RPSC AEn-2024 Main Test Series

MECHANICAL ENGINEERING | **Test 8**

Test Mode : • Offline • Online

Subject : Energy Systems

(IC Engines, PP including Nuclear & Hydro-Electric Power Plant)

DETAILED EXPLANATIONS

1. Solution:

"Blow by loss" is the phenomenon of leakage of combustion products past the piston and piston rings from the cylinder into the crankcase.

2. Solution:

Two Stroke Engine:

1. Cycle is completed in two stroke of the piston or one revolution of the crankshaft.
2. It contains ports.

Four Stroke Engine:

1. Cycle is completed in four stroke of the piston or two revolution of the crankshaft.
2. It contains valves.

3. Solution:

It is also called as preparatory phase during which some fuel has been already admitted but has not yet ignited. This period is counted from the start of injection to the point where the pressure time curve separates from the motoring curve indicated as start of combustion.

4. Solution:

The main functions of a fuel injection system are :

1. Filter the fuel,
2. Meter the correct quantity of fuel to be injected,
3. Control the rate of fuel injection, and
4. Atomize the fuel into fine particles.

5. Solution:

It is a device which is placed in the vehicle exhaust system to reduce HC and CO components of emission by oxidising catalyst and NO components by reducing catalyst.

6. Solution:

An economiser preheats boiler feed water using waste heat from flue gases, reducing fuel consumption and improving boiler efficiency.

7. Solution:

Compounding is the method of reducing high steam velocity by dividing pressure or velocity drop into stages to improve efficiency and reduce blade speed.

8. Solution:

Bypass governing diverts excess steam directly to later turbine stages or condenser to prevent over speeding under low load conditions.

9. Solution:

Hydrology is the science dealing with occurrence, distribution, movement, and properties of water on and below the earth's surface.

10. Solution:

A moderator slows down fast neutrons reduce their energy, increasing probability of fission and sustaining chain reaction.

11. Solution:

The rating of SI engines fuel is done by defining a term Octane Number (ON), comprising of two reference fuels:

Isooctane (C_8H_{18}) and normal heptane (C_7H_{16}). Isooctane has good antiknock characteristics and is arbitrarily assigned ON of 100, whereas normal heptane being a poor SI engine fuel is assigned a ON of 0.

Thus, ON of a fuel is the proportion by volume of iso-octane in a mixture of iso-octane and normal heptane which gives same antiknock characteristics as that of test fuel in a standard engine under standard operating conditions.

The rating of CI engine fuel in done through a parameters called Cetane Number (CN). It involves two reference fuels: Normal Cetane ($C_{16}H_{34}$), which being a good CI engine fuel is assigned CN of 100 and alpha-methyl naphthalene ($C_{11}H_{10}$) which being a bad CI engine fuel is assigned a CN of 0.

Thus, CN of a fuel is the proportion, by volume of normal cetane in a mixture of normal cetane and a-methyl naphthalene which gives same ignition delay as that of test fuel in a standard engine under standard operating conditions.

12. Solution:

Two stroke and Four stroke IC engines

S.No.	Four-stroke cycle	Two-stroke cycle
1.	The cycle is completed in four strokes of the piston or in two revolutions of the crankshaft. Thus one power stroke is obtained in every two revolutions of the crankshaft.	The cycle is completed in two-strokes of the piston or in one revolution of the crankshaft. Thus one power stroke is obtained in each revolution of the crank-shaft.
2.	Because of the above, turning movement is not so uniform and hence heavier flywheel is needed.	More uniform turning movement and hence lighter flywheel is needed
3.	Again, because of one power stroke for two revolutions, power produced for same size of engine is small, or for the same power the engine is heavy and bulky.	Because of one power stroke for one revolution, power produced for same size of engine is more (theoretically twice, actually about 1.3 times), or for the same power the engine is light and compact.
4.	Because of one power stroke in two revolutions lesser cooling and lubrication requirements. Lesser rate of wear and tear.	Because of one power stroke in one revolution greater cooling and lubrication requirement. Greater rate of wear and tear.
5.	The four-stroke engine contains valves and valve mechanism.	Two-stroke engines have no valves but only ports (some two-stroke engines are fitted with conventional exhaust valve or reed valve).
6.	Because of the heavy weight and complication of valve mechanism, higher in initial cost.	Because of light weight and simplicity due to the absence of valve mechanism, cheaper in initial cost.
7.	Volumetric efficiency more due to greater time of induction.	Volumetric efficiency less due to lesser time for induction.
8.	Thermal efficiency higher, part load efficiency better than two-stroke cycle engine.	Thermal efficiency lower, part load efficiency lesser than four-stroke cycle engine. In two stroke petrol engines some fuel is exhausted during scavenging.
9.	Used where efficiency is important, in cars, buses, trucks, tractors, industrial engines aeroplanes, power generation, etc.	Used were (a) low cost, and (b) compactness and light weight important. Two-stroke (air-cooled) petrol engines used in very small sizes only: lawn mowers, scooters, motor cycles, mopeds, etc. (Lubricating oil mixed with petrol).
		Two-stroke diesel engines used in very large sizes, more than 60 cm bore, for ship propulsion because of low weight and compactness.

