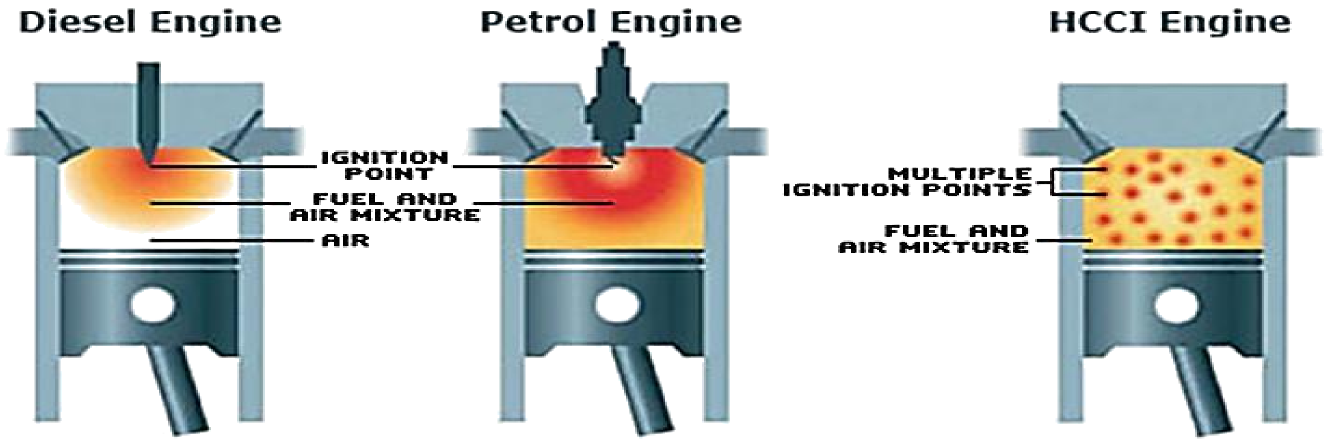
# UNIT V

# RECENT TRENDS

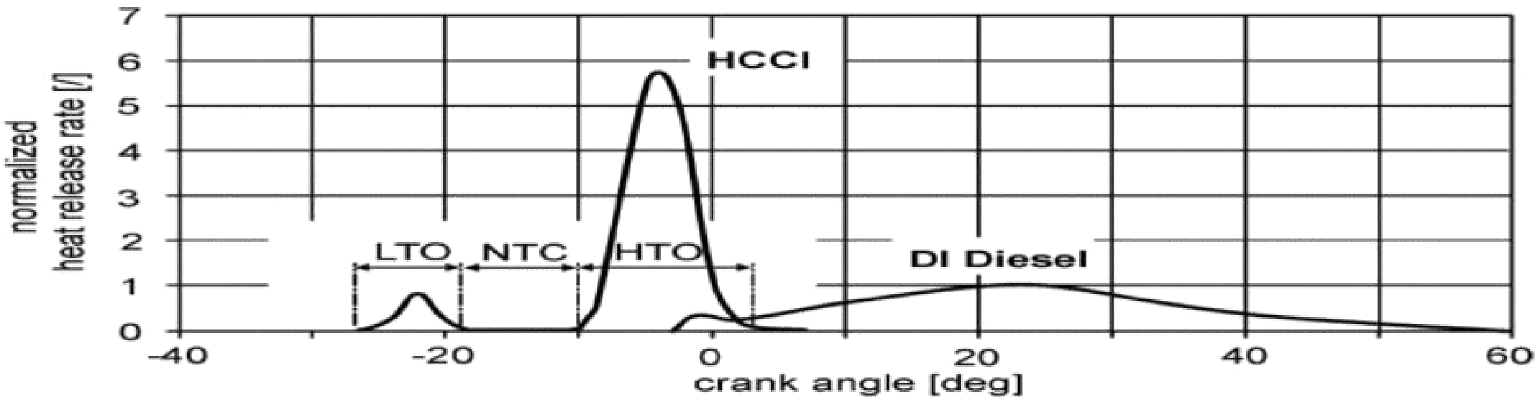
# Homogeneous charge compression ignition engine

- HCCI is the auto-ignition of a homogeneous mixture by compression.
- An HCCI engine can be described as a hybrid of SI (Spark Ignition) engine and CI (Compression Ignition) engine.
- As in a SI engine, fuel is homogenously premixed with air, but the fuel auto ignites from compression heating, as in a CI (Diesel) engine.



