

1/14

SCHEME OF VALUATION

(Scoring indicators)

REVISION – 2015

COURSE CODE - 5023

COURSE TITLE - **POWER PLANT ENGINEERING**

QST: No.	SCORING INDICATOR	Split-up score	Sub- total	Tot al
I.	<u>PART - A</u>			
1.	A substance on burning with oxygen, produces a large amount of heat energy.	2	2	2
2.	Induced draught, Forced draught, Balanced draught	2	2	4
3.	a) Maintain low pressure so as to max. possible energy from steam and thus secure a high efficiency. b) Supply pure feed water to the hot well, from there pumped back to boiler	1 1	2	6
4.	Jet propulsion is the propelling force generated in the direction opposite to the flow of a mass of gas or liquid under pressure. The mass escapes through a hole or opening called a jet nozzle.	2	2	8
5.	Fission , Fusion	2	2	10
II.	<u>PART - B</u>			
1.	HCV :- when unit mass of fuel is burnt completely, hot flue gases are produced and some of heat is utilized to form steam. If heat is recovered from flue gases and steam is condensed back to water at room temp. (15°C), the total amount of heat produced per kg of fuel is known as HCV. $\text{HCV} = 33800 C + 144000 H_2 + 9270 S \text{ kJ/kg}$ if the fuel contains no Oxygen (O ₂),and where C,H ₂ ,and S represents mass of carbon, hydrogen and sulfur respectively $\text{HCV} = 33800 C + 144000 [H_2 - \frac{O}{8}] + 9270 S \text{ kJ/kg}$ if fuel contains O ₂ LCV:- when unit mass of fuel is burnt completely, the amount of heat in which the heat carried away by the steam produced is not considered , is known LCV. $\text{LCV} = \text{HCV} - \text{Heat of steam formed during combustion}$	3 3	6	16

2. Condensers classified as
1. Jet condensers
 - a). parallel flow jet condenser
 - b). counter flow --
 - c). barometric or high level --
 - d). ejector --

 2. Surface condensers
 - a). Down flow surface condenser
 - b). Central flow --
 - c). Regenerative --
 - d). Evaporative --

3

6

22

3

3.

<i>Gas turbines</i>	<i>Steam turbines</i>
The important components are compressor and combustion chamber.	The important components are steam boiler and accessories.
The mass of gas turbine per kW developed is less.	The mass of steam turbine per kW developed is more.
It requires less space for installation.	It requires more space for installation.
The installation and running cost is less.	The installation and running cost is more.
The starting of gas turbine is very easy and quick.	The starting of steam turbine is difficult and takes long time.
Its control, with the changing load conditions, is easy.	Its control, with the changing load conditions, is difficult.
A gas turbine does not depend on water supply.	A steam turbine depends on water supply.
Its efficiency is less.	Its efficiency is higher.

FIG
(3)

6

28

Expln
(3)

4. Nuclear fission;

- Nuclear fission is a reaction in which a large nuclei breaks apart into two smaller nuclei, releasing a great deal of energy.
- Nuclei can fission on their own spontaneously, but only certain nuclei, like uranium-235 and plutonium-239, can sustain a fission chain reaction. This is because these nuclei release neutrons when they break apart, and these neutrons can slam into other nuclei, causing them to also break apart and release more neutrons.

3 + 3

6

34

Nuclear fusion ;
 is a reaction in which two or more atomic nuclei are combined to form one or more different atomic nuclei and subatomic particles (neutrons or protons). The difference in mass between the reactants and products is manifested as either the release or absorption of energy

5 Given,
 $C = 85\% = 0.85\text{kg}$,
 $H_2 = 12.5\% = 0.125\text{kg}$
 Residual matter = $2.5\% = 0.025\text{kg}$

2+2+2

6

$$\begin{aligned} \text{HCV per kg of fuel} &= 33800C + 144000H_2 + 9270S \text{ kJ/kg} \\ &= 33800 \times 0.85 + 144000 \times 0.125 + 9270 \times 0 = \underline{46730 \text{ kJ/kg}} \end{aligned}$$

40

$$\begin{aligned} \text{LCV per kg of fuel} &= \text{HCV} - (9H_2 \times 2466) \\ &= 46730 - (9 \times 0.125 \times 2466) = \underline{43956 \text{ kJ/kg}} \end{aligned}$$