13. Solution:

Supercharging: When the density of air increases, the amount of air inducted in increases. The process of increasing the inlet air density is called supercharging.

Factors affecting power output of an engine:

- Quantity of ambient air inducted per unit time.
- Extent to which the air is utilized.
- Thermal efficiency of the engine.

When tendency to knock is present in CI engines, supercharging will be more appropriate. When supercharged, the intake air reaches high pressure and temperature which will reduce the ignition delay. So knocking is reduced.

Hence, CI engines are suitable for supercharging.

14. Solution:

(i) Load curve: A load curve represents variation of electrical demand over time, showing daily, monthly, or yearly load patterns.

(ii) Maximum demand: Maximum demand is the highest power demand on a system during a specified period.

(iii) Load factor: Load factor is the ratio of average load to maximum demand over a given period.

(iv) Capacity factor: Capacity factor is the ratio of actual energy generated to maximum possible energy generation during the same period.

(v) Plant utilization factor: Plant utilization factor is the ratio of maximum demand to installed capacity of the plant.

15. Solution:

The selection of a suitable site for the construction of a dam depends on various factors which are briefly described below:

(i) Suitable foundations should be available at the dam site.

(ii) The length of the dam should be as small as possible from economic point of view and for a given height it should store large volume of water.

(iii) The river valley at the dam site should be as narrow as possible and it should open out upstream to create a reservoir with as far as possible large storage capacity.

(iv) The dam should be located on high ground as far as possible compared to the river basin in order to reduce the cost and facilitate drainage of the dam section.

(v) A suitable site for the spillway should be available in the vicinity of the dam if the spillway is to be located separately from the dam.

(vi) The value of the property and land submerged in the reservoir created by the proposed dam should be as low as possible.

(vii) The dam site should be such that the reservoir would not silt up soon. For this if any of the tributaries of the river is transporting relatively large quantity of sediment, then the dam site may be selected on the upstream of the confluence of this tributary with the river.

(viii) It is preferable to select a dam site which is already connected or can be conveniently connected to a nearby rail or road in order to facilitate transportation of men, material, machinery and various other essential items to the dam site.

16. Solution:

S.No.	Fire Tube Boilers	S.No.	Water Tube Boilers
(i)	Hot gases inside the tubes and water outside the tubes	(i)	Water inside the tubes and hot gases outside the tubes
(ii)	Generally internally fired	(ii)	Externally fired
(iii)	Operating pressure limited to 16 bar	(iii)	Can work under as high pressure as 100 bar
(iv)	Lower steam production rate	(iv)	Higher rate of steam production
(v)	Various parts not so easily accessible for cleaning, repair and inspection	(v)	Various parts are more accessible
(vi)	Difficult in construction	(vi)	Simple in construction

17. Solution:

Electrostatic precipitation is a method of dust collection that uses electrostatic forces, and consists of discharge wires and collecting plates. A high voltage is applied to the discharge wires to form an electrical field between the wires and the collecting plates, and also ionizes the gas around the discharge wires to supply ions. When gas that contains an aerosol (dust, mist) flows between the collecting plates and the discharge wires, the aerosol particles in the gas are charged by the ions. The Coulomb force caused by the electric field causes the charged particles to be collected on the collecting plates, and the gas is purified. This is the principle of electrostatic precipitation, and Electrostatic precipitator apply this principle on an industrial scale. The particles collected on the collecting plates are removed by methods such as (1) dislodging by rapping the collecting plates, (2) scraping off with a brush, or (3) washing off with water, and removing from a hopper. Dust collection efficiency is affected by the following factors:

1. Electrical resistivity of dust
2. Particle size distribution
3. Aerosol concentration

18. Solution:

Given: p = 20 kPa; $\dot{m}_s = 20 \times 10^3$ kg/h = 5.55 kg/s; $(\Delta T)_w = 10°C$

Let inlet conditions to the condenser are represented as

$$x_1 = 0.95$$

$$h_1 = h_f + x_1 h_{fg} = 251.4 + 0.95 \times 2358.3 = 2491.785 \text{ kJ/kg}$$

Outlet condition, $h_2 = h_f = 251.4$ kJ/kg

Let mass flow rate of cooling water = $\dot{m}_w$

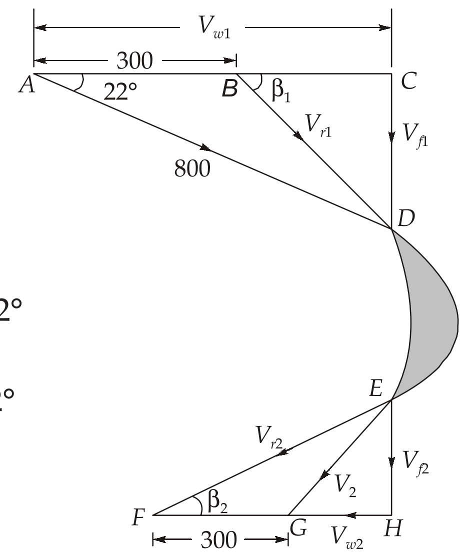
Energy balance in condenser will give,

$$\dot{m}_w c_{pw} (\Delta T)_w = \dot{m}_w (h_1 - h_2)$$

$$\dot{m}_w \times 4.18 \times 10 = 5.55 \times (2491.785 - 251.4)$$

$$\dot{m}_w = 297.46 \text{ kg/s}$$

19. Solution:



Given : For a simple impulse turbine

Symmetrical blades, $\beta_1 = \beta_2$

Steam velocity, $V_1 = 800$ m/s

Mean peripheral velocity of blades, $u = 300$ m/s

Nozzle angle, $\alpha_1 = 22°$

Steam flow rate, $\dot{m}_s = 2$ kg/sec

$$V_{w1} = V_1 \cos\alpha = 800 \times \cos 22°$$
$$= 741.75 \text{ m/s}$$
$$V_{f1} = V_1 \sin\alpha = 800 \times \sin 22°$$
$$= 299.68 \text{ m/s}$$
$$V_{r1} = \sqrt{(V_{w1} - u)^2 + V_{f1}^2}$$
$$= \sqrt{(741.75 - 300)^2 + 299.68^2}$$
$$V_{r1} = 533.80 \text{ m/s}$$
$$\tan\beta_1 = \frac{V_{f1}}{V_{w1} - u}$$
$$\beta_1 = \tan^{-1}\left(\frac{299.68}{741.75 - 300}\right) = 34.15° = \beta_2$$

Assuming smooth blade, i.e., $K = 1 \Rightarrow V_{r2} = V_{r1}$

$\therefore$ $$V_{r2} = V_{r1} = 533.80 \text{ m/s}$$
$$V_{w2} = V_{r2}\cos\beta_2 - u = 533.80\cos(34.15)° - 300$$
$$V_{w2} = 141.76 \text{ m/s}$$
$$V_{f2} = V_{r2}\sin\beta_2 = 533.80 \sin 34.15°$$
$$V_{f2} = 299.65 \text{ m/s}$$

Tangential thrust, $$F_t = \dot{m}_s(V_{w1} + V_{w2})$$
$$F_t = 2 \times (741.75 + 141.76)$$
$$F_t = 1767.02 \text{ N}$$

Diagram power, $$P = F_t \times u = 1767.02 \times 300$$
$$P = 530.11 \text{ kW}$$

Axial thrust, $$F_a = \dot{m}_s(V_{f1} - V_{f2}) = 2 \times (299.68 - 299.65) = 0.06 \text{ N}$$

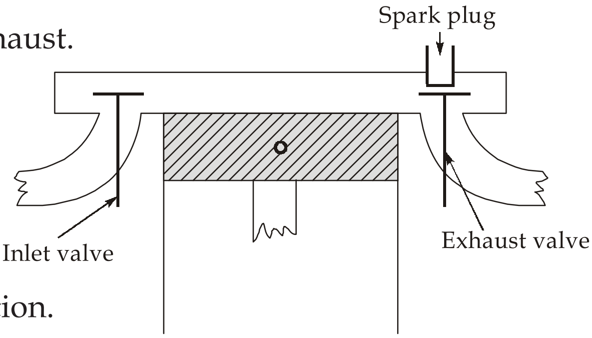
Diagram efficiency, $$\eta_{dig} = \frac{P}{\left(\frac{\dot{m}_s \cdot V_1^2}{2}\right)} = \frac{530.11 \times 10^3 \times 2}{2 \times 800^2} = 0.8283$$

