4ME6A: I.C. ENGINES

I Mid-Term Examination, 2017-18

B. Tech. (Mechanical) 4th Semester **Max. Marks: 20**

Date of Exam: 09.03.2018 **Roll No.:**

Q.1 Define the valve timing diagram and draw valve timing diagram for two stroke and four stroke CI engine. [6]

Q.2 Explain the combustion phases in CI engine. [6]

Q.3 A single cylinder, four stroke hydrogen fuelled SI engine delivers a brake power of 20 kW at 6000 rpm. The air-gas ratio is 8:1 and the calorific value of fuel is 11000 kJ/m^3. Tthe compression ratio is 8:1. If volumetric efficiency is 70%, indicated thermal efficiency is 33% and the mechanical efficiency is 90%, calculate the cubic capacity of the engine. **[OR]** [8]

Q.3 Explain the causes of the following emissions in CI engines. [8]

(a) NO_X (b) CO (C) HC

Also explain the working principal and working of the measuring instrument for any one of above species.

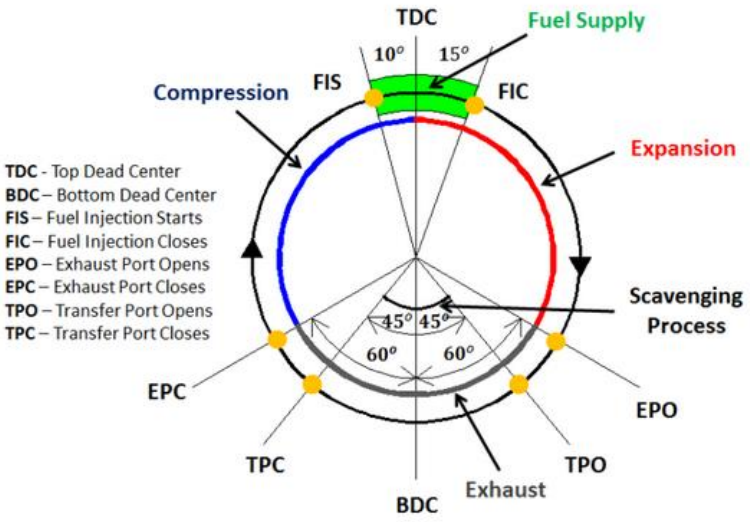
Solutions:

Q.1 Define the valve timing diagram and draw valve timing diagram for two stroke and four stroke CI engine.

Solutions:

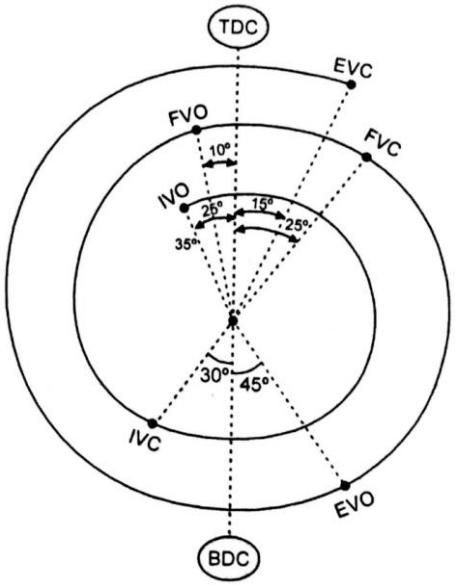
An automotive engine uses valves for it's 'breathing' (inhale/exhale) process. The engine's camshaft opens and closes the valves at a specific interval. The timing of opening & closing of valves is specified in degrees corresponding to the position of engine's pistons and shown in valve timing diagram. Engine valve timing is the most critical process of IC engines.

Valve timing diagram for two stroke CI engine



Valve timing diagram for four stroke CI engine

- IVO: 10°-25° before TDC
- IVC: 25°-50° after BDC
- EVO: 30°-50° before BDC
- EVC: 10°-15° after TDC
- SOI (FVO): 5°-10° before TDC
- EOI (FVC): 10°-15° after TDC



Q.2 Explain the combustion phases in CI engine.