6

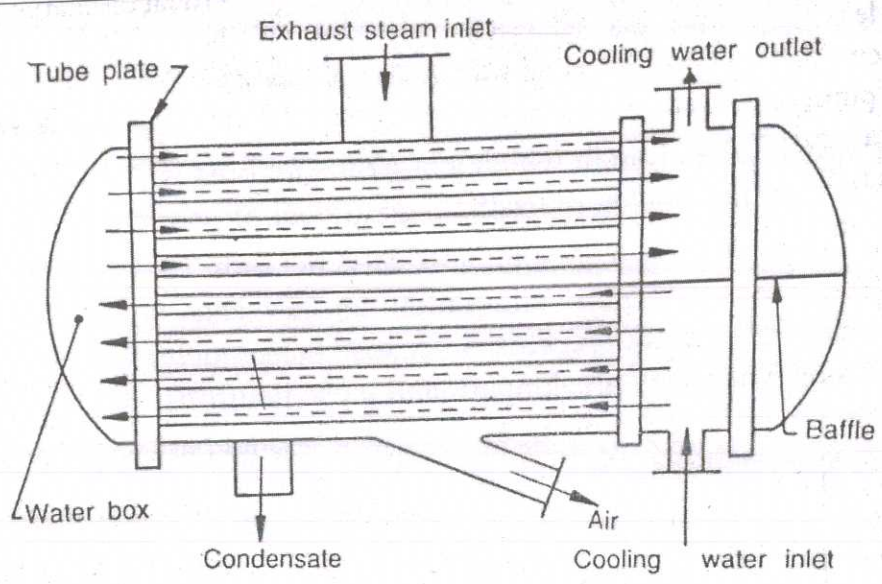


Fig - (6)

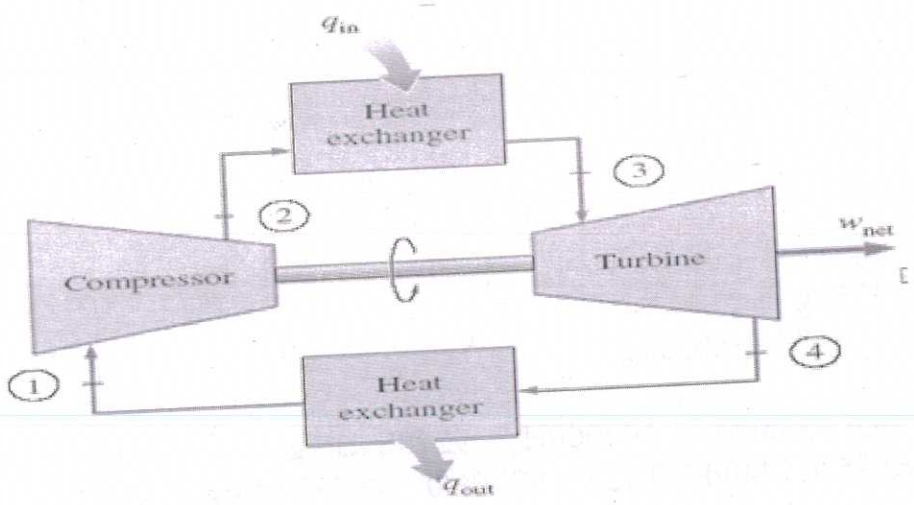
(6)

(6)

46

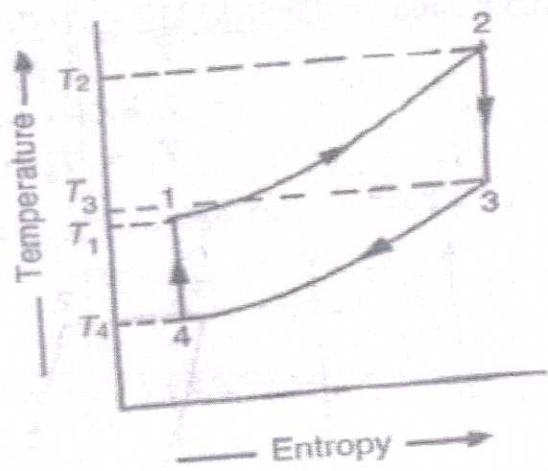
7

FLOW DIAGRAM (or, Similar figures)



(3)

T-s diagram



(3)

(6)

52

III
(a)

PART - C

(or, Similar figures)

