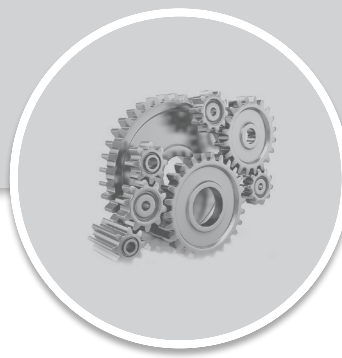
MECHANICAL ENGINEERING

Internal Combustion Engine



Comprehensive Theory
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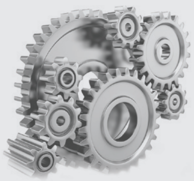

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CHAPTER 1

Basics and Air Standard Cycles

1.1 INTRODUCTION

Engine is a machine used for converting one form of energy into another form. Engine generally converts thermal energy into mechanical work and therefore they are called heat engines. When fuel burns in presence of air, a tremendous amount of heat energy is released. This energy is converted into useful work by means of heat engine. Heat engines are broadly classified into:

(a) External Combustion Engine: In external combustion engines, the combustion of fuel takes place outside the engine. For example in steam engine, heat generated due to combustion of fuel is used to generate high pressure steam which is used as working fluid in steam engine. A steam turbine is a good example of external combustion engine.

(b) Internal Combustion Engine : In internal combustion engine, combustion take place inside the engine. In this engine chemical energy of fuel is first converted to thermal energy by means of combustion of fuel with air inside the engine. This thermal energy raises the temperature and pressure of the gases inside the engine, and the high pressure gas then expands against the mechanical mechanism of the engine. This expansion of gas is converted by the mechanical linkage of the engine to a rotating crankshaft, which is the output of the engine.

1.2 CLASSIFICATION OF IC ENGINES

The internal combustion engines are usually of reciprocating type. The reciprocating internal combustion engines are classified on the basis of the thermodynamic cycle, mechanical method of operation, type of fuel used, type of ignition, type of cooling system and cylinder arrangement, etc. The detailed classification is given below :

1. **According to number of strokes in the working cycle :**
   - **(a) Four Stroke Engine :** In this engine, the thermodynamic cycle is completed in four strokes of piston.
   - **(b) Two Stroke Engine :** In this engine, thermodynamic cycle is completed in two strokes of piston.
2. **According to fuel used :**
   - **(a) Petrol Engine :** It uses petrol and needs a spark plug to ignite petrol.
   - **(b) Diesel Engine :** It uses diesel and self ignition occurs in the combustion chamber due to high temperature of air.

(c) **Gas Engine :** These engine use fuel like CNG, LPG, biogas. Gaseous fuels are better compared to liquid fuels because of reduced ignition delay.

(d) **Multi fuel Engine :** In these engines a gaseous fuel is supplied along with air during initial part of compression and other fuel is injected into combustion space at end of compression stroke.

3. **According to method of ignition :**

(a) **Spark Ignition Engines :** These engines requires an external source of energy for initiation of spark and thereby the combustion process starts.

(b) **Compression Ignition Engines :** In these engines there is no need for an external means to produce ignition. They have high compression ratio which results in high temperature at end of compression process which is sufficient to self ignite the fuel.

4. **According to charge feeding system :**

(a) **Naturally Aspirated Engines :** In these engines admission of air or air-fuel mixture is at atmospheric pressure.

(b) **Supercharged Engines :** In these engines admission of air or air-fuel mixture is at pressure that is above atmospheric pressure.

5. **According to cooling system :**

(a) **Air Cooled Engine :** These engines uses fins to dissipate heat to surrounding to keep the engine within operating temperature.

(b) **Water Cooled Engines :** In these engines water is circulated continuously by means of a external pump which absorbs the engine heat and rejects it to surrounding by using radiator.

6. **According to cylinder arrangements :** To classify engines according to cylinder arrangement two terms must be defined.

(i) **Cylinder Row :** In this arrangement centreline of crankshaft journal is perpendicular to plane containing centreline of engine cylinder.

(ii) **Cylinder Bank :** In this arrangement the centreline of crankshaft journal is parallel to plane containing centreline of engine cylinder.

(a) **In-Line Engine :** In these engines all cylinders are arranged linearly and transmit power to single crankshaft.

(b) **V-Engine :** In these engines there are two banks of cylinders inclined at an angle to each other with one crankshaft.

