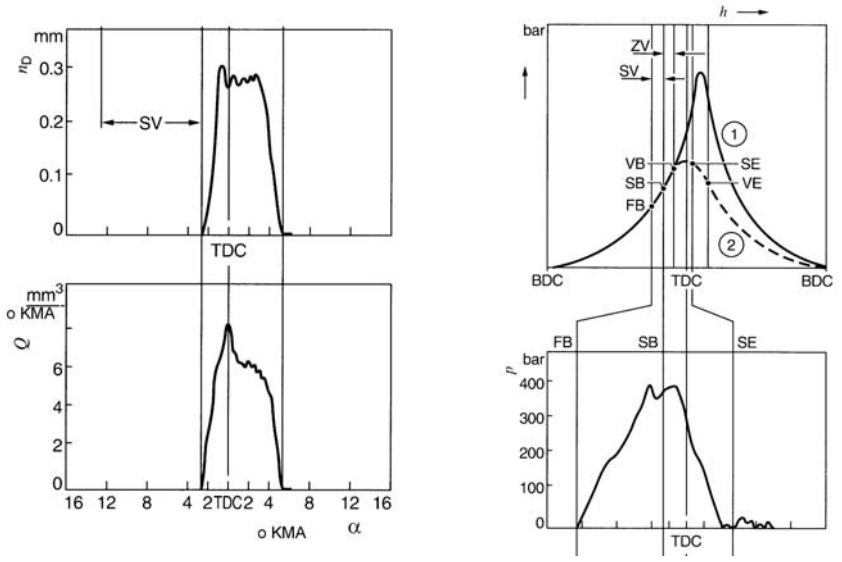


Temperature Contours

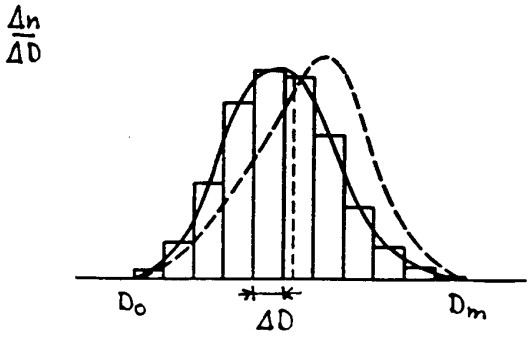


Temperature distribution inside the cylinder

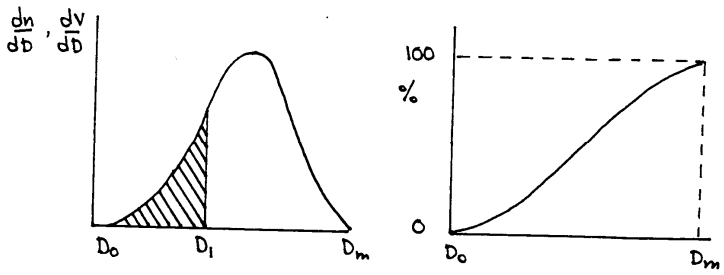
Diesel Combustion Phases



Droplet Size Distribution



Droplet Size Distribution



Sauter Mean Diameter

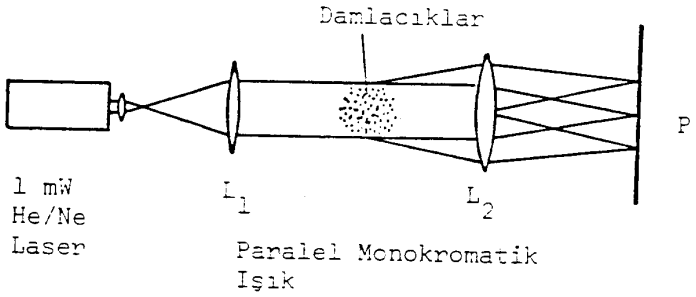
$$D_{qp}^{q-p} = \frac{\int_{D_m}^{D_o} D^q \frac{dn}{dD} dD}{\int_{D_m}^{D_o} D^p \frac{dn}{dD} dD} = \frac{\int_{D_m}^{D_o} D^{q-3} \frac{dV}{dD} dD}{\int_{D_m}^{D_o} D^{p-3} \frac{dV}{dD} dD}$$