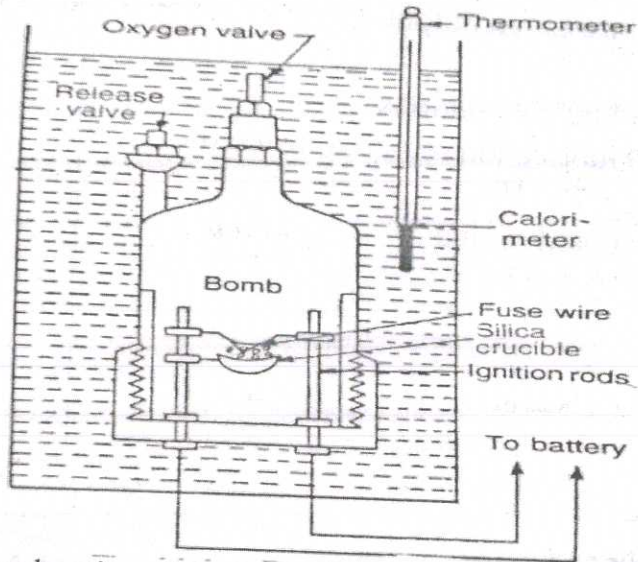


Fig - 4

(.9)

Combustion Calorimeters measure the heat released from a solid-liquid fuels. This is done by weighing a precise measure of the sample substance into a crucible, placing the crucible inside a "bomb" (a sealed metal cylinder called a vessel), filling the bomb vessel with oxygen and igniting the substance. The bomb is completely immersed in a measured qty of water contained in an copper vessel and this vessel is placed within a large insulated copper vessel to reduce the loss of heat by radiation.

Expln-
(5)

The sample in the crucible ignites and release the heat resulting temperature increase of the water is measured at the steady condition and calorific value (CV) is calculated.

Let,

- m_f = mass of fuel sample ignited in the bomb in kg
- m_w = mass of water filled in the calorimeter in kg
- m_e = water equivalent of apparatus in kg
- t_1 = initial temp. of water and apparatus in °C
- t_2 = final temp of water and apparatus in °C and,
- HCV = Higher Calorific Value of fuel specimen in kJ/kg

$$\text{Heat liberated by fuel} = m_f \times \text{HCV} \quad \text{--- (1)}$$

$$\text{Heat absorbed by water and apparatus} = (m_w + m_e) C_w (t_2 - t_1) \quad \text{--(2)}$$

(1) = (2) we get,

$$\text{HCV} = \frac{(m_w + m_e) C_w (t_2 - t_1)}{m_f} \text{ kJ/kg}$$

61

III
.b)

- Higher speeds and greater steam range
- Less steam consumption for a given output
- Higher efficiency
- Requires less space and lighter foundations
- Less frictional loss and no lubrication required inside the turbine
- Uniform and evenly distributed torque
- Repair cost is less

Any -6
(6)

(6)

67

IV
(a)

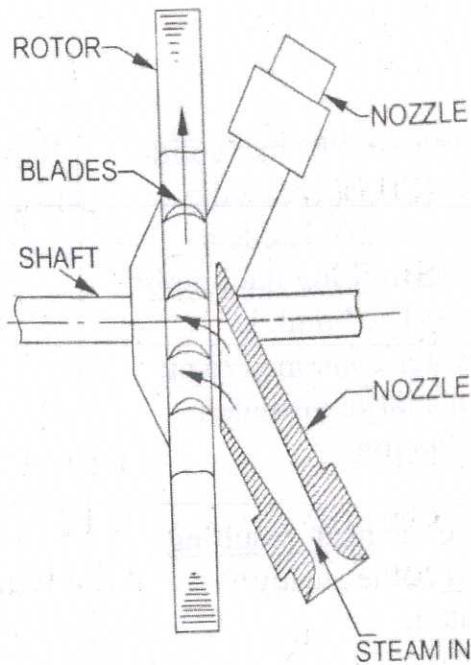


Fig -
(5)

(9)

26

De lavel turbine is an impulse turbine
Main components are – Nozzles , Runner , shaft , casing etc