Solution:

- Combustion in a CI engine is an unsteady process occurring simultaneously at many spots in a very non-homogeneous mixture at a rate controlled by fuel injection.
- Air intake into the engine is un-throttled, with engine torque and power output controlled by the amount of fuel injected per cycle.
- Compression ratios of modern CI engines range from 12 to 24.
- Injection time is usually about 20° of crankshaft rotation, starting at about 15° bTDC and ending about 5° aTDC.
- Ignition delay is fairly constant in real time, so at higher engine speeds fuel injection must be started slightly earlier in the cycle.
- Combustion process comprises the following series of events:
- *Atomization; Vaporization; Mixing; Self-Ignition and Combustion.*

Stages of combustion in CI engines:

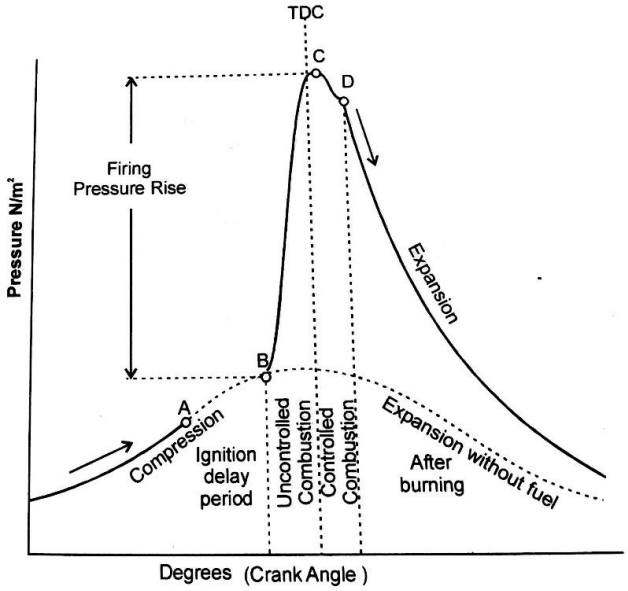
Ignition delay (ab). The period between the start of fuel injection into the combustion chamber and the start of combustion.

Premixed or rapid (uncontrolled) combustion phase (bc). In this phase, combustion of the fuel which has mixed with air to within the flammability limits during the ignition delay period occurs rapidly in a few crank angle degrees.

Mixing controlled combustion phase (cd). Once the fuel and air which premixed during the ignition delay have been consumed, the burning rate or heat release rate is controlled by the rate at which mixture becomes available for burning.

Late combustion phase (de). Heat release or burning continues at a lower rate well into the expansion stroke.

- The slower pressure rise that occurs after the initial fast rise.
- Combustion lasts for about 40° to 50° of engine rotation, much longer than the 20° of fuel injection.



Q.3 A single cylinder, four stroke hydrogen fuelled SI engine delivers a brake power of 20 kW at 6000 rpm. The air-gas ratio is 8:1 and the calorific value of fuel is 11000 kJ/m³. Tthe compression ratio is 8:1. If volumetric efficiency is 70%, indicated thermal efficiency is 33% and the mechanical efficiency is 90%, calculate the cubic capacity of the engine.

Solutions:

Energy Input = bp/ (η_m x η_{ith}) = 75.76 kJ/sec

Power stroke = N/ (2 x 60) = 50

Energy input/ power stroke = 75.76 / 50 = 1.52 kJ

Actual volume of H_2 x CV = 1.52 kJ

Actual volume of H_2 taken = 1.52 x 10^6 / 11000 = 138.18 cc

Actual volume of air taken in = A/F x 138.18 = 8 x 138.18 = 1105.44 cc

Swept volume V_s = Act. Volume / η_v = 1105.44 / 0.7 = 1579.2 cc

Cubic capacity of the engine = Vs x k = 1579.2 x 1 = 1579.2 cc

OR

Q.3 Explain the causes of the following emissions in CI engines. [8]

(a) NOX (b) CO (C) HC

Also explain the working principal and working of the measuring instrument for any one of above species.