# HCCI Chemistry

- The HCCI oxidation chemistry determines the auto-ignition timing.
- The heat release rate, displays a two-stage heat release as shown in figure.
- The first stage of heat release is associated with low temperature kinetic reactions (low temperature oxidation, LTO).
- The second and much stronger one (main reaction) is the high temperature oxidation (HTO).
- The time delay between LTO and HTO is attributed to the negative temperature coefficient regime (NTC).



# Methods of fuel injection in HCCI engines

The following are the main three types of fuel injection in HCCI engines

- Early Direct Injection HCCI
- Late Direct Injection HCCI
- Premixed/Direct-injected HCCI Combustion

# Early Direct Injection HCCI Engines

- In early direct injection the fuel is injected well before the conventional fuel injection.
- In this the fuel is approximately injected well before 23° before combustion TDC.
- This gives sufficient time for the formation of homogeneous mixture.

# Advantages Of Early DI – HCCI Engines

- By injecting the fuel in the compression stroke, the higher in-cylinder temperatures and densities can help vaporize the Diesel fuel and promote mixing.
- This allows cooler intake temperatures, reducing the natural tendency for early ignition.
- With a carefully designed fuel injectors, the possibility exists to minimize fuel wall wetting that can cause combustion inefficiency and oil dilution.
- Only one fuelling system is required for both HCCI and conventional Diesel operation.

# Disadvantages Of Early DI – HCCI Engines

- It causes wall wetting due to over penetration of fuel.

- Controlling combustion phasing is still a critical issue for early-DI HCCI because injection timing does not provide an effective means of directly controlling combustion phasing as in conventional Diesel combustion.

# Late Direct Injection HCCI Engine

- To achieve the late DI – HCCI modulated kinetic (MK) combustion system is used.
- A long ignition delay is extended by retarding the injection timing from 7° before TDC to 3° after TDC
- High levels of EGR, sufficient to reduce the oxygen concentration to 15-16%.
- Rapid mixing is achieved by combining high swirl with toroidal combustion-bowl geometry.

# Advantages Of Late DI – HCCI Engines

- $NO_x$ emissions were reduced substantially (to about 50 ppm) without an increase in Particulate Matter.
- Combustion noise was also significantly reduced.
- With this late DI HCCI technique, combustion phasing is controlled by injection timing.

# Disadvantages Of Late DI – HCCI Engines

- The operating range for the first generation MK system is limited to about one-third of peak torque and half speed.

# Premixed / Direct-injected HCCI Combustion

- In this system, most of the fuel is injected into the intake manifold to form a homogeneous pre-mixture and is ignited with a small amount of fuel directly injected into the cylinder.

# Advantages of Premixed DI - HCCI engines

- This system can reduce both $NO_x$ and smoke emissions better than ordinary Diesel engines.

- Smoke is reduced near-uniformly as the premixed fuel ratio is increased.

# HCCI Challenges

There are many obstacles that must be overcome in order to realize the advantages of HCCI combustion in modern engines.

- Combustion Phasing Control
- Noise, UHC and CO Emissions
- Operation Range
- Cold Start
- Homogeneous Mixture Preparation

# Benefits Of HCCI Combustion

- Since HCCI engines are fuel-lean, they can operate at diesel-like compression ratios (>15), thus achieving 30% higher efficiencies than conventional SI gasoline engines.
- Homogeneous mixing of fuel and air leads to cleaner combustion and lower emissions. Because peak temperatures are significantly lower than in typical SI engines, $NO_x$ levels are almost negligible. Additionally, the technique does not produce soot.
- HCCI engines can operate on gasoline, diesel fuel, and most alternative fuels.
- HCCI avoids throttle losses, which further improves efficiency.