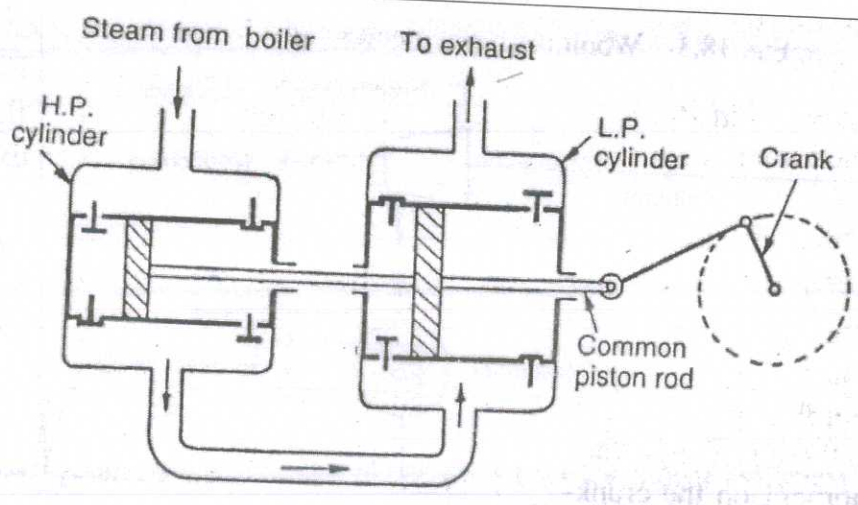
Expln-
(4)

The runner is a circular disc mounted on a horzondal shaft – fitted a number of blades / buckets

High pr. Steam expands inside the nozzles exit and it impinges/ strike on the buckets

The runner with shaft rotates

IV
(b)



(6)

(6)

82

(OR, Similar figures)

V

- (a) Actual vacuum = 700mm of Hg
 Barometer reading = 760 mm of Hg
 Temperature $t = 34^{\circ}\text{C}$

Pr. in the condenser = $760 - 700 = 60\text{mm of Hg}$
 From steam tables, corresp. To temp = 34°C ideal pr. of steam
 = $0.0532\text{bar} = 0.0532 / 0.00133 = 40\text{mm of Hg}$
 Ideal vacuum = barometer reading - ideal pr.
 = $760 - 40 = 720\text{ mm of Hg}$

3+3+3

(9)

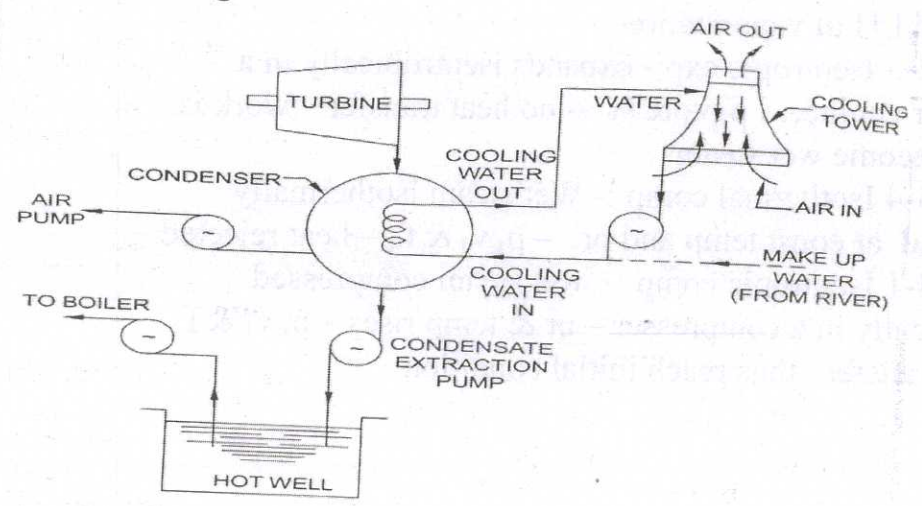
91

Vacuum efficiency = $\frac{\text{Actual vacuum } 700}{\text{Ideal vacuum } 720} = \frac{700}{720} = 0.972$
 = 97.2%

(9)

V
(b)

OR, similar figures



(6)

97

(6)

VI

a)

very.