(c) **Opposed Cylinder Engine :** These engines has two cylinder banks located in same plane on opposite side of crankshaft.

(d) **Radial Engine :** These engines has more than two cylinders in each row and are equally spaced around crankshaft.

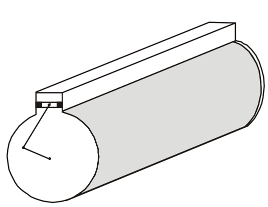


Figure: Inline cylinder Engine

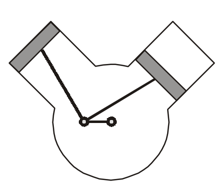


Figure: V engine

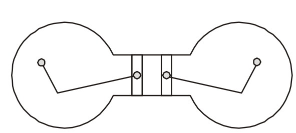


Figure: Opposed cylinder engine

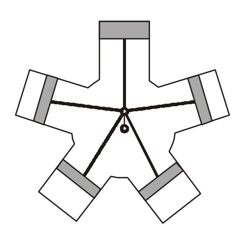


Figure: Radial engine

OBJECTIVE BRAIN TEASERS

Q.1 With increasing temperature of intake air, IC engine efficiency
(a) decreases
(b) increases
(c) remains same
(d) depends on other factors

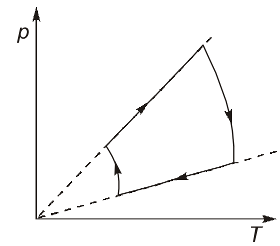
Q.2 The silencer of an internal combustion engine
(a) reduces noise
(b) decreases brake specific fuel consumption (*bsfc*)
(c) increases *bsfc*
(d) has no effect on its efficiency

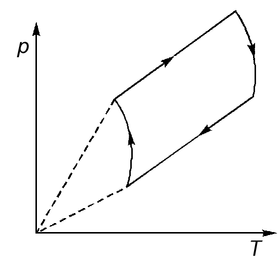
Q.3 A Diesel engine is usually more efficient than a spark ignition engine because
(a) diesel being a heavier hydrocarbon, releases more heat per kg than gasoline
(b) the air standard efficiency of diesel cycle is higher than the Otto cycle, at a fixed compression ratio
(c) the compression ratio of a diesel engine is higher than that of an SI engine
(d) self-ignition temperature of diesel is higher than that of gasoline

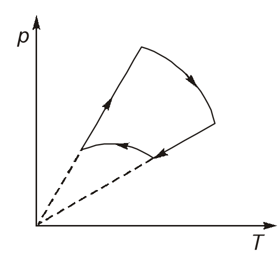
Q.4 Piston compression rings are made of
(a) Cast iron (b) Bronze
(c) Aluminum (d) White metal

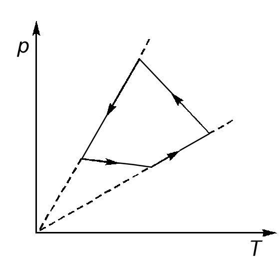
Q.5 **Statement (I):** For a given compression ratio, the thermal efficiency of the Diesel cycle will be higher than that of the Otto cycle.
Statement (II): In the Diesel cycle, work is also delivered during heat addition.
(a) Both Statement (I) and Statement (II) are true and Statement (II) is the correct explanation of Statement (I).
(b) Both Statement (I) and Statement (II) are true but Statement (II) is not a correct explanation of Statement (I).
(c) Statement (I) is true but Statement (II) is false.
(d) Statement (I) is false but Statement (II) is true.

Q.6 Which one of the following p-T diagrams illustrates the Otto cycle of an ideal gas?

(a)


(b)


(c)


(d)


ANSWER KEY

1. (a) 2. (a) 3. (c) 4. (a) 5. (d)
6. (a)

CONVENTIONAL BRAIN TEASERS

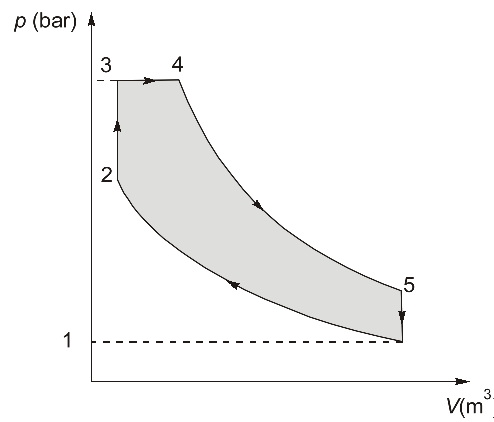
Q.1 In an engine working on Dual cycle, the temperature and pressure at the beginning of the cycle are 90°C and 1 bar respectively. The compression ratio is 9. The maximum pressure is limited to 68 bar and total heat supplied per kg of air is 1750 kJ.