p = 2 and q = 3 : Sauter Mean Diameter

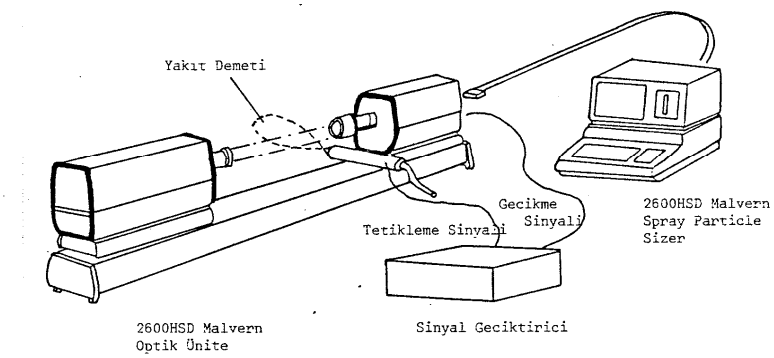
indicates the total Area-to-Volume ratio applicable for the whole spray

$$D_{32} = \frac{\sum D_i^3 n_i}{\sum D_i^2 n_i}$$

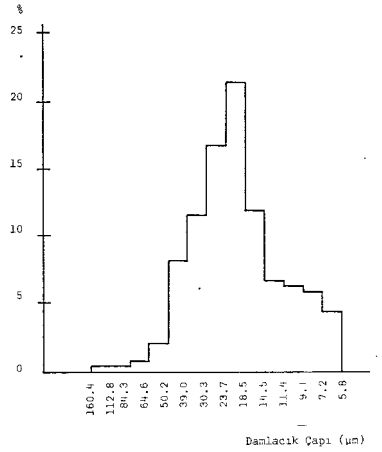
Droplet Size Measurements



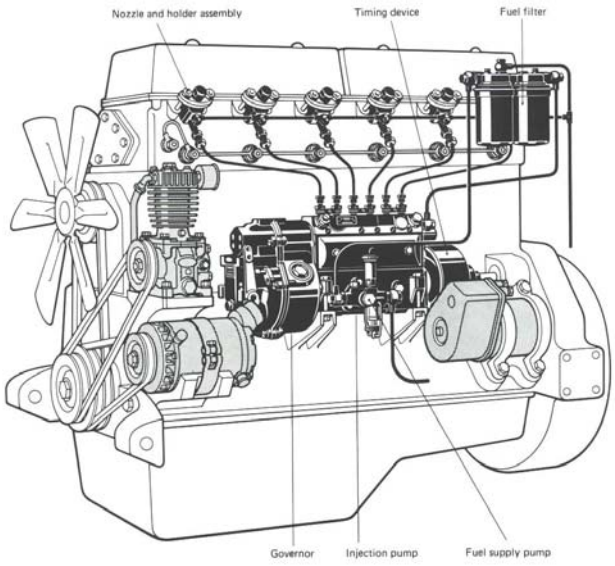
Droplet Size Measurements



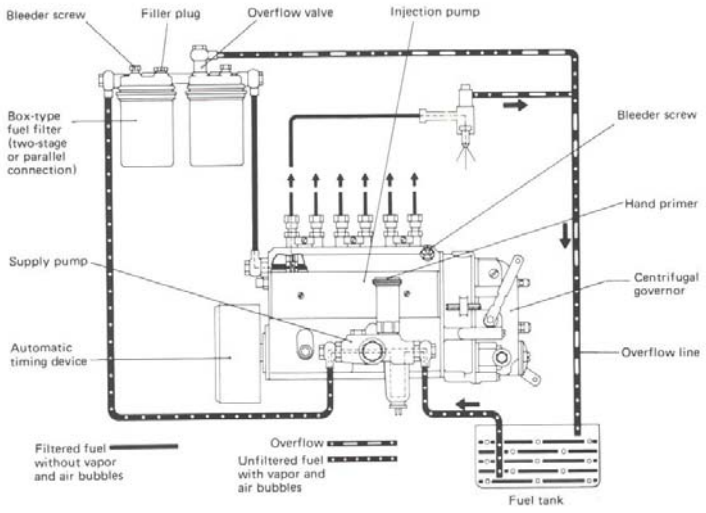