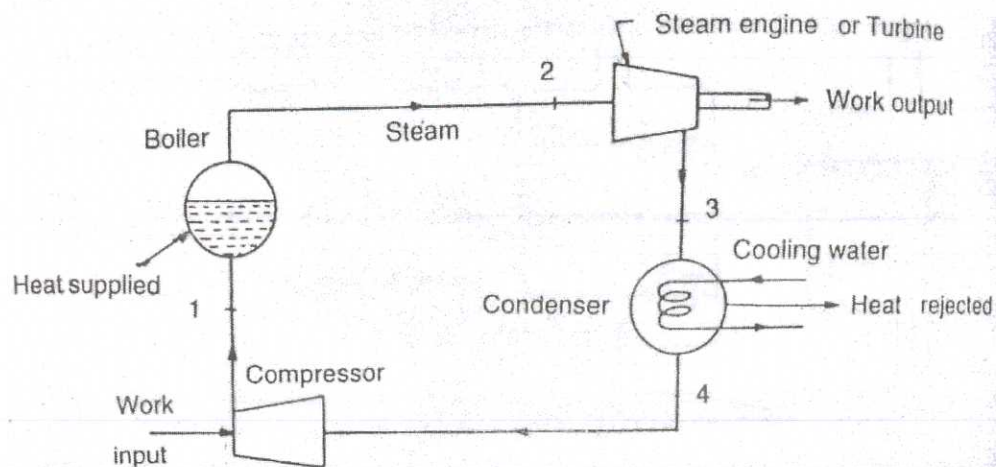
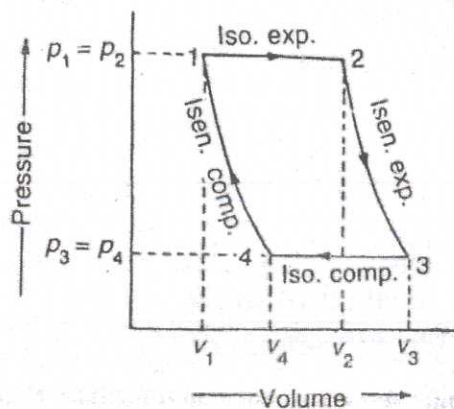


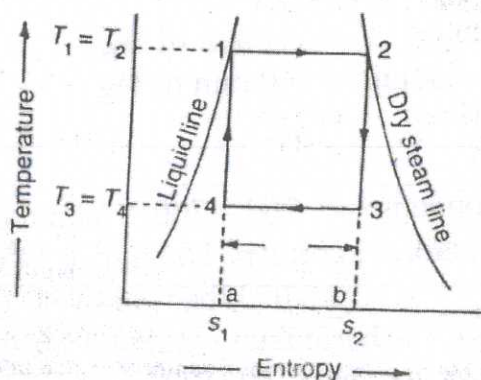
Fig-1+
fig -2+
expln.

2+3+4

106



(a) $p-v$ diagram.



(b) $T-s$ diagram.

(9)

Consider unit mass of saturated water at initial pr., volume and temp as p_1, v_1 and T_1 resply. The cycle is completed by the following four process: [hints;]

1. Process 1-2 Isothermal exp:- heat absorbs and isothermally coverts to sat'd steam. Pr & Temp are same and p_2, v_2 & T_2 Absorbed LH of vaporization
2. Process 2-3 Isentropic exp:- expands isentropically in a turbine or engine.... p_3, v_3 & T_3 -- no heat transfer – work is done – become wet steam
3. Process 3-4 Isothermal comp :- Wet steam isothermally condensed at const temp and pr. – p_4, v_4 & T_4 – heat rejected –
4. Process 4-1 Isentropic comp :- wet steam compressed isentropically in a compressor – pr & temp rises – p_1, v_1 & T_1 – no heat transfer –thus reach initial condition

VI

b) $p_1 = 16 \text{ bar}$, $p_2 = 0.2 \text{ bar}$

2+2+2

from steam tables, corresp. to 16 bar, we get $T_1 = 201.4^\circ\text{C} = 474.4\text{K}$
from steam tables, corresp. to 0.2 bar, we get $T_2 = 60.1^\circ\text{C} = 331.1\text{K}$

efficiency of carnot cycle = $\eta = \frac{T_1 - T_3}{T_1} = \frac{474.4 - 331.1}{474.4} = 0.298$
or, 29.8%

(6)

112

VII

a)

