



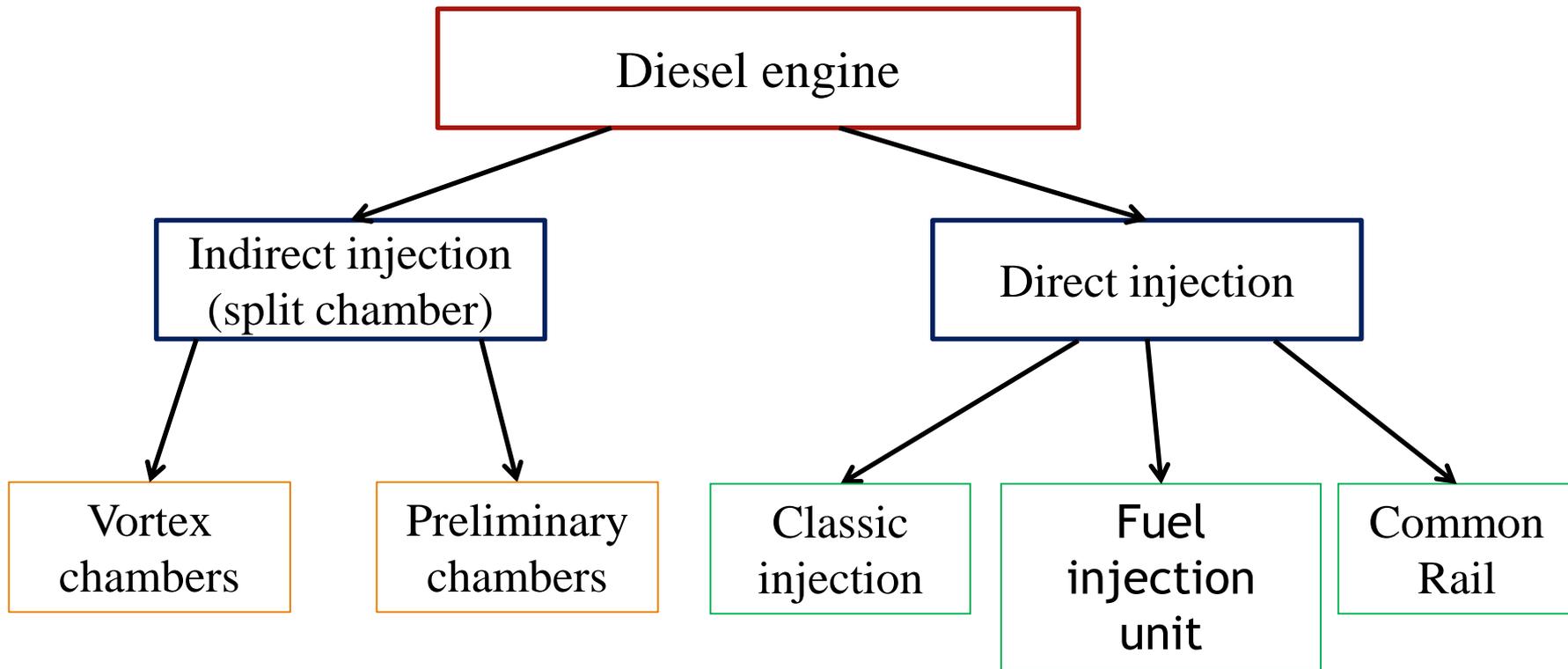
Politechnika Wroclawska

**Fuel Supply System  
for diesel engine  
Common Rail**

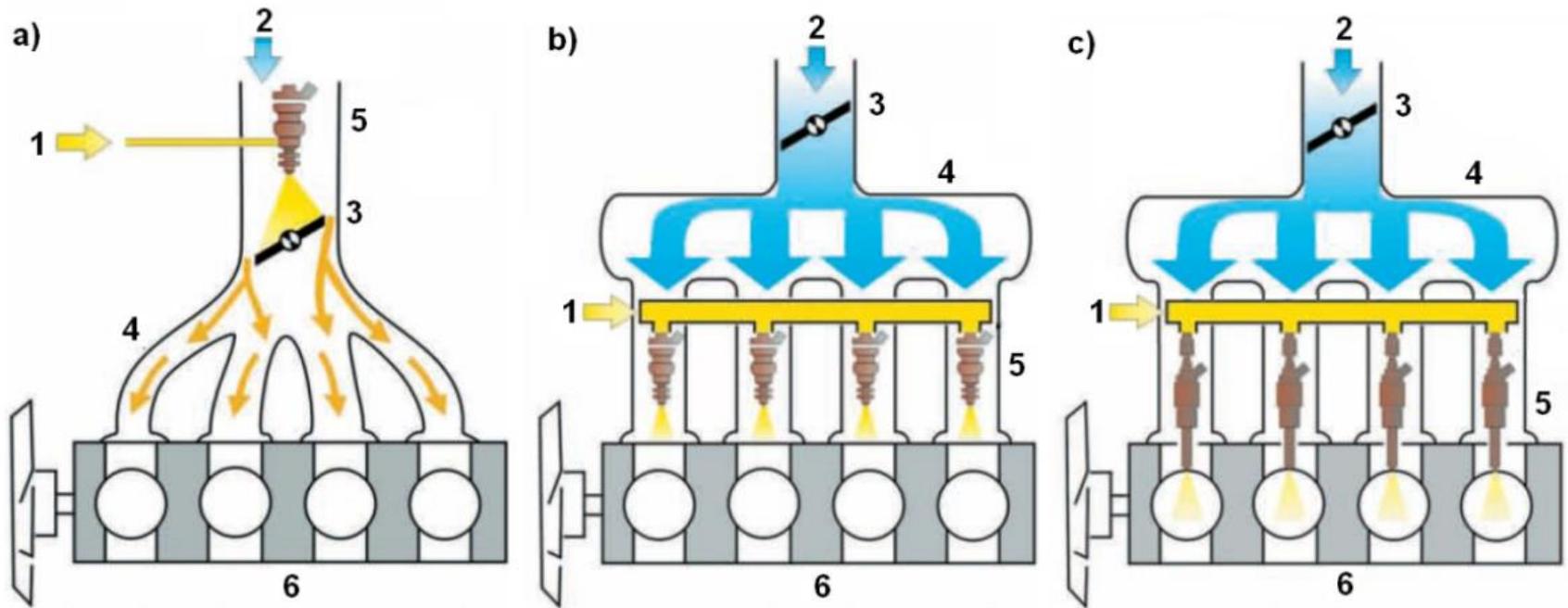




# Classification



# Direct/indirect



**Figure 1.** Systems of fuel injection [1]: a) Single Point Injection, b) Multipoint Injection, c) Direct Injection; 1 – Fuel supply, 2 – Air intake, 3 – Throttle, 4 – Intake manifold, 5 – Fuel injector (or injectors), 6 – Engine



# Diesel engine

Diesel engines are characterized by an internal mixing system



Fuel is injected at high pressure into a combustion chamber in which the pre-compressed air

## **Diesel oil:**

- high incidence of spontaneous combustion (self-ignition temperature in atmospheric air 570-620 C); from ambient pressure and vapor concentration in the air,
- conditions: not very high temperature (suitable compression ratio) and appropriate fuel concentration (suitable spraying)



# Conditions necessary for self-ignition

1. Ensure self-ignition at low temperatures
2. Obtain adequate concentration of fine particles and fuel vapors

These conditions are fulfilled by:

- Obtaining the appropriate air compression ratio ( $\epsilon = 16 - 22$ ) - At the end of the compression stroke, the temperature is 800 - 900°C at a pressure of 3 - 3.5 MPa (spontaneous ignition temperature of diesel oil 570 - 620°C)
- Good spraying of the fuel provided by the injection system



# Creating a fuel-air mixture

CI engine power supply tasks:

- triggering the correct fuel pressure,
  - injection of a suitable fuel dose (quantitative regulation),
  - Setting the injection start (angle of injection in the crankshaft rotation stages)
- In the compression ignition engine, the cylinder is only supplied with air
  - The air is introduced under atmospheric pressure (naturally aspirated engines) or the pressure resulting from the pre-compression (supercharged engines)
  - Power regulation is achieved by varying the fuel injection dose per engine cycle (quality control).



