SNS COLLEGE OF TECHNOLOGY

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DEPARTMENT OF AUTOMOBILE ENGINEERING

23AUT202 – AUTOMOTIVE ENGINES AND EMISSION CONTROL

II YEAR / III SEMESTER

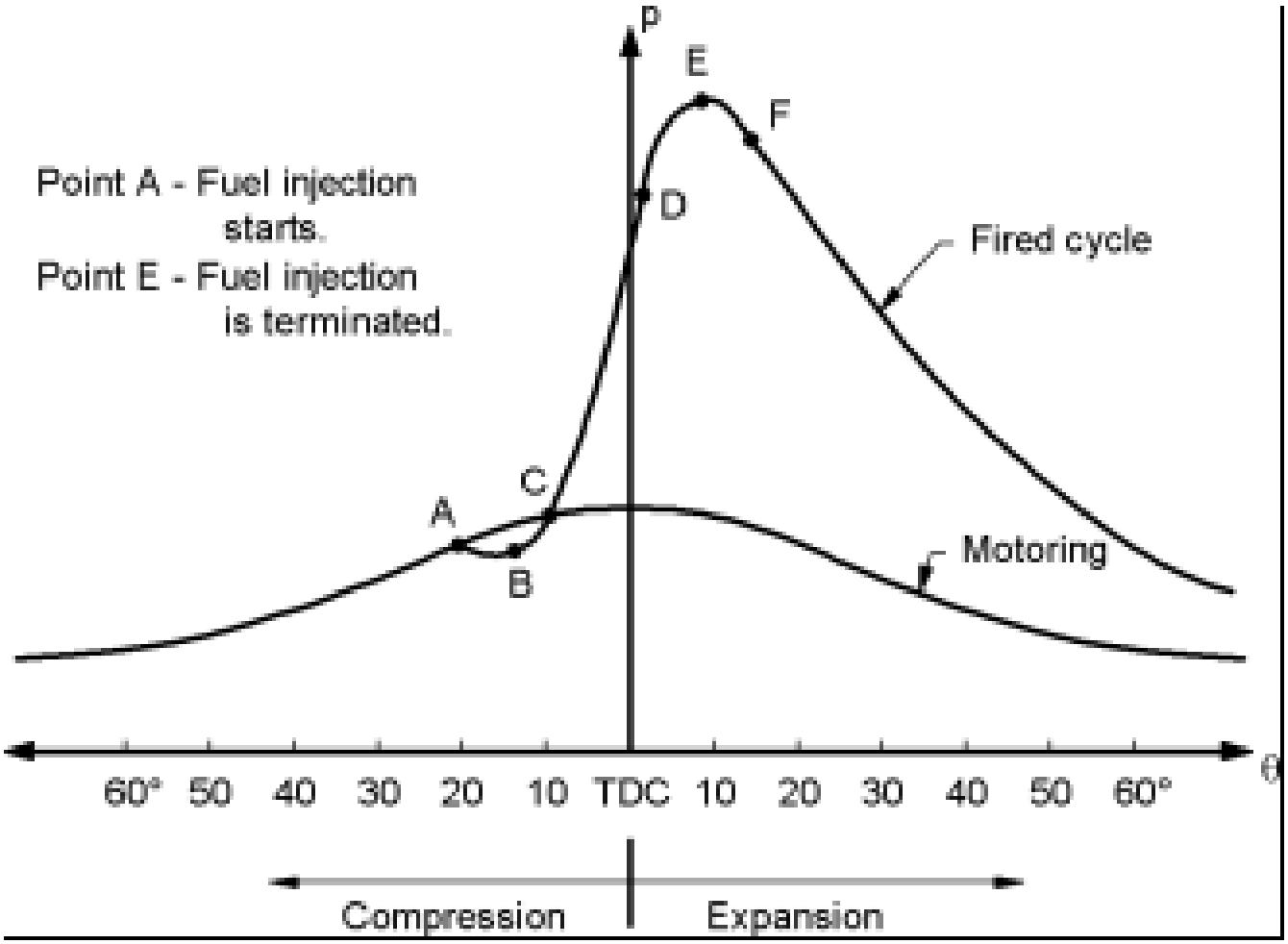
Topic – Introduction to Combustion in CI Engines

- C.I. engine only air sucks during suction and fuel is injected at the end of compression stroke.
- In S.I. engine nearly stoichiometric air fuel mixture is supplied while in C.I. engine 40 to 75% excess air is required for better combustion. For induction of this excess air, the size of C.I. engine compared to S.I. engine is always larger and heavier to generate the 1 same power.
- C.I. engine the combustion starts at I number of points simultaneously i.e. multipoint combustion takes place.
- In S.I. engine combustion takes place due to spark, whereas in C.I, engine combustion takes place due to compression ignition. As self-ignition temperature (SIT) of diesel is low, fuel can be ignited without spark.

- During compression stroke only air is compressed to higher pressure (CR = 16 to 22), so that temperature of air inside the cylinder increases (440 to 540°C) beyond SIT of diesel fuel. At the end of compression, diesel fuel is injected in liquid state at very high pressure (120 to 200 bar) with the help of fuel pump and injector.
- The atomized fuel vaporize, mix with air, and combustion starts.