# Disadvantages of HCCI Combustion

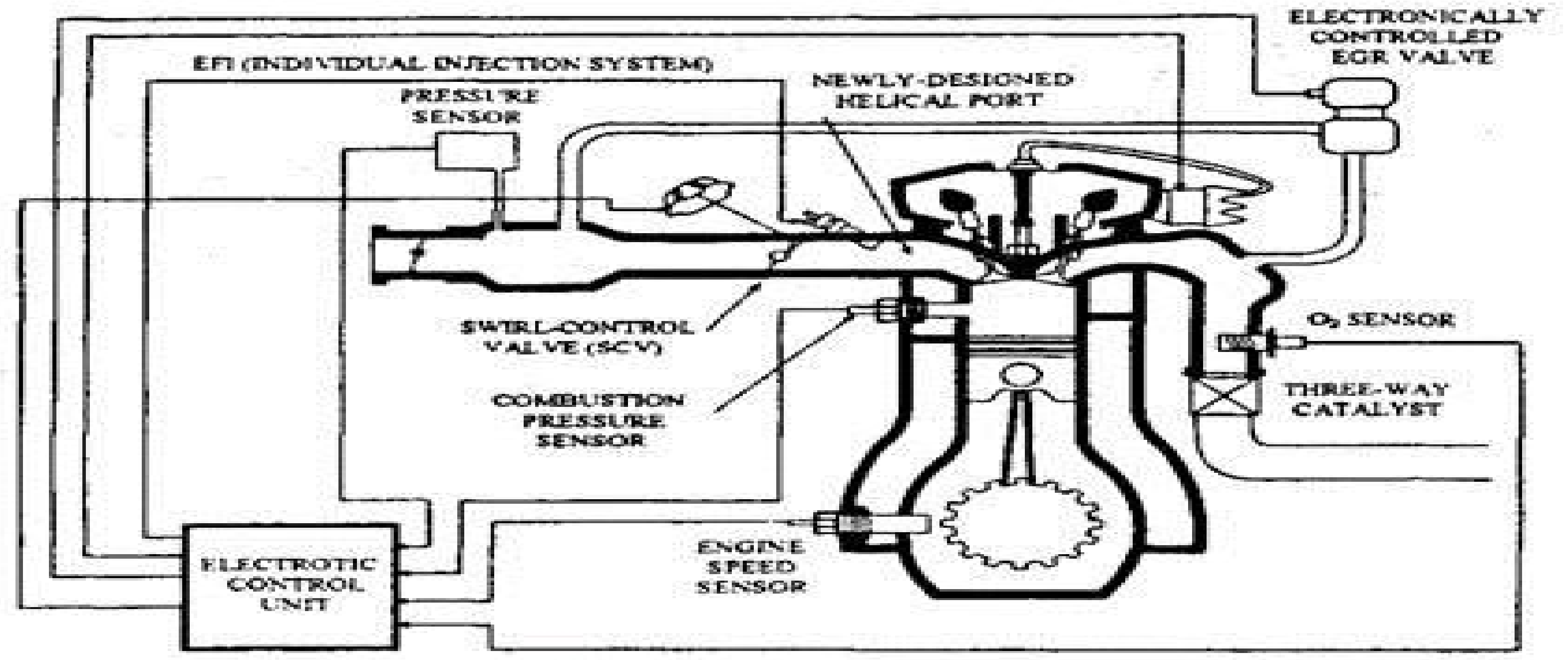
- Achieving cold start capability
- High in-cylinder peak pressures may damage the engine.
- High heat release and pressure rise rates contribute to engine wear.
- Auto-ignition is difficult to control, unlike the ignition event in SI and diesel engines, which are controlled by spark plugs and in-cylinder fuel injectors, respectively.
- HCCI engines have a small power range, constrained at low loads by lean flammability limits and high loads by in-cylinder pressure restrictions.
- Carbon monoxide (CO) and hydrocarbon (HC) pre-catalyst emissions are higher.

# Lean Burn Engine

- Lean-burn engines (both gasoline and diesel) enjoy higher fuel economy and cleaner emissions than conventionally tuned engines.
- By nature they use less fuel and emit fewer unburned hydrocarbons and greenhouse gases while producing equivalent power of a like-sized "normal" combustion engine.
- They achieve lean-burn status by employing higher combustion chamber compression ratios (higher cylinder pressure), significant air intake swirl and precise lean-metered direct fuel injection.
- The current generation of lean-burn engines run on ratios of around 17:1 or 25:1.

# Lean Burn Engine

- A lean-burn engine control system uses in-cylinder sensors to monitor combustion pressure, and a sequential injection system to control fuelling on a cylinder-by-cylinder basis.



# Lean Burn Engine

- A novel feature incorporated is the use of a swirl control valve (SCV) mounted in the intake system.
- The intake tract for each cylinder is divided into two passages.
- One passage is smooth, which allows maximum gas flow for good cylinder charging, and the other passage is fitted with a corkscrew-shaped flange, which introduces swirl into the incoming air.
- The engine ECU can switch air flow in one of the two tracts by actuating the SCV.
- The engine operates in a lean burn mode when it is running under light to medium load conditions.