Determine:

(i) Pressure and temperature at all salient points

(ii) Air standard efficiency

(iii) Mean effective pressure.



Solution:

Initial pressure, $p_1 = 1$ bar

Initial temperature, $T_1 = 90° = 363$ K

Compression ratio, $r = 9$

Maximum pressure, $p_3 = p_4 = 68$ bar

Total heat supplied = 1750 kJ kg

(i) Pressures and temperatures at salient points:

For the isentropic process 1-2,

$$p_1V_1^{\gamma} = p_2V_2^{\gamma}$$

$$p_2 = p_1 \times \left(\frac{V_1}{V_2}\right)^{\gamma} = 1 \times (r)^{\gamma} = 1 \times (9)^{1.4}$$

$$= \mathbf{21.67\ bar}$$

Also,
$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1} = (r)^{\gamma-1} = (9)^{1.4-1} = 2.408$$

$\therefore$
$$T_2 = T_1 \times 2.408 = 363 \times 2.408 = \mathbf{874.1\ K}$$

$$p_3 = p_4 = 68 \text{ bar}$$

For the constant volume process 2–3,

$$\frac{p_2}{T_2} = \frac{p_3}{T_3}$$

$\therefore$
$$T_3 = T_2 \times \frac{p_3}{p_2} = 874.1 \times \frac{68}{21.67} = \mathbf{2742.9\ K}$$

Heat added at constant volume $= c_v(T_3 - T_2) = 0.71(2742.9 - 874.1)$

$= 1326.8$ kJ/kg

$\therefore$ Heat added at constant pressure = Total heat added – Heat added at constant volume

$= 1750 - 1326.8 = 423.2$ kJ/kg

$\therefore$ $c_p(T_4 - T_3) = 423.2$

or $1.0(T_4 - 2742.9) = 423.2$

$\therefore$ $T_4 = \mathbf{3166\ K}$

For constant pressure process 3–4,
$$\rho = \frac{V_4}{V_3} = \frac{T_4}{T_3} = \frac{3166}{2742.9} = 1.15$$

CHAPTER

7

Engine Performance and Testing

7.1 INTRODUCTION

Internal combustion engines generally operate over a range of speed while some engines are required to run at a constant speed using a speed governor. The power output varies at each speed within the useful range and has a maximum useful value. Also the specific fuel consumption varies with speed and load. The engine performance depends on inter-relationship between power developed, speed and specific fuel consumption. Engine performance is a relative term and usually means how effectively it provides useful energy in relation to some other comparable engines. Engine performance characteristics can be determined either by experimental results obtained from engine tests or by analytical calculation based on theoretical data. Engine performance is an indication of the degree of success of the engine performing its assigned task, i.e., the conversion of the chemical energy contained in the fuel into the useful mechanical work. In this chapter, various performance parameters, their measurement methods and engine testing methods are discussed.

7.2 ENGINE POWER

Power is defined as the rate of doing work. In analysis of cycles the net work is expressed in kJ/kg of air. By multiplying this quantity with mass flow rate of air through the engine (kg/sec), power can be obtained. Energy flow through the engine is expressed in three distinct terms: Indicated power (IP), Brake power (BP) and Friction power (FP).

7.2.1 Indicated Power

Indicated power is the total power developed by combustion of fuel in the combustion chamber. The indicated work (net work produced in the cylinder) can be obtained from the p-v diagram drawn by an indicator mechanism. So the indicated power can be expressed as

$$\text{IP} = \dot{m}_a \times W_{net}$$

where, $\dot{m}_a$ is the mass flow rate of air in kg/s.

7.2.2 Brake Power

Indicated power is a measure of power developed at the piston. Not all the power developed at the piston reaches the drive shaft. The net power available at the engine crank shaft (also called drive shaft) is known as brake power. This power is also referred to as shaft power or delivered power.