20. Solution:

Various types of combustion chamber used in SI engines are as follow:

(i) T-Head combustion chamber:

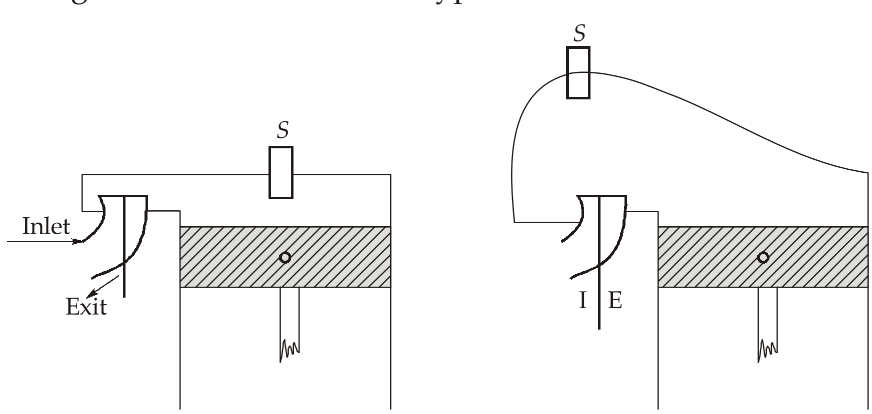
1. This type of combustion chamber has inlet and exhaust valves on opposite side of cylinder.
2. The spark plug is located near the exhaust.
3. It has the following characteristics.
   - Good turbulence
   - Short cylinder block
   - Long flame travel and greater tendency to knock
   - Unsatisfactory fuel and air utilization.



T-head combustion chamber

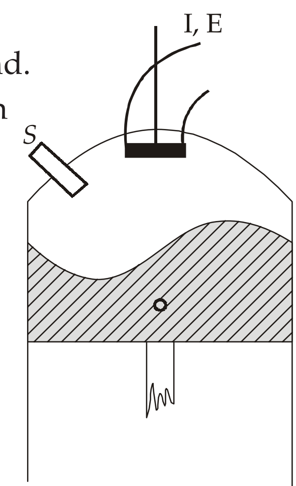
(ii) L-Head combustion chamber:

1. This is a modification of T-type of combustion chamber.
2. In this combustion chamber, the two valves are on the same side of the cylinder and the valves are operated by a single camshaft.
3. The main objectives of the Ricardo's turbulent head design as shown in figure, is to obtain fast flame speed and reduced knock.
4. It has following characteristics:
   - Providing high turbulence.
   - Short flame travel.
   - High power output.
   - Design is better than *T* and *F* type.



L-head type

(iii) I-Head Type or Overhead Valve:

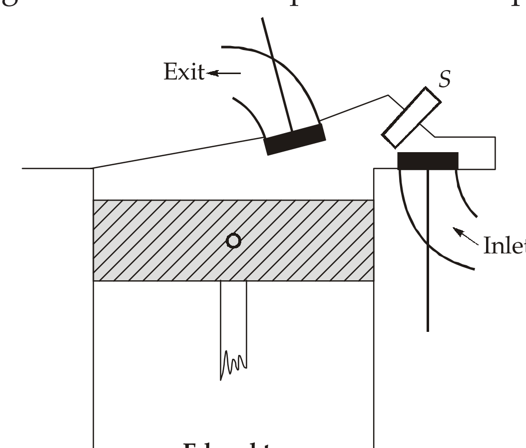


I-head type

1. In this type, both the valves are located on the cylinder head.
2. The overhead valve engine is superior to a side valve or an L-head engine at high compression ratio.
3. Some of the important characteristics of this type of valve arrangement are:
   - Very high turbulence
   - Smooth operation
   - Higher volumetric efficiency
   - Hig

(iv)F-Head combustion chamber:

1. Combustion chamber in which one valve is in head and other is in block is known as F-head combustion chamber.
2. This design is better than T-head type combustion chamber in performance but valve operating mechanism is complicated and required two sets of cam shafts.



F-head type

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