# Lean Burn Engine

- The ECU directs the SCV to open-up the curved inlet passage to have well mixed incoming vapour due to a high level of turbulence through swirl.
- Because of the continuous monitoring of the exhaust gas oxygen concentration, these facilities permit the engine to produce high efficiency at A/F ratios up to 25:1.
- When the engine runs under high load conditions, specifically during overtaking or when hill climbing , the ECU switches to stoichiometric operation for maximum power.
- To achieve this the ECU directs the SCV to open the smooth intake passage and uses the oxygen sensor signal to maintain an A/F ratio of 14.7:1.

# Advantages and Disadvantages of Lean Burn Engine

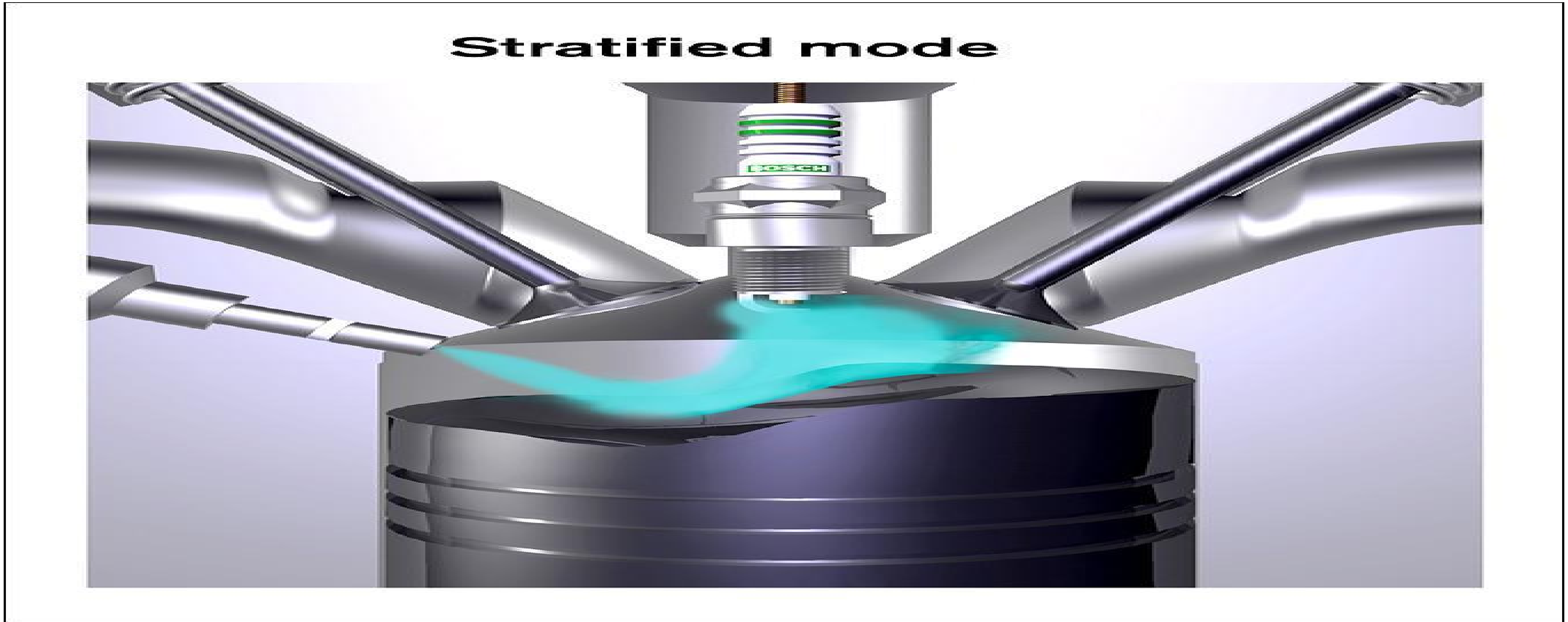
- Advantages
  - Higher fuel economy.
  - Emit fewer unburned hydrocarbons and greenhouse gases.
  - A lean burn mode is a way to reduce throttling losses.
- Disadvantages
  - Lean burning is that a complex catalytic converter system is required to reduce NOx emissions.
  - Relatively high cost.

