Lectures

8th Semester B. Tech. Mechanical Engineering

Subject: Internal Combustion Engines

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Chapter: Combustion in Compression Ignition Engines

Topic: Essential Features of Process- 02-05-2020

Essential Features of Process:

1. In case of compression ignition engines fuel is injected into the engine cylinder towards the end of the compression process, just before the desired start of combustion.
2. The liquid fuel is injected at high velocity as one or more jets through small orifices or nozzles in the injector tip.
3. The fuel gets atomized into small droplets and penetrates into the combustion chamber.
4. The fuel vaporizes and mixes with the high temperature and high pressure air in the cylinder.
5. Since the pressure and temperature of air in the combustion chamber are above the ignition point of fuel, a portion of the already mixed fuel and air gets ignited after a certain delay period of few crank angle degrees.
6. The cylinder pressure increases as combustion of fuel-air mixtures occurs.
7. This makes the remaining fuel-air mixture to burn rapidly by shortening the delay at high temperatures.
8. Injection of fuel continues until the desired amount of fuel has entered the cylinder.
9. Atomization, vaporization, fuel-air mixing and combustion continues until essentially all the fuel has passed through each process.

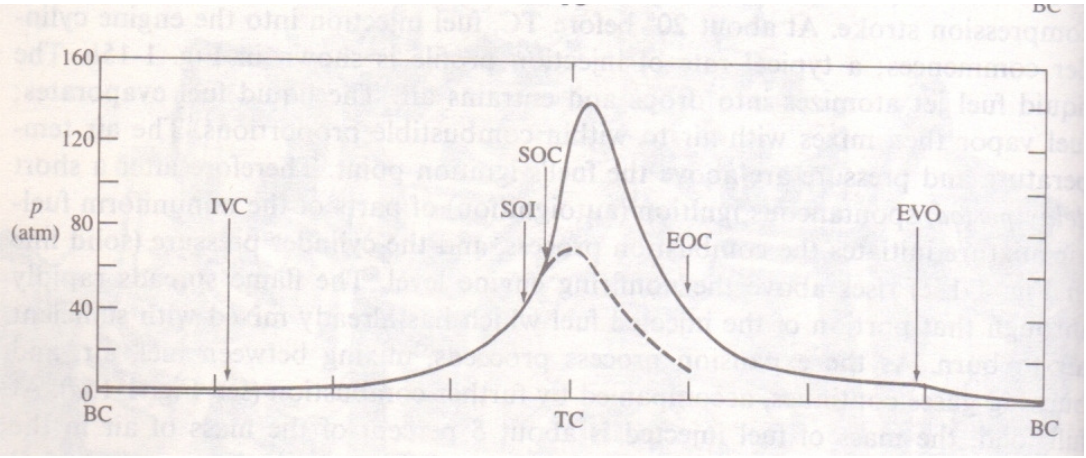

Fig. Pressure Versus Crank Angle Diagram For Combustion In CI Engines Under Motoring and Firing Modes.

Stages Of Combustion Process in Compression Ignition Engines:

The following **heat release rate versus crank angle diagram** shows the various stages of combustion for a compression ignition engine.

The various stages of combustion are:

1. **Ignition delay (ab):**
   The period between the start of fuel injection into the combustion chamber and the start of combustion
   [determined from the change in slope on the p-Θ diagram, or from a heat release analysis of the p(Θ) data, or from a luminosity detector].
2. **Premixed or rapid combustion phase (bc):**
   In this phase, combustion of the fuel which has been mixed with air to within the flammability limits during the ignition delay period occurs rapidly in a few crank angle degrees.
   In addition to this some of the fuel being injected during this phase also burns.
   Therefore a high heat release rate is a characteristic feature of this phase.
3. **Mixing-controlled combustion phase (cd):**
   Once the fuel accumulated during the ignition delay period has been consumed, the burning rate (or heat release rate) is controlled by the rate at which the mixture becomes available for burning.
   Several processes involved in compression ignition engine combustion are:
   (i) Liquid fuel atomization
   (ii) Vaporization
   (iii) Mixing of fuel vapor with air, and
   (iv) Pre-flame chemical reactions
   In this phase the rate of burning is controlled by the fuel vapor-air mixing process.
   The heat release rate may or may not reach a second (usually lower) peak in this phase.
   The heat release rate decreases after the end of fuel injection during this phase.
4. **Late combustion phase (de):**
   Heat release still continues at a lower rate during the expansion stroke. The reasons are:
   (i) A small fraction of the fuel may not have yet burned.
   (ii) A fraction of fuel energy present in soot and fuel-rich combustion products may be released.
   (iii) The cylinder charge for the heterogeneous combustion being non-uniform and mixing during this phase promotes more complete combustion.
   The temperature of the burned gas mixture decreases towards the end of expansion process resulting in a drop in the kinetics of combustion and decreasing the dissociation of combustion products.

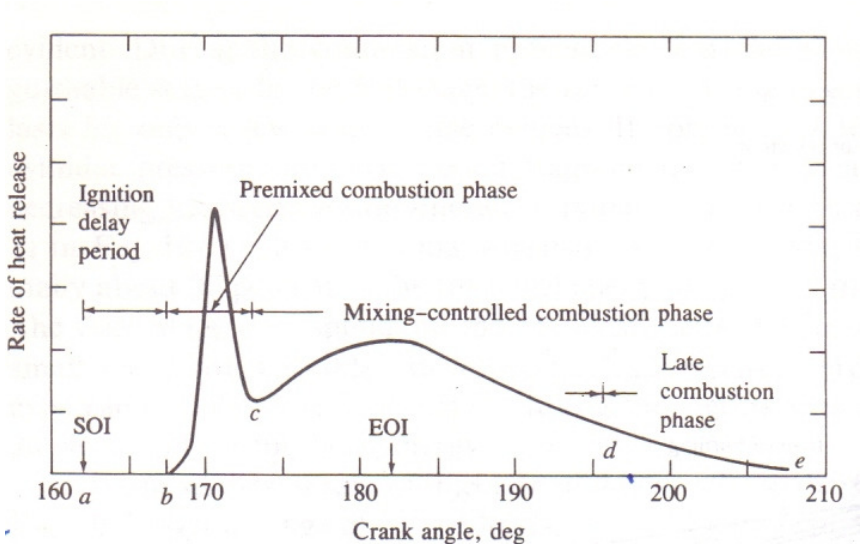

Fig. Heat Release Rate Versus Crank Angle Diagram For Combustion in CI engines

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Text Book:
Internal Combustion Engine Fundamentals
By John B Heywood
Published By: McGraw-Hill Book Company