# Fuel supply system for compression-ignition engines

Tasks of engine power supply:

- Measure the amount of fuel suitable for the rotational speed and load of the engine,
- put fuel into the combustion chamber at the right time,
- properly disassemble and distribute the fuel in the combustion space.

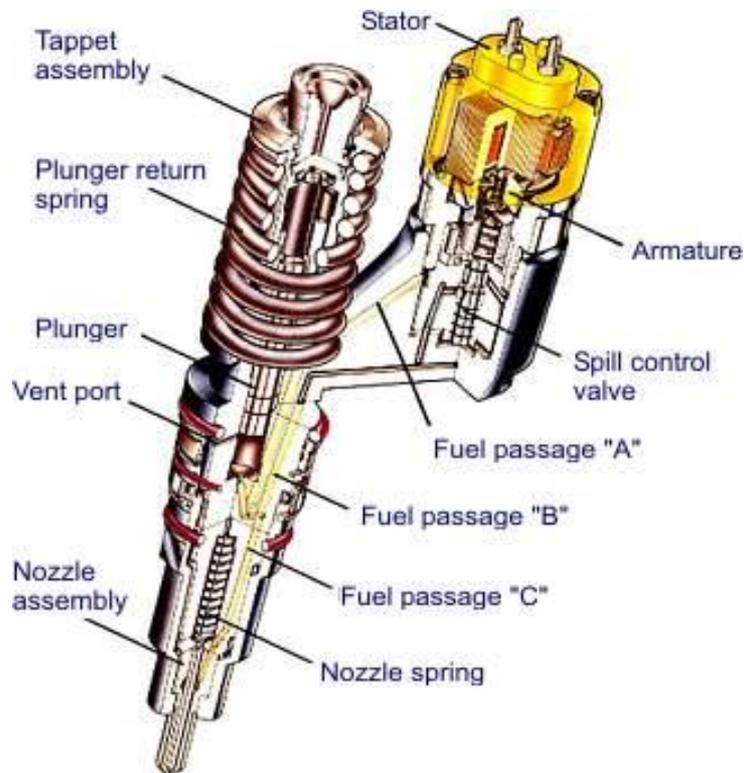


# Basic components of the classic injection system

- injection pump
  - inline pump
  - distributor pump with horizontal or radial piston
- low pressure pumps
- injectors
- injection timing control
- fuel filters
- pressure control valves
- high pressure hoses
- speed regulators
- controls and sensors

# Fuel injection unit

- Fuel injection system controlled electronically
- Each cylinder is powered by a separate injector
- Injection pressure up to 220 MPa (2200 bar)



- Injector drive - cams that drive the injector on the camshaft
- Fuel injection regulation (injection time) and injection start - control of the solenoid (electromagnetic) valve

# Idea of Common Rail

- The theoretical basis for common rail injection was given in 1987 by the University of Zurich researchers - the idea was sold to Fiat;
- In 1990, the industrial deployment of Unijet based on the Common Rail, an innovative installation developed by Magneti Marelli, the Fiat Research Center and Elasis began.
- This phase ended in 1994 when Fiat Auto decided to select the most experienced diesel engine partner - Robert Bosch to finalize development and deployment to industrial production.





# 1997 – Common Rail

- Alfa Romeo 156 JTD



Bosch, Simens, Denso, Delphi



- Mercedes-Benz C 220 CDI

JTD, HDI, DCI, CDI, TDCI, CRDI,  
CDTI, CTDI, TDI



# Common Rail Development

## *Based on Bosch*

1997 - 1st generation system - maximum pressure in the rail to 1400 bar, electromagnetic injectors;

2001 - second generation system - maximum pressure up to 1600 bar, dose divided into 5 smaller;

2005 - 3rd generation system - injection pressure up to 1800 bar, use of piezo injectors

2005 - 4th generation system - injection pressure 2200 - 2500 bar, trucks

# Rail

Thick-walled steel pipe with connectors for connection of fuel lines, pressure sensor and fuel pressure control valve

The purpose of the distributor is to collect the fuel under high pressure and damping pressure pulsations originating from the high-pressure pump

The pressure in it is constant because its volume is much higher than the injection dose and the volume of the delivery tubing