# Stratified Charge Engine

- The fuel spray is directed by air motion or by the geometry of piston crown or by combination of the both towards spark plug.
- Rich mixture is provided close to the spark plug and combustion promotes ignition of a lean mixture in the remainder of the cylinder.
- Input of air is such that it generates a swirl in the cylinder.
- In a stratified charge engine, the fuel is injected into the cylinder just before ignition.
- This allows for higher compression ratios without "knock," and leaner air/fuel mixtures than in conventional internal combustion engines.

# Stratified Charge Engine

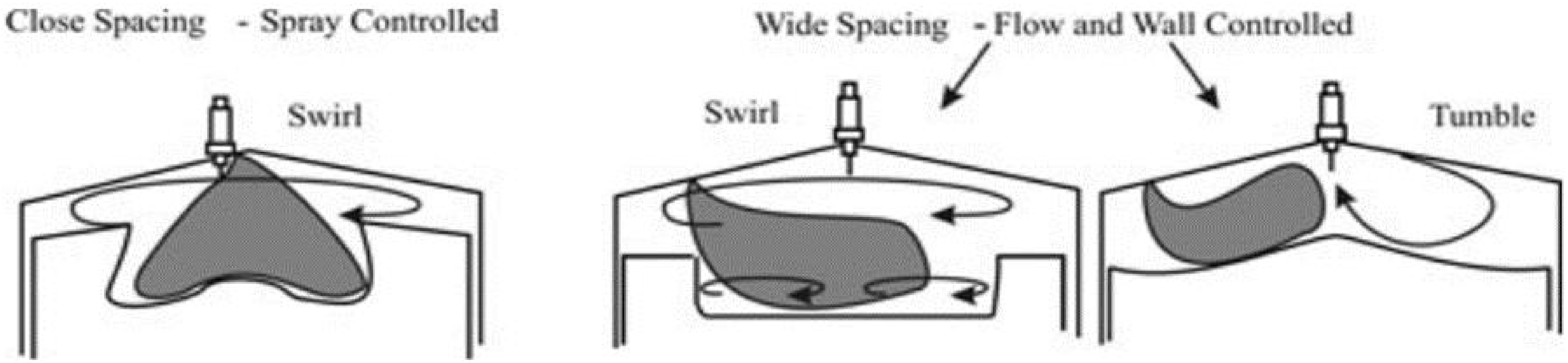
- As the fuel is ignited and burned, the surrounding air provides almost complete combustion before the exhaust port opens which further burns the lean mixture.



# Methods Of Charge Stratification

The charge stratification can be achieved by either of three ways,

- Spray Controlled
- Wall Controlled
- Flow controlled

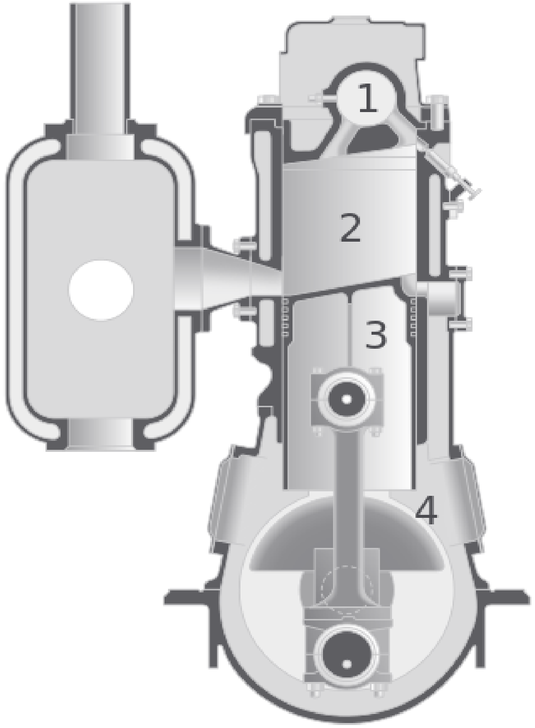


# Advantages and Disadvantages of Stratified Charge Engine

- Advantages
  - It can tolerate a wide variety of fuels.
  - It has low exhaust emissions.
  - It can be manufactured by existing technology.
- Disadvantages
  - Charge stratification results in lower power for the given size of engine.
  - Higher weight than conventional engine.
  - Cost is increased.