Droplet Size Measurements



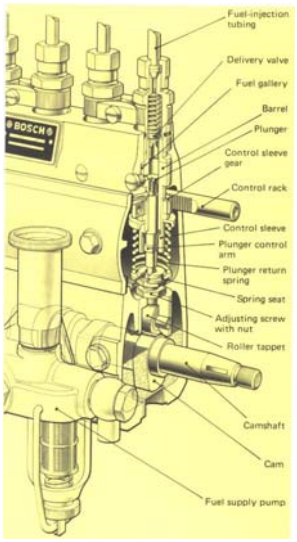
Diesel Engines



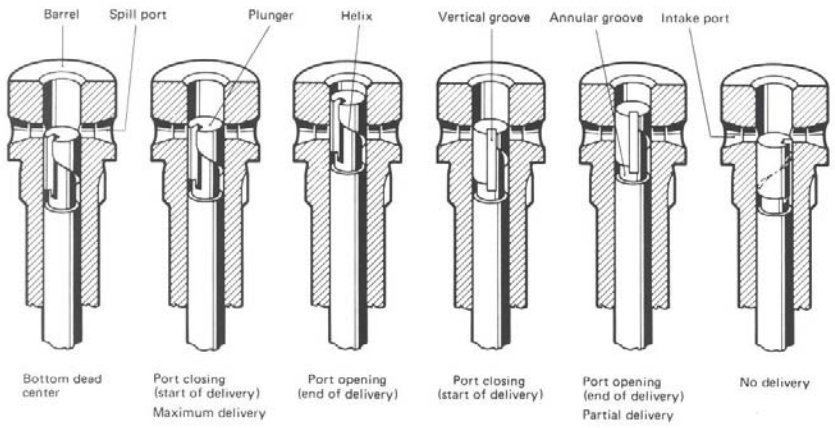
Fuel system



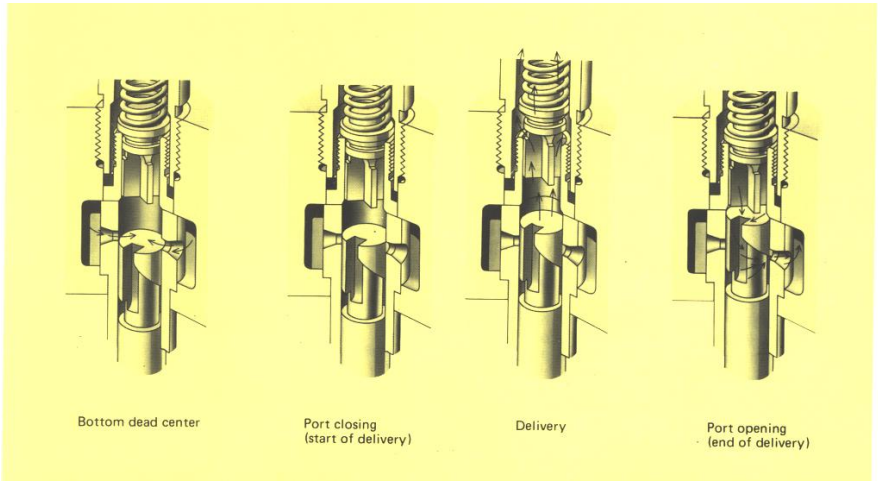
Injection Pump – in line system



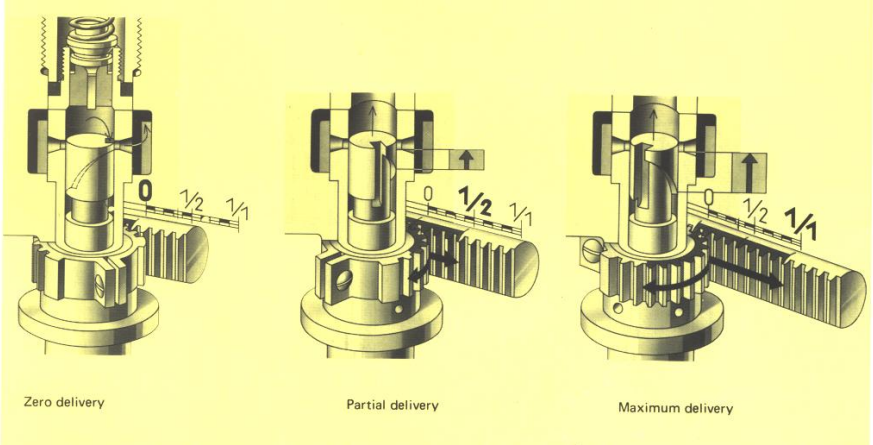
Injection Pump



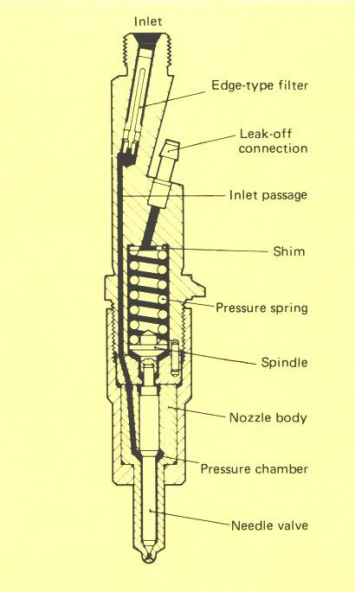
Injection Pump



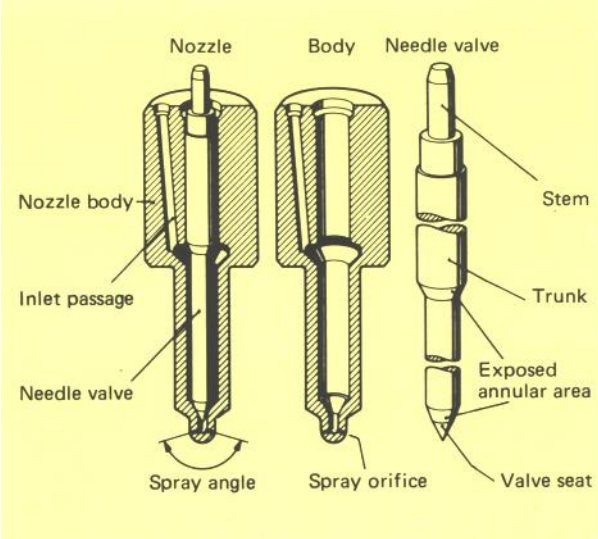