Or, similar figs

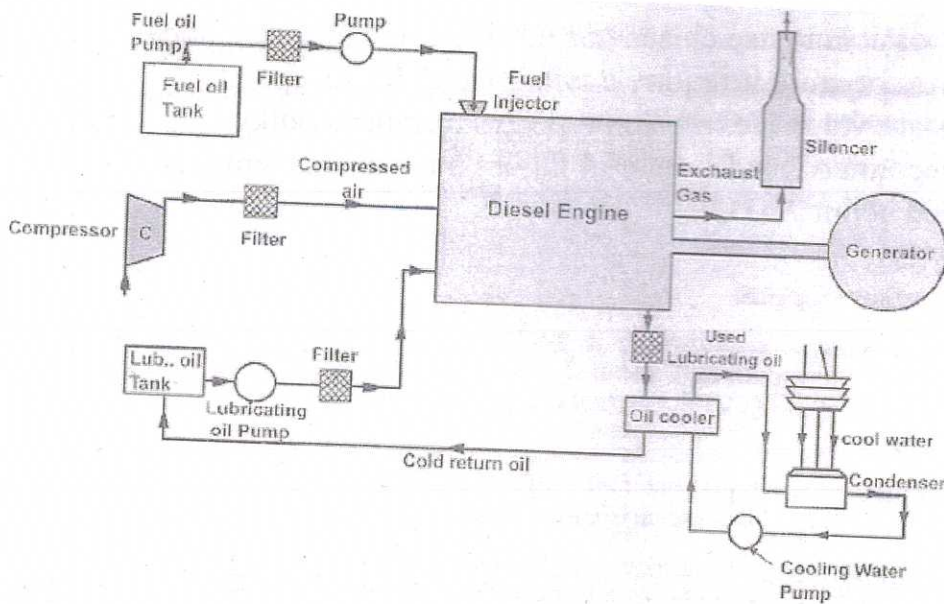


Fig- (5)

(9)

121

Advantages :

1. dpp is in the range of 2 to 50 MW capacity ---- used as central station for small or medium power supplies
2. used as standby plants to hydro EPP and Steam PP for emergency services
3. can be used as peak load plants in combination with thermal or hydro plants
4. quite suitable for mobile power generation and widely used in transportation systems – automobiles, railways, aeroplanes, ships etc.
5. in industrial sector installing diesel power generator is a best solution to overcome power shortage / power cut

Adv- (4)

VII
b) GAS TURBINES (answer : hints)

Applications :

- For electrical power generation
- In ships as propulsion units
- In jet propulsion units of air crafts
- To run locomotives and automobiles
- In the process of supercharging IC engines

Limitations :

- Compared to thermal efficiency of IC engines that of gas turbine is less
- The max. combustion pr. in gas turbine is less that to IC engines
- Not possible to use closed gas turbine cycle in aeronautical engines because it require cooling water for its operation
- Constant volume explosion type gas turbine is bulky
- On account of blade material failure the max gas temp. is limited about 750°C

Any 3+
any 3

(3)+(3)

(6)

127

VIII
a)

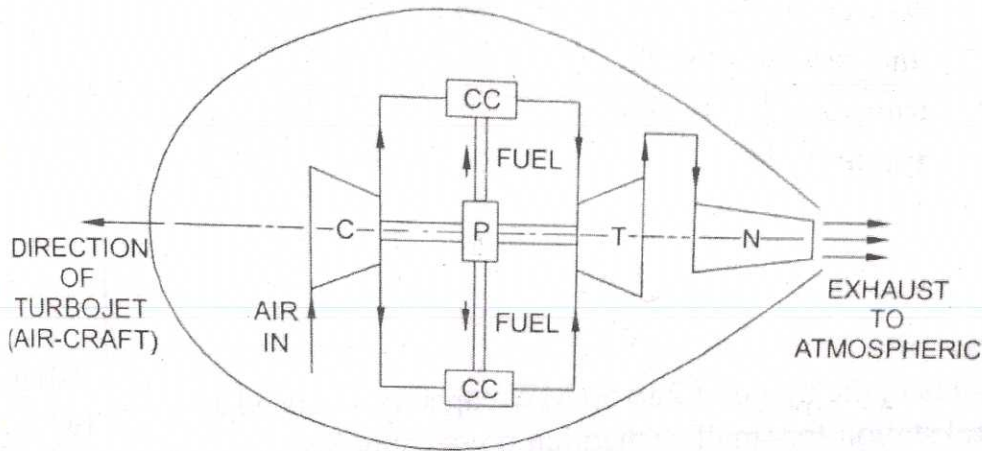


Fig- (5)
+
Expln
(4)

Or, similar figs

Working : (Hints)

- ❖ The air from surrounding atmosphere drawn through orifice and compressed to a pr. about 4 atm (approx. 3,5 bar)
- ❖ Compressed air passes into the annular combustion chamber
- ❖ Fuel compressed to high pr. and forced through fuel nozzle into CC
- ❖ Fuel burnt at const. pr. raises the temp. and vol. mixture of air and products of combustion.
- ❖ Wt. of air supplied is about 50 to 70 times of the wt. of fuel burnt.