7.2.3 Friction Power

The friction power can be estimated by motoring the engine or other methods. It can also be calculated as the difference between the indicated power and brake power if these two are known.

$$IP = BP + FP$$

$$\Rightarrow \quad FP = IP - BP$$

7.3 MEAN EFFECTIVE PRESSURE

While torque is an important measure of a particular engine's ability to do work, it depends on engine size. A more useful relative engine performance measure is obtained by dividing the work per cycle by the cylinder volume displaced per cycle. The parameter so obtained has units of force per unit area and is called the mean effective pressure. It is defined as a hypothetical/average pressure which is assumed to be acting on the piston throughout the power stroke.

Indicated Mean Effective Pressure:

On an actual engine, the p-v diagram (called the indicator diagram) is obtained by a mechanical or electrical instrument attached to the cylinder taking into consideration to the spring constant. The area enclosed by the actual cycle on the indicator card may be measured by a Planimeter. The value of the area measured, when divided by the piston displacement, results in the mean ordinate, or indicated mean effective pressure, *imep* or p_{im}.

$$imep \text{ or } p_{im} = \frac{\text{Net work of the cycle}}{\text{Displaced volume}}$$

$$= \frac{\text{Area of the indicator diagram}}{\text{Length of the indicator diagram}}$$

$$\text{Indicated net work/cycle} = p_{im} V_s$$

By definition, $\quad$ Indicated power = Indicated net work × Cycles/s

$$IP = \frac{p_{im} V_s n K}{1000 \times 60} = \frac{p_{im} L A n K}{60000} \text{ kW}$$

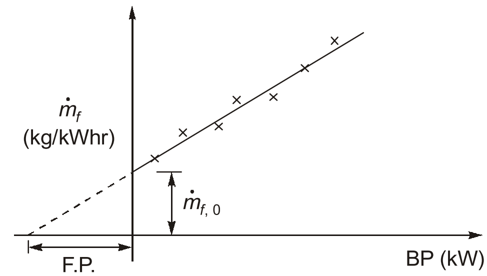
where,
IP = Indicated power (kW)
p_{im} = Indicated mean effective pressure (N/m^2)
L = Length of the stroke (m)
A = Area of the piston (m^2)
N = Speed in revolutions per minute
n = Number of power strokes per minute
N/2 for a four-stroke engine
N for a two-stroke engine
K = Number of cylinders

Indicated mean effective pressure may be considered to consist of *fmep* and *bmep*, two hypothetical pressures. Friction mean effective pressure is that portion of *imep* which is required to overcome friction losses, and brake mean effective pressure is the portion which produces the useful power delivered by the engine.

$$imep = bmep + fmep$$

Since *bmep* is that portion of *imep* which goes into the development of useful power, it has the same relationship to BP as *imep* has to IP, or

Solution:



$$\dot{m}_f = \lambda \times B.P. + \dot{m}_{f,0}$$

Observation 1: $10 = 100 \times \lambda + \dot{m}_{f,0}$ ...(i)

Observation 2: $20 = 220 \times \lambda + \dot{m}_{f,0}$ ...(ii)

Solving equation (i) and (ii), we get,

$$\lambda = \frac{1}{12} \text{ and } \dot{m}_{f,0} = 1.67 \text{ kg/hr}$$

(i) F.P. (when $\dot{m}_f = 0$) $\Rightarrow 0 = \frac{1}{12} \times (-F.P) + 1.67$ [$\because$ F.P = –B.P.]

$\Rightarrow$ $FP = 20$ kW

(ii) $\dot{m}_{f,0} = 1.67$ kg/hr

(iii) $15 = \frac{1}{12} \times BP + 1.67 \Rightarrow BP = 160$ kW

$$\text{bsfc} = \frac{\dot{m}_f}{BP} = \frac{15}{160} = 0.0937 \text{ kg/kWhr}$$

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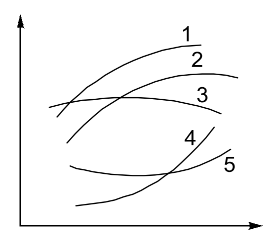
OBJECTIVE BRAIN TEASERS

Q.1 BHP of a diesel engine can be increased by
(a) Increasing the pressure of intake air
(b) Increasing the temperature of intake air
(c) Increasing the density of intake air
(d) Decreasing the density of intake air

Q.2 Match **List-I** (Performance parameters of an IC Engine) with **List-II** (Performance curves) and select the correct answer using the codes given below the lists:

List-I
A. Indicated power
B. Volumetric efficiency
C. Brake power
D. Specific fuel consumption

List-II



Codes:

	A	B	C	D
(a)	1	3	2	5
(b)	1	3	2	4
(c)	1	2	3	5
(d)	2	1	4	3

Q.3 An engine is used on a job requiring a shaft output of 100 kW. The mechanical efficiency of the engine is 80 per cent and it uses 30 kg of fuel per hour under conditions of operation. If an improvement in engine design reduces the frictional losses by 5 kW, the amount of fuel

Swept volume,

$$V_s = \frac{\pi}{4}d^2L = \frac{3.14}{4}\times(7)^2\times 9$$

$$= 346.18 \text{ cm}^2$$

Compression ratio,

$$r = \frac{V_c + V_s}{V_c} = \frac{50+346.18}{50} = 7.92$$

Air standard efficiency,

$$\eta_{ASE} = 1 - \frac{1}{r^{r-1}} = 1 - \frac{1}{7.92^{1.4-1}}$$

$$= 0.5629$$

$$\therefore \quad \eta_{b,th} = 0.50 \times 0.5629 = 0.2814$$

also $$\eta_{b,th} = \frac{bp}{m_f \times C.V.}$$

$$\therefore \quad 0.2814 = \frac{20}{m_f \times 43000}$$

or $$m_f = 1.65 \times 10^{-3} \text{ kg/s}$$

$$= 1.65 \times 10^{-3} \times 3600 \text{ kg/hr}$$

$$\mathbf{= 5.94 \text{ kg/hr}}$$

16. (b)

N = 1800 rpm

d = 85 mm = 0.085 m

L = 110 mm = 0.11 m

m_a = 0.56 kg/min

bp = 6 kW

$$\frac{m_a}{m_f} = 20$$

C.V. = 42550 kJ/kg

ρ_{air} = 1.18 kg/m^3

$$m_f = \frac{m_a}{20} = \frac{0.56}{20} = 0.028 \text{ kg/min}$$

$$\eta_v = \frac{\text{Actual mass flow rate}}{\text{Theoretical mass flow rate}}$$

$$= \frac{m_a}{\rho \times \frac{\pi}{4}d^2 L \times \frac{N}{2}}$$

$$= \frac{0.56}{1.18 \times \frac{3.14}{4}\times(0.85)^2 \times 0.11 \times \frac{1800}{2}}$$

$$= 0.8452 = 84.52\%$$

$$\simeq \mathbf{84.47\%}$$

17. (c)

Brake specific fuel consumption,

$$bsfc = \frac{m_f}{bp} \text{ kg/kWhr}$$

where m_f in kg/hr and bp in kW

$$\therefore \quad bsfc = \frac{0.028\times 60}{6} = \mathbf{0.28}$$

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CONVENTIONAL BRAIN TEASERS

Q.1 A four stroke SI engine has a cylinder diameter of 300 mm and stroke of 500 mm. The effective diameter of the brake is 1.5 m. The observations made in a test of the engine were as follows:

Duration of test = 35 min;	Total number of revolution = 9000
Total number of explosions = 3600;	Net load on the brake = 100 kg
Mean effective pressure = 6 bar;	Volume of gas used = 7.5 m^3

Pressure of gas indicated in meter = 150 mm of gauge water

Atmospheric temperature = 27°C;	Calorific value of gas = 20 MJ/m^3 at NTP
Rise in temperature of cooling water = 50°C;	Cooling water supplied = 180 kg

Draw up the heat balance sheet and estimate indicated thermal efficiency and brake thermal efficiency. Assuming atmospheric pressure as 760 mm of Hg.

Solution:

Given : Four stroke SI engine, d = 300 mm = 0.3 m; L = 500 mm = 0.5 m; D_{eff} = 1.5 m; R_{eff} = 0.75 m; t = 35 min; N = 9000; N_E = 3600; W_{net} = 100 kg = 100 × 9.81 = 981 N; P_{in} = 6 bar; V_{gas} = 7.5 m^3 ; CV = 20 MJ/m^3 at NTP

CHAPTER

8

IC Engine Emissions

8.1 INTRODUCTION

During the combustion process, both SI and CI engines generate undesirable emission which when exhausted into the surroundings cause several environmental and health problems. The major causes of these emissions include non-stoichiometric combustion, dissociation of nitrogen, and impurities in the fuel and air. The most concerning emissions include unburnt hydrocarbons (HC), oxides of carbon (COx), oxides of nitrogen (NOx), oxides of sulphur (SOx), and solid carbon particulates. These emissions are worse from the spark ignition engine than from the compression ignition engine. Other important pollutants in exhaust emissions are aldehydes, lead components produced by use of leaded fuels, etc.