# Surface Ignition Engine

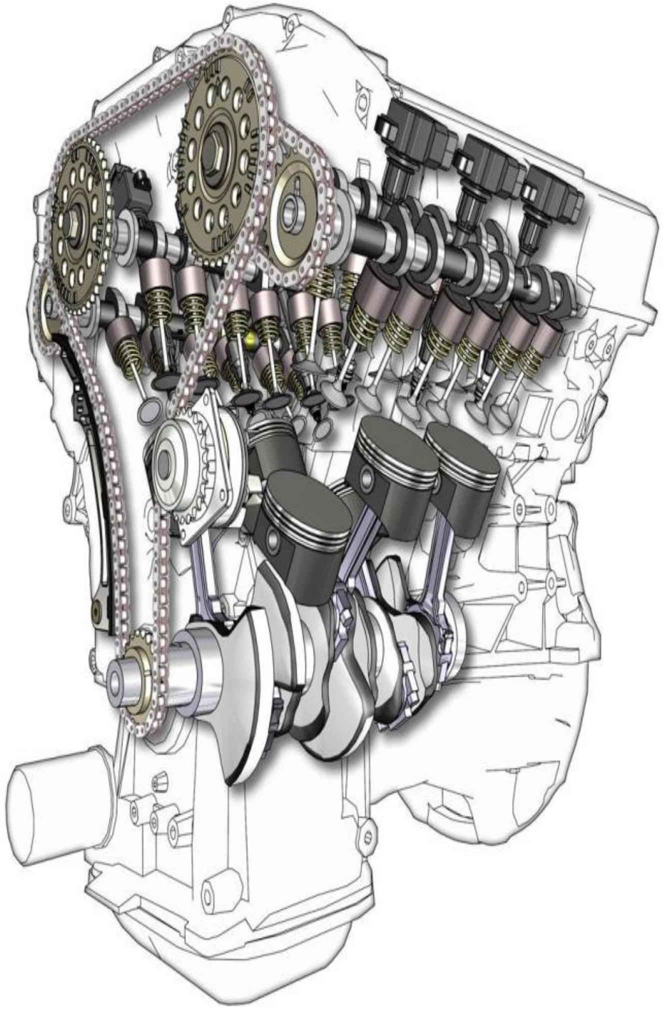
- It is an engine in which fuel is ignited by being brought into contact with a red-hot metal surface inside a bulb, followed by the introduction of air (oxygen) compressed into the hot-bulb chamber by the rising piston.
- There is some ignition when the fuel is introduced, but it quickly uses up the available oxygen in the bulb.
- Vigorous ignition takes place only when sufficient oxygen is supplied to the hot-bulb chamber on the compression stroke of the engine.
- Most surface ignition engines are produced as one -cylinder, low-speed two-stroke crankcase scavenged units.




1. Hot bulb
2. Cylinder
3. Piston
4. Crankcase

# Four Valve and Overhead Cam Engines

- Four Valve and Overhead cam setup is also called as dual overhead camshaft (DOHC) valve train.
- A typical DOHC engine has two camshafts and 4 valves per cylinder.
- One camshaft operates intake valves that are installed on one side, while another camshaft controls exhaust valves on the opposite side.
- With this design, camshafts can be installed further apart from each other.
- This allows the intake valves to be at a larger angle from the exhaust valves, which results in a more direct air flow through the engine with less obstruction.