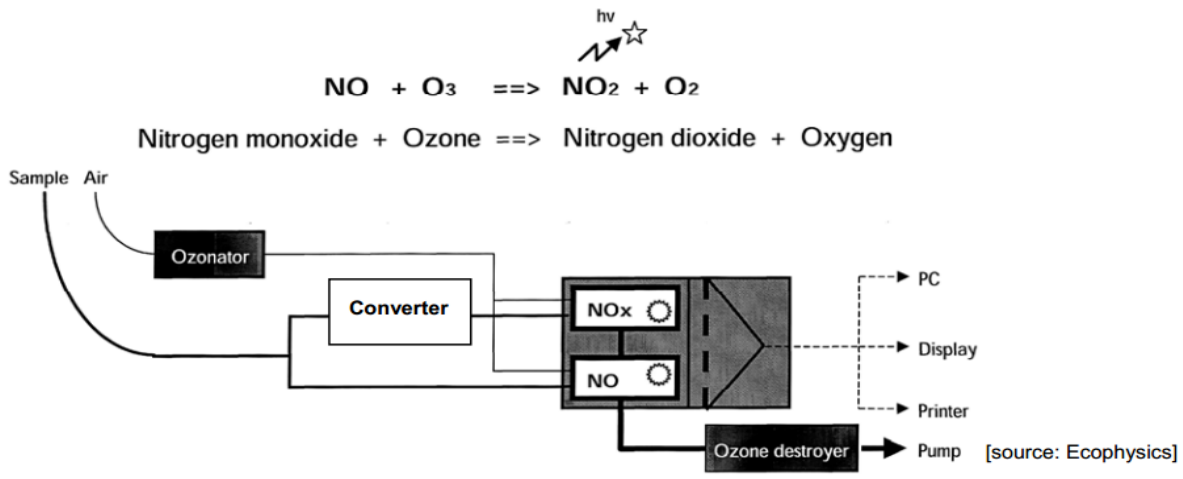
Solutions:

(a) NOx:

- A chemi-luminescence detector (CLD) is the industry standard method of measuring nitric oxide (NO) concentration.
- The reaction between NO and O_3 (ozone) emits light.
- This reaction is the basis for the CLD in which the photons produced are detected by a photo multiplier tube (PMT).
- The CLD output voltage is proportional to NO concentration.
- The light-producing reaction is very rapid so careful sample handling is important in a very rapid response instrument.

  $NO + O_3 \rightarrow NO_2^* + O2$

  $NO_2^* \rightarrow NO_2 + hv$
- In order to measure NO2 in the sample gas, it has first to be converted into NO.
  - $NO_2 + C \rightarrow NO + CO$



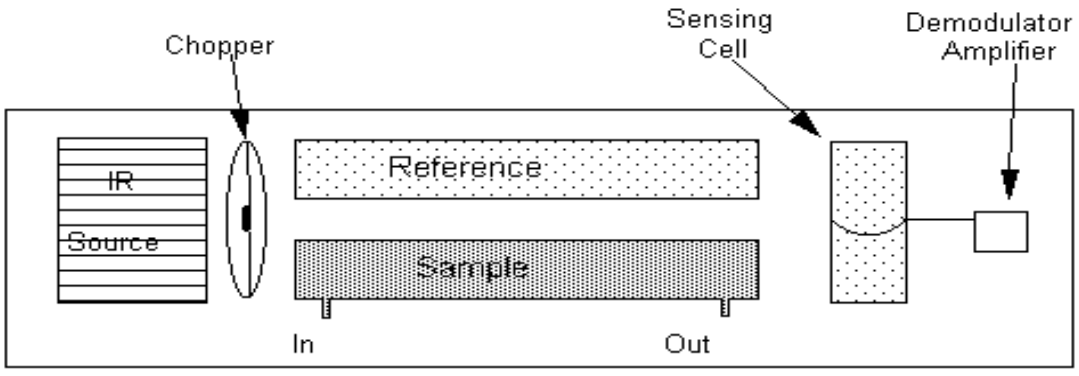
(b) CO

A spectrum shows the light absorbed as a function of wavelength (or frequency).

a. Each compound shows a different spectrum for the light absorbed.
b. All the spectroscopic analyzers work on the principle that the quantity of energy absorbed by a compound in a sample cell is proportional to the concentration of the compound in the cell.