For reduction of the emissions it becomes quite essential to study sources and characteristics of different emissions for both SI and CI engines.

Engine emissions can be classified into two categories:

(i) Exhaust emissions (ii) Non-exhaust emissions

8.2 EXHAUST EMISSIONS

As already mentioned major exhaust emissions are

(i) Unburnt hydrocarbons (HC)
(ii) Oxides of carbon (CO and CO_2)
(iii) Oxides of nitrogen (NO and NO_2)
(iv) Oxides of sulphur (SO_2 and SO_3)
(v) Particulates, soot and smoke.

The first four are common to both SI and CI engines. The main non-exhaust emission is the unburnt hydrocarbons from fuel tank and crankcase blowby.

The figure (a) shows the variation of HC, CO and NOx emission as a function of equivalent ratio for an SI engine. It is clearly seen that all the three emissions are a strong function of equivalence ratio.

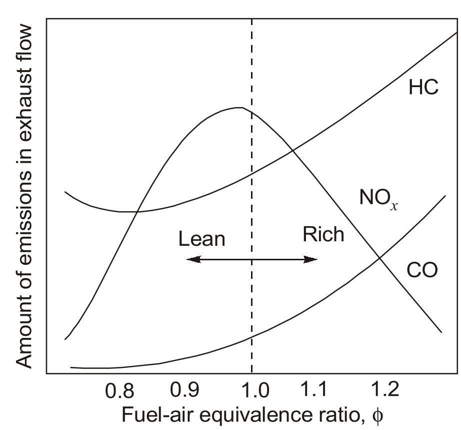

Figure: (a) Emissions as a function of equivalence ratio for a SI engine

As it can be noticed from the figure that a rich mixture does not have enough oxygen to react with all the carbon and hydrogen, and both HC and CO emissions increase. HC emissions also increase for $\phi < 0.8$ due to poor combustion and misfire. The generation of nitrogen oxide emissions is a function of the combustion temperature, highest near stoichiometric conditions when temperatures are at the peak value. Maximum NO_x emissions occur at slightly lean conditions, where the combustion temperature is high and there is an excess of oxygen to react with the nitrogen.

The figure (b) below shows a qualitative picture of HC, CO and NO_x emissions with respect to equivalence ratio, ϕ for a four-stroke Diesel engine. As can be seen, HC will decrease slightly with increase in ϕ due to higher cylinder temperatures making it easier to burn up any over-mixed (very lean) or under-mixed (rich) fuel-air mixture. At high loads, however, HC may increase again if the amount of fuel in regions too rich to burn during primary combustion process. CO emissions will be very low at all equivalence ratio since excess air is always available. NOx emission will steadily increase as ϕ increase due to increasing fraction of cylinder contents being burnt gases close to stoichiometric condition during combustion, and also due to higher peak temperatures and pressures.

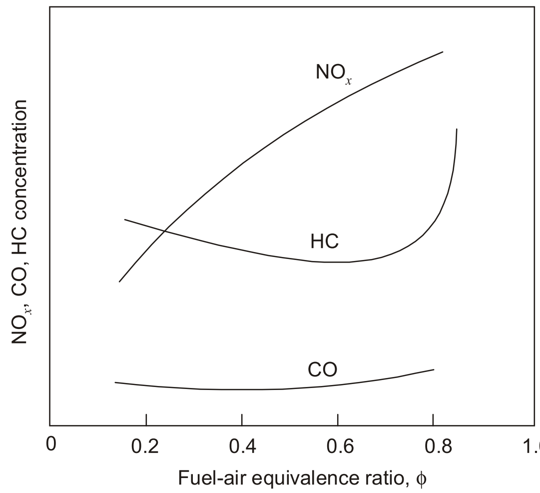

Figure: (b) Emissions as a function of equivalence ratio for a CI engine

8.2.1 Hydrocarbon Emission

Figure (a) shows the variation of HC emission levels with respect to equivalence ratio for an SI engine. It is evident that it is a strong function of air-fuel ratio. With a fuel-rich mixture there is not enough oxygen to react with all the carbon, resulting in high levels of HC and CO in the exhaust products. This is particularly true during starting, when the air-fuel mixture is purposely made very rich. It is also true to a lesser extent during rapid acceleration under load. This occurs more often as air-fuel ratio is made leaner.