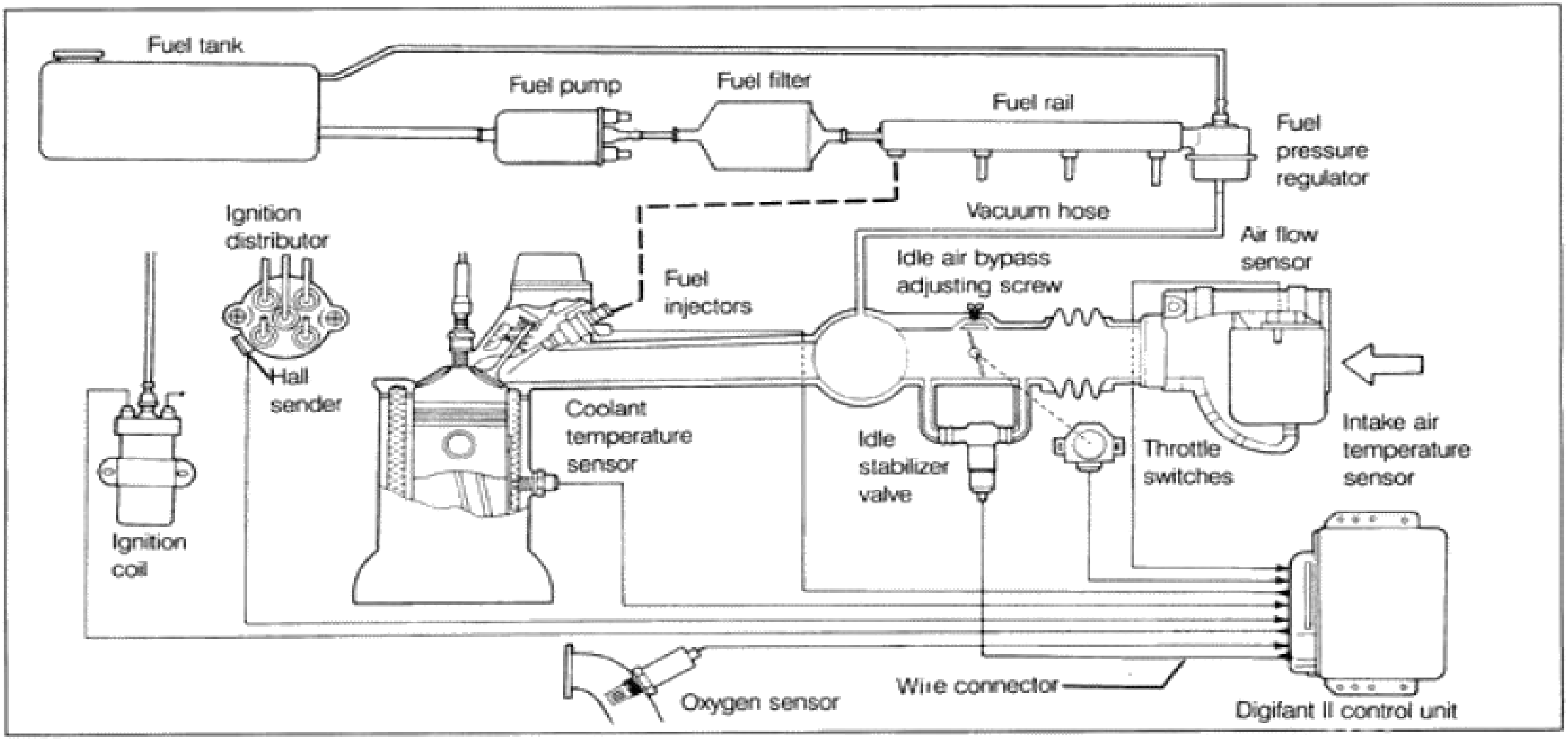
# Electronic Engine Management

- An engine control unit (ECU), most commonly called the powertrain control module (PCM), is a type of electronic control unit that controls a series of actuators on an internal combustion engine to ensure the optimum running.

- It does this by reading values from a multitude of sensors within the engine bay, interpreting the data using multidimensional performance maps (called Look-up tables), and adjusting the engine actuators accordingly.