Non-Dispersive Infra-red (NDIR) Analyzers:

- In the NDIR analyzer the exhaust gas species being measuring is used to detect itself. This is done by selective absorption.
- The infrared energy of a particular wavelength or frequency is peculiar to a certain gas in that the gas will absorb the infracted energy of this wavelength and transmit the infrared energy of other wavelengths.
- For example, the absorption band for carbon monoxide is between 4.5 and 5 microns.
- So the energy absorbed at this wavelength is an indication of the concentration of CO in the exhaust gas.
- NDIR consists of two infrared sources, interrupted simultaneously by an optical chopper.
- Radiation from these sources passes in parallel paths through a reference cell and a sample cell to opposite side of a common detector.

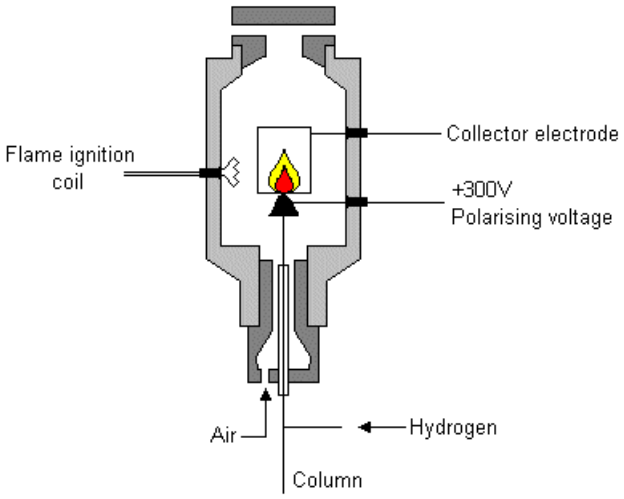


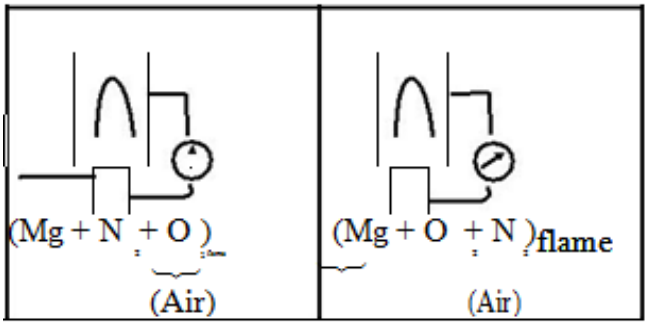
- The sample cell contains the compounds to be analyzed, whereas this compound is not present in the reference cell. The reference cell is usually filled with an inert gas, usually nitrogen.

- The detector is divided into two equal volumes by a thin metallic diaphragm.
- When the chopper blocks the radiation, the pressure in both parts of the detector is same and the diagram remains in the neutral position. As the chopper blocks and unblocks the radiation, the radiant energy from one source passes through the reference cell unchanged whereas the sample cell absorbs the infrared energy at the wavelength of the compound in cell.
- The absorption is proportional to the concentration of the compound to be measured in the sample cell. Thus unequal amounts of energy are transmitted to the two volumes of the detector and the pressure differential so generated causes movement of the diaphragm and a fixed probe.
- The signal is a function of the concentration of the compound to be measured.
- The NDIR can accurately measure CO, CO_2 and those hydrocarbons which have clear infrared absorption peaks.

(C) HC

- A hydrogen-air flame contains a negligible amount of ions. However, if even trace amounts of an organic compound such as HC are introduced into the flame, a large number of ions are produced.
- If a polarized voltage is applied across the burner jet and an adjacent collector, an ion migration will produce a current proportional to the number of ions and thus to the HC concentration present in the flame.
- The output of the FID depends on the number of carbon atoms passing through the flame in a unit time.
- Doubling the flow velocity would also double the output. Hexane (C_6H_{14}) would give double the output of propane (C_3H_8). Therefore, FID output is usually referred to a standard hydrocarbon, usually as ppm of normal hexane.
- FID analyzer is a rapid, continuous and accurate method of measuring HC in the exhaust gas.


Flame ignition coil
Collector electrode
+300V
Polarising voltage
Air
Hydrogen
Column


(Mg + N + O)
(Air)
(Mg + O + N)flame
(Air)