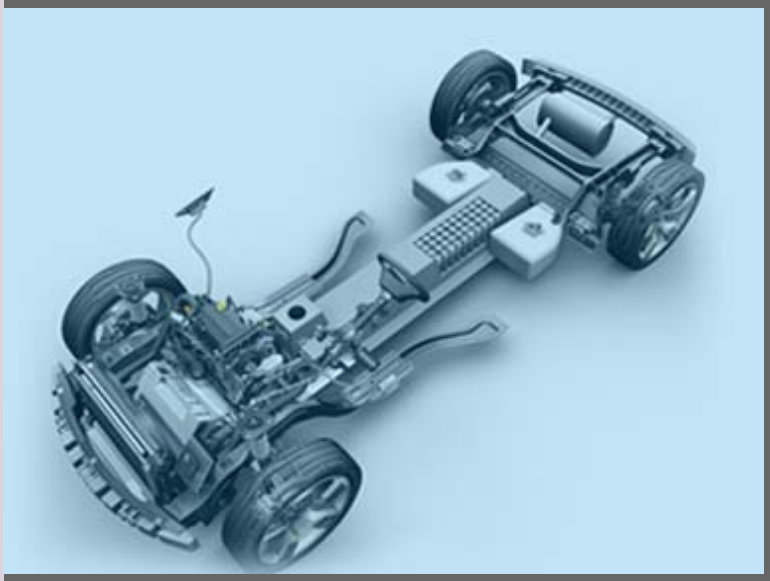

Course Name Engine Emissions

Department Mechanical Engineering

IIT Kanpur

Instructor Prof. BP Pundir

Next

Module 1: An Overview of Engine Emissions and Air Pollution

Lecture 1:Introduction to IC Engines and Air Pollution

The Lecture Contains:

Previous Next

Historical Overview of IC Engine Development

The modern reciprocating internal combustion engines have their origin in the Otto and Diesel Engines invented in the later part of 19th century. The main engine components comprising of piston, cylinder, crank-slider crankshaft, connecting road, valves and valve train, intake and exhaust system remain functionally overall similar since those in the early engines although great advancements in their design and materials have taken place during the last 100 years or so. An historical overview of IC engine development with important milestones since their first production models were built, is presented in Table 1.1

Table 1.1
Historical Overview and Milestones in IC Engine Development

Year	Milestone
1860-1867	J. E. E. Lenoir and Nikolaus Otto developed atmospheric engine wherein combustion of fuel-air charge during first half of outward stroke of a free piston accelerating the piston which was connected to a rack assembly. The free piston would produce work during second half of the stroke creating vacuum in the cylinder and the atmospheric pressure then would push back the piston.
1876	Nikolaus Otto developed 4-stroke SI engine where in the fuel-air charge was compressed before being ignited.
1878	Dougald Clerk developed the first 2-stroke engine
1882	Atkinson develops an engine having lower expansion stroke than the compression stroke for improvement in engine thermal efficiency at cost of specific engine power. The Atkinson cycle is finding application in the modern hybrid electric vehicles (HEV)
1892	Rudolf Diesel takes patent on engine having combustion by direct injection of fuel in the cylinder air heated solely by compression , the process now known as compression ignition (CI)
1896	Henry Ford develops first automobile powered by the IC engine
1897	Rudolph Diesel developed CI engine prototype, also called as the Diesel engine
1923	Antiknock additive tetra ethyl lead discovered by the General Motors became commercially available which provided boost to development of high compression ratio SI engines
1957	Felix Wankel developed rotary internal combustion engine
1981	Multipoint port fuel injection introduced on production gasoline cars
1988	Variable valve timing and lift control introduced on gasoline cars
1989-1990	Electronic fuel injection on heavy duty diesel introduced
1990	Carburettor was replaced by port fuel injection on all US production cars
1994	Direct injection stratified charge (DISC) engine powered cars came in production by Mitsubishi and Toyota

Previous Next

IC Engine Classification based on Combustion Process

IC Engines may be classified based on the state of air-fuel mixture present at the time of ignition in the engine cycle, the type of ignition employed and the nature of combustion process subsequent to ignition of the air-fuel mixture.

A. Physical State of Mixture

- Homogeneous Charge
  - Premixed outside(conventional gasoline and gas engines with fuel inducted in the intake manifold)
  - Premixed in-cylinder: In- cylinder direct injection and port fuel injection
- Heterogeneous Charge

B. Ignition Type

- Positive source of Ignition e.g., spark ignition
- Compression ignition

C. Mode of Combustion

- Flame propagation
- Spray combustion

This course primarily deals with combustion generated engine emissions and approaches the subject from the point of fundamentals of engine combustion processes. The engines are therefore, categorized based on the mode of ignition employed viz., '***Spark Ignition (SI) Engines***' and '***Compression Ignition (CI) Engines***'.

Method of ignition has been adopted as the main criterion of classification as in the conventional type IC engines it governs

- Fuel type
- Mixture preparation methods
- Progression of combustion process
- Combustion chamber design
- Engine load control, and
- Operating and emission characteristics

More advanced and newer combustion systems are dealt as special variations of the IC engines. For example the direct injection stratified charge (DISC) engine is taken as a special variant of SI engine. The homogeneous charge compression ignition engines are being developed around the conventional SI and CI engines and are discussed accordingly.

Previous Next

Main Events in Four-Stroke SI Engine Cycle

Figure 1.1 shows typical pressure –crank angle (P-θ) history for a four-stroke SI engine cycle. The sequence of main events in the cycle are given in Table 1.2

Figure 1.1	Sequence of Events in 4-Stroke SI Engine Cycles

Table 1.2

Sequence of Events in 4-Stroke SI Engine Cycle

Event	Time of Occurrence, Crank angle
Intake valve opens (IO)	20 - 5º CA bTDC at the end of exhaust stroke
Exhaust valve closes (EC)	8 to 20º CA aTDC in the beginning of intake stroke
Intake valve closes (IC)	60 -40º CA aBDC in the beginning of compression stroke
Spark ignition	45 -15º CA bTDC towards the end of compression stroke
Combustion by turbulent flame propagation	Begins shortly after ignition up to 15 to 30º CA aTDC Early in the expansion stroke
Exhaust valve opens (EC)	50 -30º CA bBDC Shortly before the end of expansion stroke

CA: Crank Angle, ATDC: After Top Dead Centre; BTDC: Before Top Dead Centre; ABDC: After Bottom Dead Centre;
BBDC:Before Bottom Dead Centre;

Previous Next

Main Events in Four-Stroke CI Engine Cycle

Figure 1.2 shows typical pressure –crank angle (P-θ) history for a four-stroke CI engine cycle. The sequence of main events in the cycle are given in Table 1.3

Figure 1.2 Main Events in Four-Stroke CI Engine Cycle

Table 1.3
Sequence of Events in 4-Stroke CI Engine Cycle

Event	Time of occurrence, Crank angle
Intake valve opens (IO)	5 -20º CA bTDC at the end of exhaust stroke
Exhaust valve closes (EC)	8 to 20º CA aTDC in the beginning of intake stroke
Intake valve closes (IC)	40 -20º CA aBDC in the beginning of compression stroke
Start of Injection (SOI)	15-5º CA bTDC towards the end of compression stroke. Injection duration at full engine load about 15 to 25º CA
Start of combustion (SOC)	5 -0 º CA bTDC, (considering ignition delay after injection)
End of combustion (EOC)	20 to 30 CA aTDC in expansion stroke
Exhaust valve opens (EC)	40 to 30º CA bBDC Shortly before the end of expansion stroke