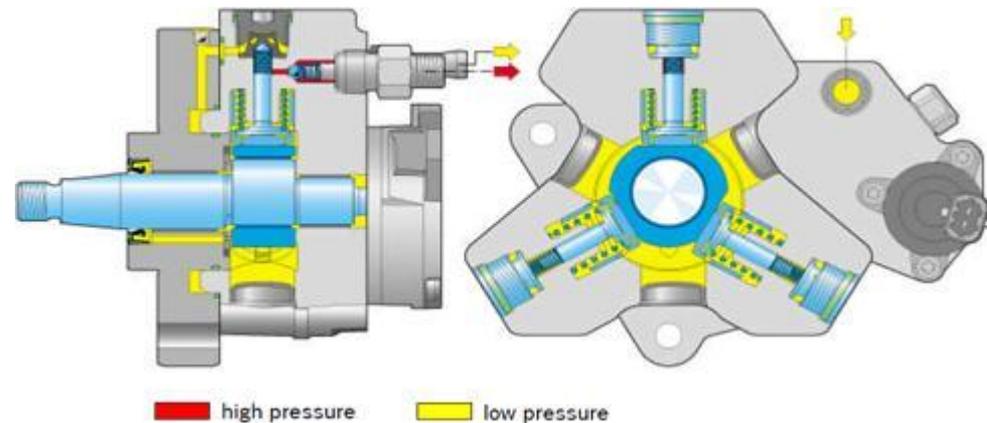
# High pressure pump

Task: Generate sufficiently high fuel pressure in all operating conditions and throughout the life of the vehicle; Fuel up to 200 MPa

Generates continuous pressure independent of fuel injection and directs them to the rail.

The pump can be driven by a camshaft pinion or camshaft gear directly coupled to the camshaft.

Radial piston pump equipped with three delivery sections





## Forming the mixture inside the combustion chamber and starting self-ignition:

1. The fuel is injected into the hot air and remains as a slime of liquid particles (fuel mist - slime).
2. The fuel evaporates when it reaches the evaporated temperature.
3. Fuel vapors mix with hot air.
4. The fuel vapors heat up until they reach the autoignition temperature.
5. The fuel-air mixture is self-igniting.



# questions

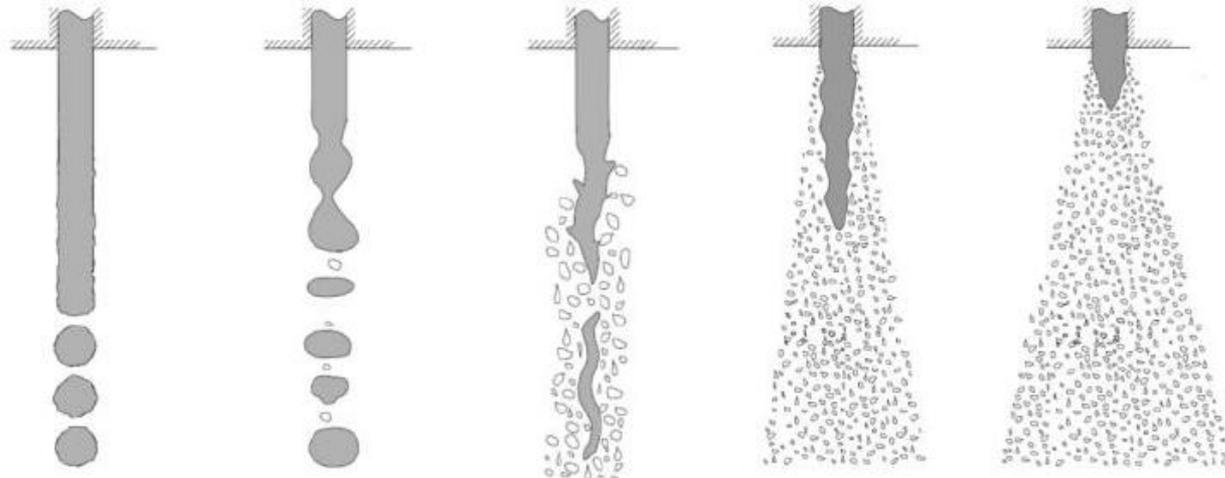
- +// of common rail and fuel injector units,
- Why fuel injectors are constantly improved?
- What does it mean pre-injection and post-injection, and why we have it??