(9)

136

- ❖ This excess air produces sufficient mass for the propulsion jet and limiting the gas temp. within practical limits
- ❖ Hot gases pass through turbine nozzle ring – partially expand on turbine blades producing power
- ❖ Expanded gases exhausted through discharge nozzle, by which remaining pr. energy converted into KE

VIII
b)

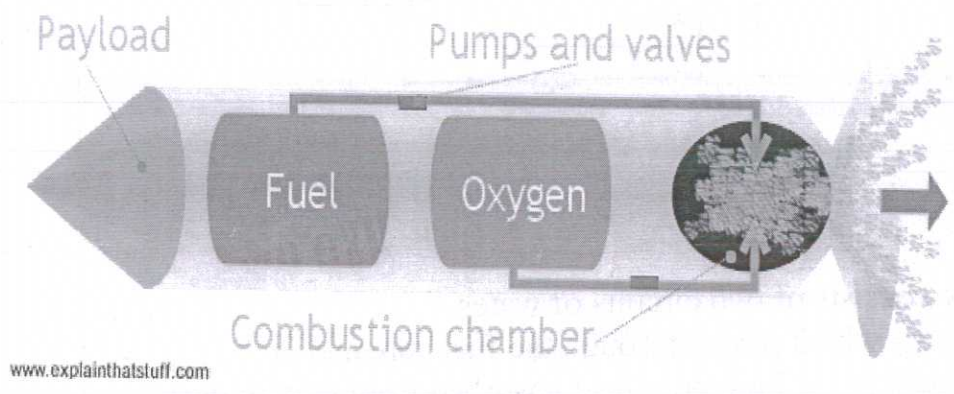


Fig-(3)
+
Expln-
(3)

Or, similar figs

(Hints)

It is the **principle** of action and reaction. In the case of **rockets**, the action is the force produced by the expulsion of gas, smoke, and flames from the nozzle end of a **rocket** engine. The reaction force propels the **rocket** in the opposite direction. ... The law states that it takes a force to change the motion of an object.

- ❖ Fuel and oxygen for combustion are in liquid form
- ❖ These liquids forced in to CC
- ❖ After combustion hot gases expanded through a nozzle to form propelling jet thus the rocket moves to opp. direction

(6)

142

IX
a)

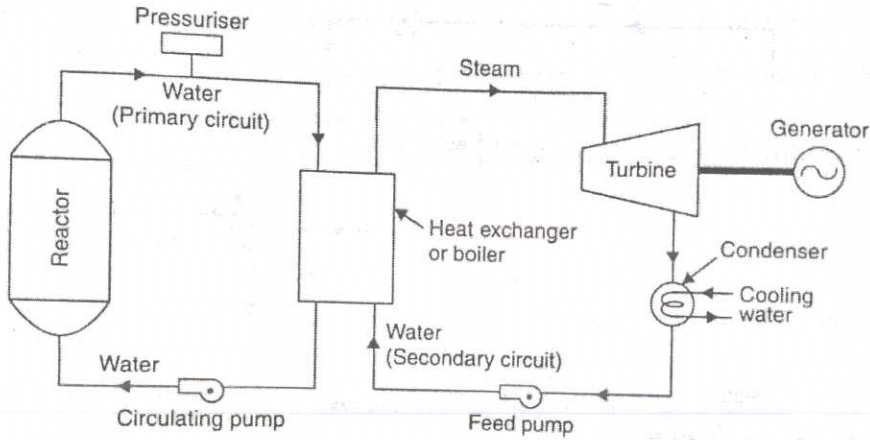


Fig -
(5)
+
Expl-
(4)

(9)