The causes for hydrocarbon emissions from SI engine are discussed below:

(i) Incomplete Combustion: There are several reasons for incomplete combustion even when the fuel and air enters at stoichiometric condition.

(a) Improper mixing: Due to incomplete mixing of the air and fuel some fuel particles do not find oxygen to react with. This causes HC emissions.

(b) Flame quenching: As the flame goes very close to the walls it gets quenched at the walls leaving a small volume of unreacted air-fuel mixture.

Another reason for flame quenching is the expansion of gases, which occurs during combustion and power stroke. As the piston moves down from TDC to BDC during power stroke, expansion of the gases lowers both pressure and temperature within the cylinder. This makes combustion slow and finally quenches the flame somewhere late in the expansion stroke. This leaves some fuel particles unreacted and causes HC emissions. HC emissions can be reduced by incorporating additional spark plug in the combustion chamber.

(ii) Crevice Volumes and flow in Crevices: The crevices consist of a series of volumes connected by flow restrictions such as the ring side clearance and ring gap. Crevice volume around the piston rings is greatest when the engine is cold, due to the differences in thermal expansion of the various materials. Upto 80% of all HC emissions can come from this source.

(iii) Leakage past the Exhaust Valve: As pressure increases during compression and combustion, some amount of air-fuel mixture is forced into the crevice volume around the edges of the exhaust valve and between the valve and valve seat. When the exhaust valve opens, the air-fuel mixture which is still in the crevice volume gets carried into the exhaust manifold.

EXAMPLE : 8.2 Which of the following is the main non-exhaust emission in internal combustion engines?

(a) CO (b) NO_2
(c) Particulate matter (d) Unburnt hydrocarbons

Solution : (d)

The main non-exhaust emission is unburnt hydrocarbons from fuel tank and crankcase blowby.

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OBJECTIVE BRAIN TEASERS

Q.1 If air fuel ratio of the mixture in petrol engine is more than 15:1

(a) NO_x is reduced (b) CO_2 is reduced
(c) HC is reduced (d) CO reduced

Q.2 The discharge of hydrocarbons from petrol automobile exhaust is minimum when the vehicle is

(a) Idling (b) Cruising
(c) Acceleration (d) Decelerating

Q.3 Which one of the following automobile exhaust gas pollutants is a major cause of photochemical smog?

(a) CO (b) HC
(c) NO_X (d) SO_X

Q.4 **Statement (I):** Catalytic converters for reduction of oxides of nitrogen in engine exhaust cannot be used with leaded fuels.

Statement (II): Catalyst will be removed due to chemical corrosion by lead salts.

(a) Both Statement (I) and Statement (II) are true and Statement (II) is the correct explanation of Statement (I).
(b) Both Statement (I) and Statement (II) are true but Statement (II) is not a correct explanation of Statement (I).
(c) Statement (I) is true but Statement (II) is false.
(d) Statement (I) is false but Statement (II) is true.

Q.5 With respect to IC Engine emissions, consider the following statements:

1. Evaporative emissions have no carbon monoxide and oxides of nitrogen.
2. Blow-by emissions are essentially carbon monoxide and suspended particulate matter.
3. Exhaust emissions contain 100% of carbon monoxide, 100% of oxide of nitrogen and around 50-55% of hydrocarbons emitted by the engine.
4. There are no suspended particulates in the exhaust.

Which of these statements are correct?

(a) 1 and 4 (b) 1 and 3
(c) 2 and 3 (d) 1, 2, 3 and 4

■■■■

ANSWER KEY

1. (d) 2. (b) 3. (c) 4. (c) 5. (c)

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3. (c)
NO_X is one of the primary cause of photochemical smog. Smog is formed by the photo chemical reaction of automobile exhaust and atmospheric air in presence of sunlight, NO_2 decomposes into NO and mono atomic oxygen.
NO_2 + energy from sunlight → NO + O + smog
$O + O_2 \rightarrow O_3$

4. (c)
The lead compounds will be sticky compound and get deposited on the honeycomb and therefore there will be no catalytic surface on which reaction takes place.

5. (c)
Blowby emission are essentially carbon monoxide and suspended particulate.

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