A.U.Meenakshi Sundareswaran

# Electronic Engine Management

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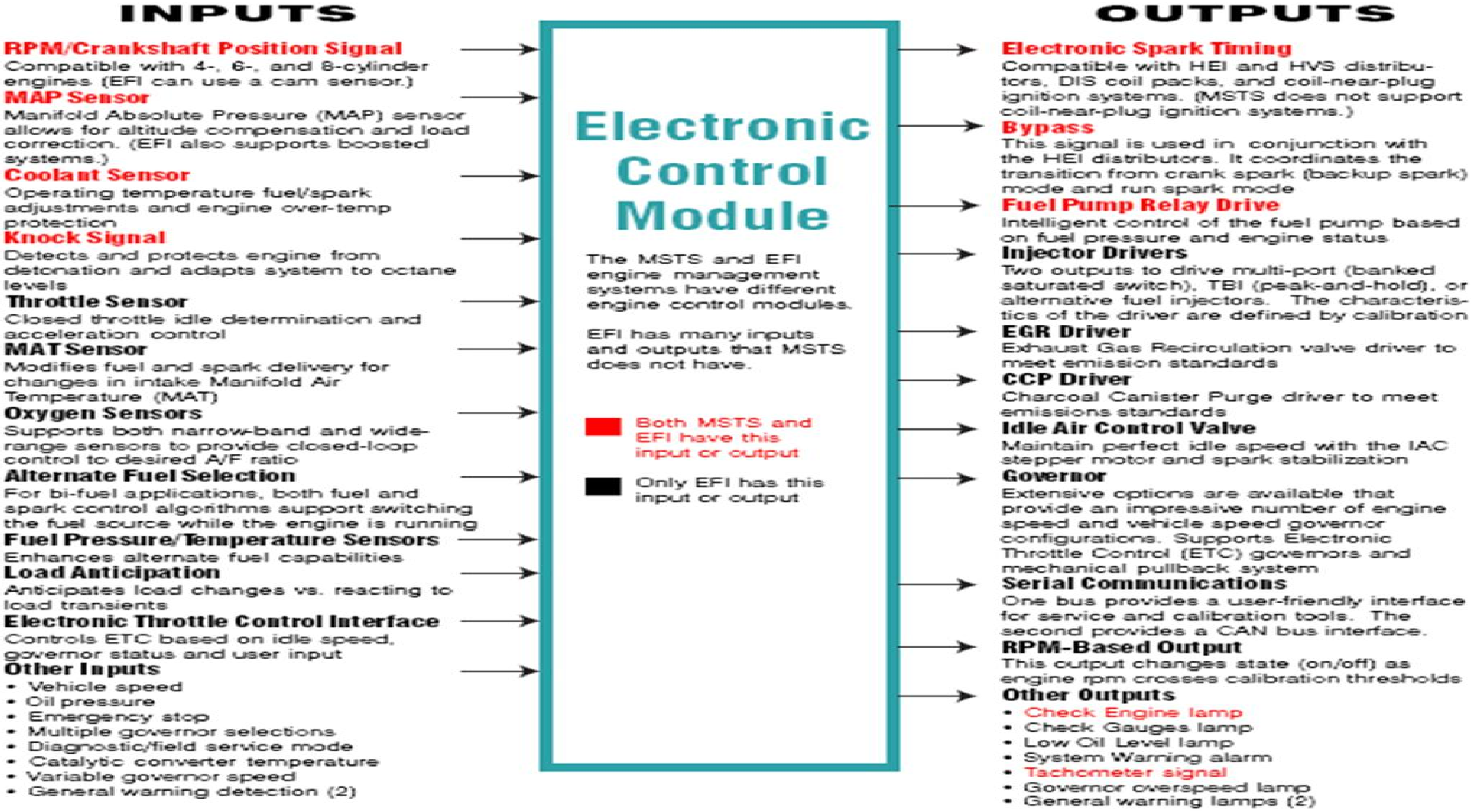
# Electronic Engine Management

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# Electronic Engine Management

**Oxygen sensor**

- The oxygen sensor provides information about the fuel mixture.
- The PCM uses this to constantly re-adjust and fine tune the air/fuel ratio.
- This keeps emissions and fuel consumption to a minimum.

**Coolant sensor**

- The coolant sensor monitors engine temperature.
- The PCM uses this information to regulate a wide variety of ignition, fuel and emission control functions.
- When the engine is cold, for example, the fuel mixture needs to be richer to improve drivability.

# Electronic Engine Management

**Throttle position sensor (TPS)**

- The throttle position sensor (TPS) keeps the PCM informed about throttle position.
- The PCM uses this input to change spark timing and the fuel mixture as engine load changes.

**Airflow Sensor**

- The Airflow Sensor, of which there are several types, tells the PCM how much air the engine is drawing in as it runs.
- There are several types of airflow sensors including hot wire mass airflow sensors and the older flap-style vane airflow sensors.

# Electronic Engine Management

**Manifold absolute pressure (MAP)**

- The manifold absolute pressure (MAP) sensor measures intake vacuum, which the PCM also uses to determine engine load.
- The MAP sensor's input affects ignition timing primarily, but also fuel delivery.

**Knock sensors**

- Knock sensors are used to detect vibrations produced by detonation.
- When the PCM receives a signal from the knock sensor, it momentarily retards timing while the engine is under load to protect the engine against spark knock.

# Electronic Engine Management

**Vehicle speed sensor (VSS)**

- The vehicle speed sensor (VSS) keeps the PCM informed about how fast the vehicle is traveling.
- This is needed to control other functions such as torque converter lockup.
- The VSS signal is also used by other control modules, including the antilock brake system (ABS).

**Crankshaft position sensor**

- The crankshaft position sensor serves the same function as the pickup assembly in an engine with a distributor.
- It monitors engine rpm and helps the computer determine relative position of the crankshaft so the PCM can control spark timing and fuel delivery in the proper sequence.
- The PCM also uses the crank sensor's input to regulate idle speed, which it does by sending a signal to an idle speed control motor or idle air bypass motor.