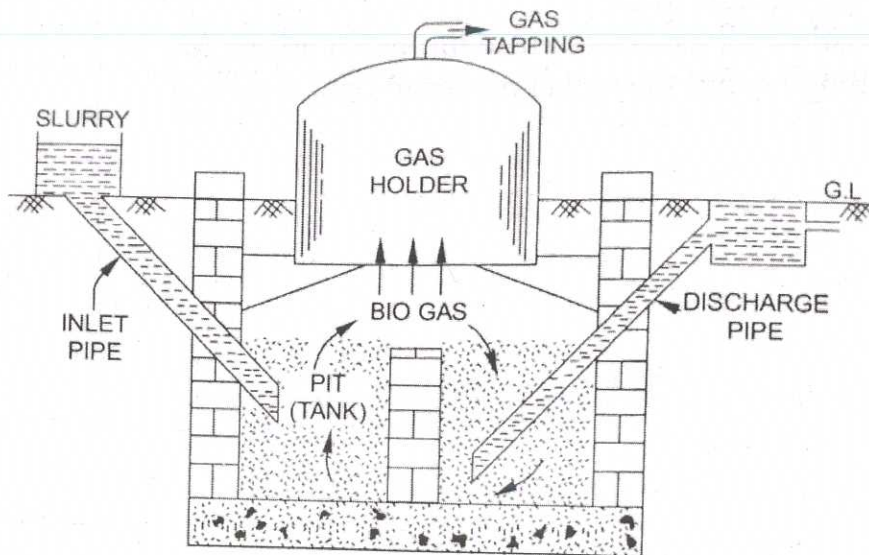
Or, similar figs

Hints:

- PWR consists of two circuits of water – Primary- which passes through the fuel core and is radioactive – at high pr. – heat absorbed from reactor core continuously
- A pressurizing tank keeps the water at high pr. (about 100kgf/cm^2) so that will not boil
- Heat exchanged though a heat exchanger to water at secondary circuit which is at a comparatively low pr. converts to steam
- pass to turbine – power generated

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IX
b)



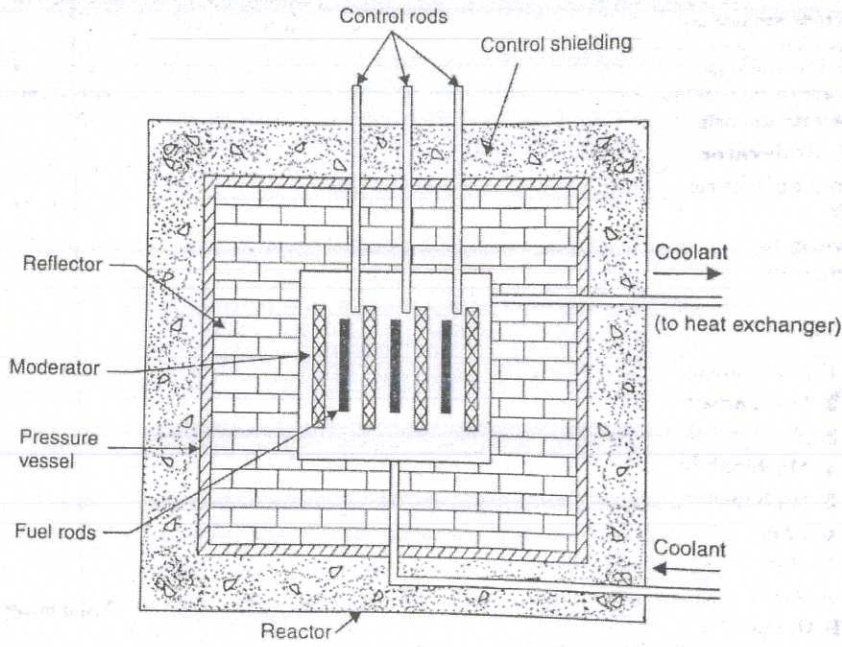
(6)

Or, Simillar figs.

(6)

157

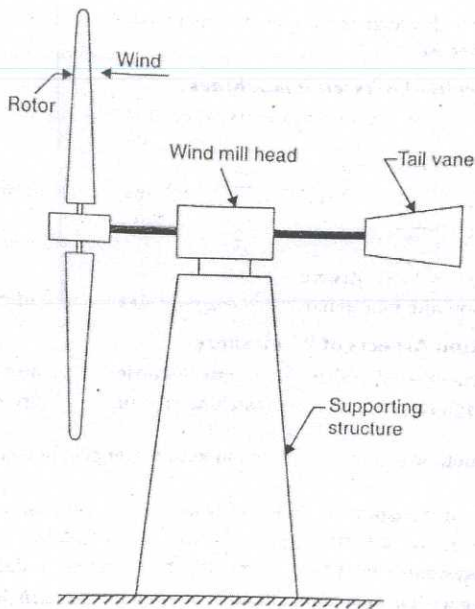
X
a)



Or, Simillar figs

- Fuel rods---
- Moderator ----
- Reflector ---
- Pr.vessel ---
- Concrete shield / Biological shield---
- Coolant ---

X
b)



OR, Simillar figs..

Fig -
(5)
+

Expln-
(4)

(9)

166

(6)

172

(6)