Injection Pump – fuel metering



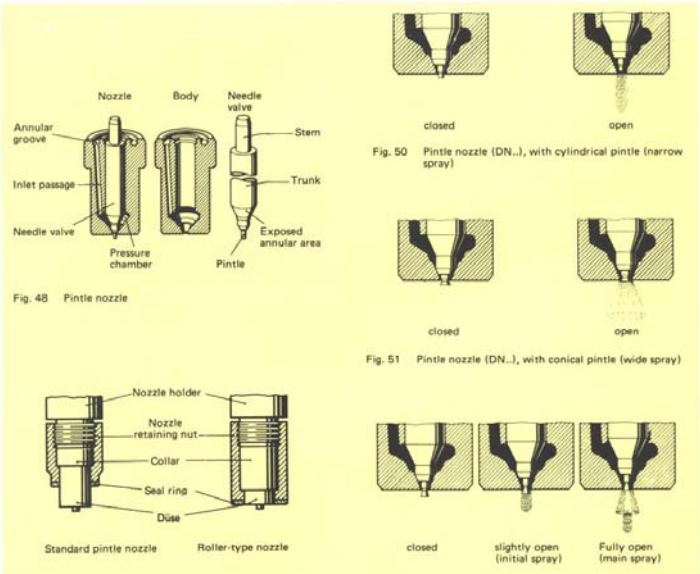
Injector



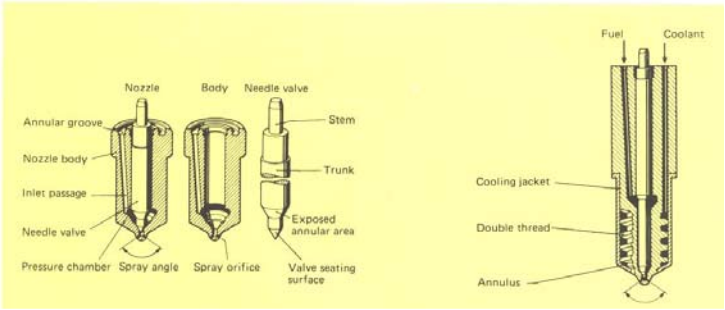
Injector

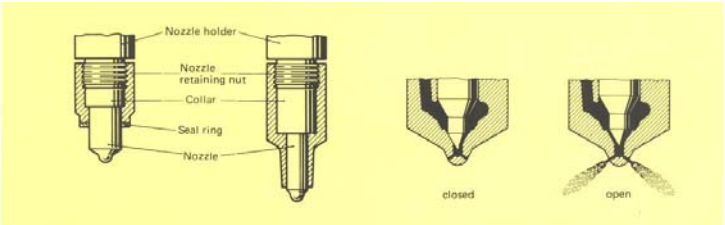


Nozzles

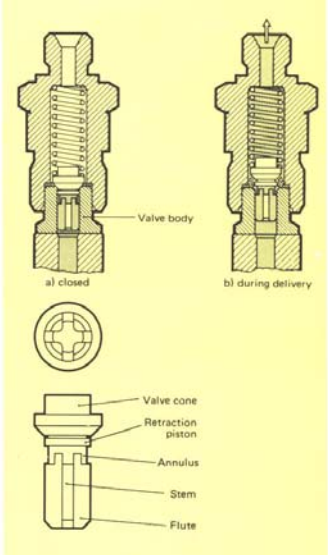


Nozzles

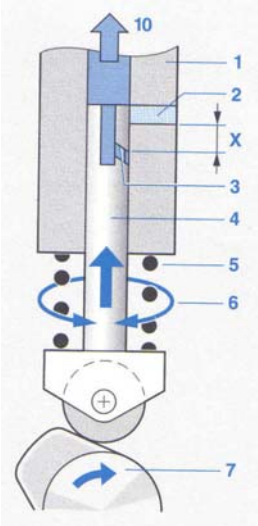




Delivery Valve

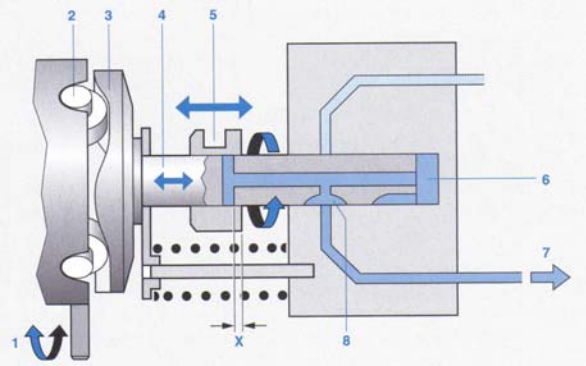


In-line Fuel Injection System



1. Pump Barrel
2. Inlet Port
3. Helix
4. Pump Plunger
5. Plunger Spring
6. Camshaft
7. Fuel Outflow to Nozzle

Distributor Fuel Injection System



1. Injection Timing Adjustement
2. Roller
3. Cam Plate
4. Axial Piston
5. Control Sleeve
6. High-Pressure Chamber
7. Fuel Outflow to Nozzle
8. Leak-Off
9. Effective Stroke

Distributor Fuel Injection System