Combustion Stages in C.I. Engines

- In case of compression ignition engines the air alone is compressed and raised to high pressure and temperatures in the compression stroke by using high compression ratios.
- The temperature of air attained is far above the self-ignition temperature of the diesel fuel used.
- The fuel is injected by a fuel pump into the combustion chamber by one or more jets under very high pressures of about 120-210 bar pressures at about (20 deg – 35 deg) before TDC.


P
E
F
D
Point A - Fuel injection starts.
Point E - Fuel injection is terminated.
Fired cycle
C
A
B
Motoring
60° 50 40 30 20 10 TDC 10 20 30 40 50 60°
Compression
Expansion

First stage (Ignition delay period)

- The fuel leaves the nozzles initially in the form of a jet, and later on, it disintegrates into a core of fuel surrounded by a spray envelope of air and fuel particles due to atomization, vaporization and mixing with hot air.
- During vaporization process of fuel it receives its latent heat from surrounding air and this causes a slight drop in pressure in the cylinder as shown by curve AB.
- As soon as the vaporization is over, the preflame reactions of the mixture start. During such chemical reactions the energy is released at slow rate and the pressure starts building up.
- Therefore, the preflame reactions first start slowly and then accelerates until the ignition of fuel takes place. It corresponds to point C on diagram.
- The time interval between the start of fuel injection and commencement of combustion is called the delay period.

Physical delay

- This represents the time interval from the time of injection of fuel to its attainment of self-ignition temperature during which the fuel is atomized, vaporized and mixed with air.

Chemical delay:

- After physical delay period is over, the time interval up to the time the fuel auto-ignites and flame appears is called chemical delay.
- During this period pre flame reactions take place. This period corresponds to ignition lag of S.I. engines.
- In practice, it is very difficult to separate exactly these two delay periods since the processes involved are very complex.

Second stage (Period of uncontrolled combustion)

- Once the delay period is over the mixture of fuel and air will auto-ignite since it is above the self-ignition temperature.
- The flame appears at one or more locations where concentration of fuel and air mixture is optimum. This is due to the fact that the mixture present in the combustion chamber at the time of ignition is extremely heterogeneous unlike the homogeneous mixture of S.I. engines.
- Once the flame appears the mixture in other regions will either be burnt by propagating flames or it will auto-ignite because of the heat transfer from the burnt mixture and high temperatures existing in the combustion chamber.
- The fuel which is accumulated during the delay period is now ready for combustion and it would burn at an extremely rapid rate causing a steep rise in cylinder pressure and temperature.
- The rate of pressure rise depends upon the fuel injected and accumulated, which is directly proportional to the time of injection and the engine speed.

Third stage (Period of controlled combustion)

- Once the fuel accumulated during the delay period is burnt in the period of uncontrolled combustion, the temperature and pressures in the cylinder will be so high that the further quantity of fuel injected will burn as soon as it leaves the nozzle provided sufficient oxygen is present in the cylinder.
- Therefore the rate of pressure rise can now be controlled by controlling the rate of fuel injection. This period of combustion is known as period of controlled combustion represented by curve DE.

Fourth state (After burning)

- Theoretically the combustion is completed at the point the maximum pressure is attained during the cycle corresponding to point E few degree after TDC.
- However, the burning of fuel continues during its expansion stroke due to reassociation of dissociated gases and any unburned fuel due to heterogeneous condition of mixture. This phase of combustion is called after burning.

Effect of Engine Variables on Delay Period

Compression ratio

- Increased compression ratio increases the density, pressure and temperature of the charge. Increased temperatures and pressure reduces the delay period.

Inlet pressure (supercharging)

- Increased inlet pressures increases the pressures in the compression stroke and reduces the delay period.

Intake temperature

Higher intake temperatures will result into high temperatures at the time of fuel injection, therefore, it will reduce the delay period.

Effect of Engine Variables on Delay Period

Engine speed

- Increased speed will increase the delay period in terms of degrees of crank rotation, since the fuel pump is driven by the engine through gears. Therefore, during the delay period more fuel will be accumulated in the cylinder with increased speed and burning of this fuel during the period of uncontrolled combustion will result into high rate of pressure rise and high temperatures. It also results into better mixing of fuel and air due to increased turbulence.

Jacket water temperature

- Increased jacket water temperature increases the air temperature in the cylinder, hence, reduces the delay period.

Load on engine

- Increased loads on the engine reduces delay period. Since the air-fuel ratio decreases with the increase in operating temperatures.

Effect of Engine Variables on Delay Period

Injection pressure

- Increased injection pressures will give better atomization of fuel. It generally tends to reduce the delay period slightly.

Fuels

- Higher the self-ignition temperature of the fuel, higher will be the delay period.

Injection timing

- If fuel is injected much before TDC the delay period is larger since the pressure and temperatures in the cylinder are low. It will give extremely high rate of pressure rise during the period of uncontrolled combustion.

Engine size

- It has no effect on delay period in terms of time. However, large engines operate at lesser speed, therefore, delay period in terms of crank angle is smaller. Hence, less fuel enters the cylinder and the engine will run smooth.

Thank You !