**Greater pressure  
Better combustion**



# WHY DIESEL FUEL INJECTORS ARE CONSTANTLY IMPROVED?

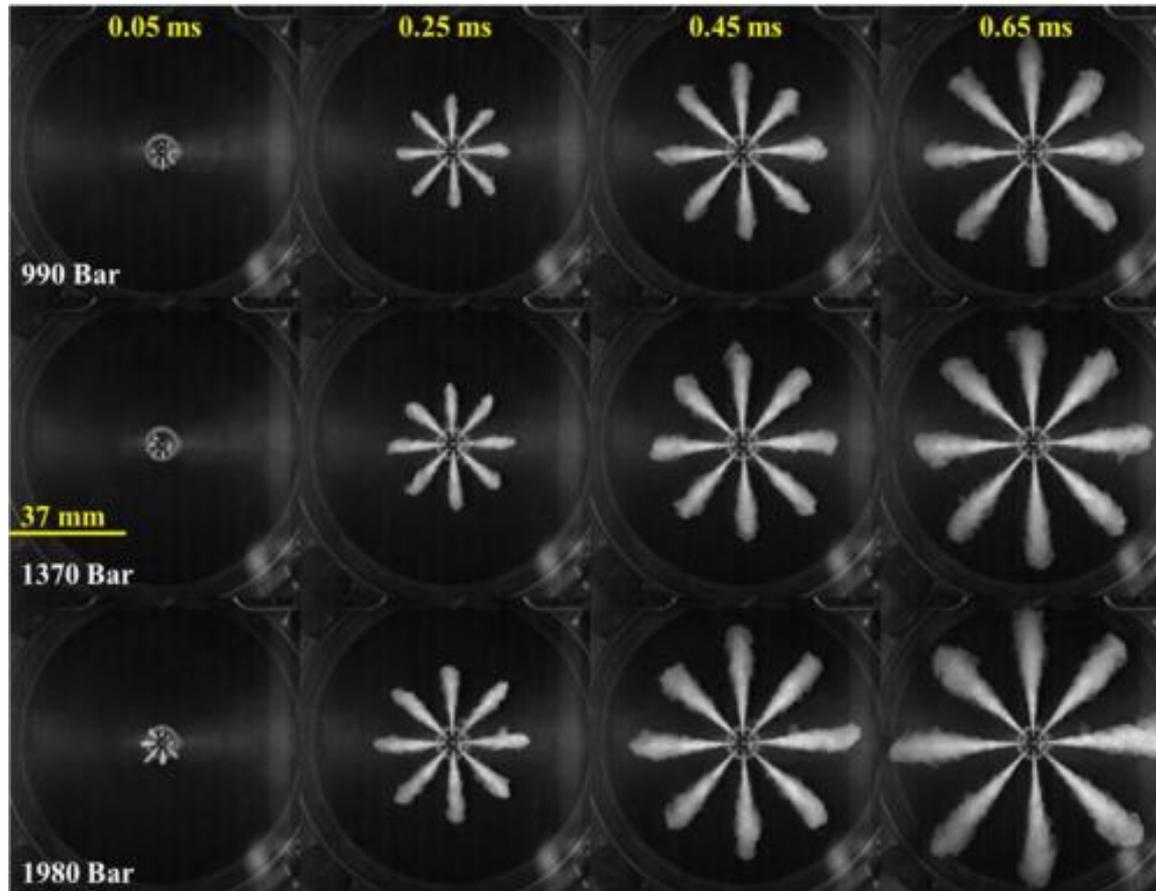


Pressure of fuel injection

- Diesel fuel injectors have to put atomized spray into combustion chamber to prepare mixture with air. Fuel has to be injected in specified position of piston, because temperature of compressed air is about 600-700 °C and only then the self-ignition can appear.



# WHY DIESEL FUEL INJECTORS ARE CONSTANTLY IMPROVED?





# UNIT INJECTORS



- Operated electronically
- Maximally 2 injections for 4-stroke cycle of engine
- Maximum injection pressure up to 250 MPa
- Produced by VAG group until 2010



## FUEL INJECTION STRATEGIES

# Politechnika Wroclawska

Unit injector



Common rail injector

