BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI, DUBAI CAMPUS

II SEMESTER 2012-2013

COMPREHENSIVE EXAMINATION (Closed book)

Year : III-MECHANICAL	**Date :** 03.06.2013 (AN)	
Course No. : ME C314	**Course Title :** POWER PLANT ENGINEERING	
Duration : 3 hrs	**Marks: 80**	**Weightage** : 40 %

Notes: (i) *answer all the questions* (ii) *Draw neat sketches wherever necessary*

(iii) *Make suitable assumptions if required and clearly state them (iv) Steam table will be provided*

Q.1 A power station has the following loads:

	Residential lighting load	Commercial Load	Industrial Load
Maximum demand **(kW)**	1200	2400	6000
Load factor	0.21	0.32	0.82
Diversity between customers	1.32	1. 2	1. 22

Assume overall diversity factor may be taken as 1.42

Determine the following

i) Overall maximum demand on system

ii) Overall daily energy consumption (total)

iii) Overall load factor

iv) Connected load (total) assuming that demand factor for each load is unity

[6 M]

Q.2 A steam power plant equipped with regenerative as well as reheat arrangement is supplied with steam to the H.P turbine at 80 bar 470°C as shown in Fig.1. For feed heating, a part of steam is extracted at 7 bar and remainder of the steam is reheated at 350°C in a reheater and then expanded in L.P. turbine down to 0.035 bar.

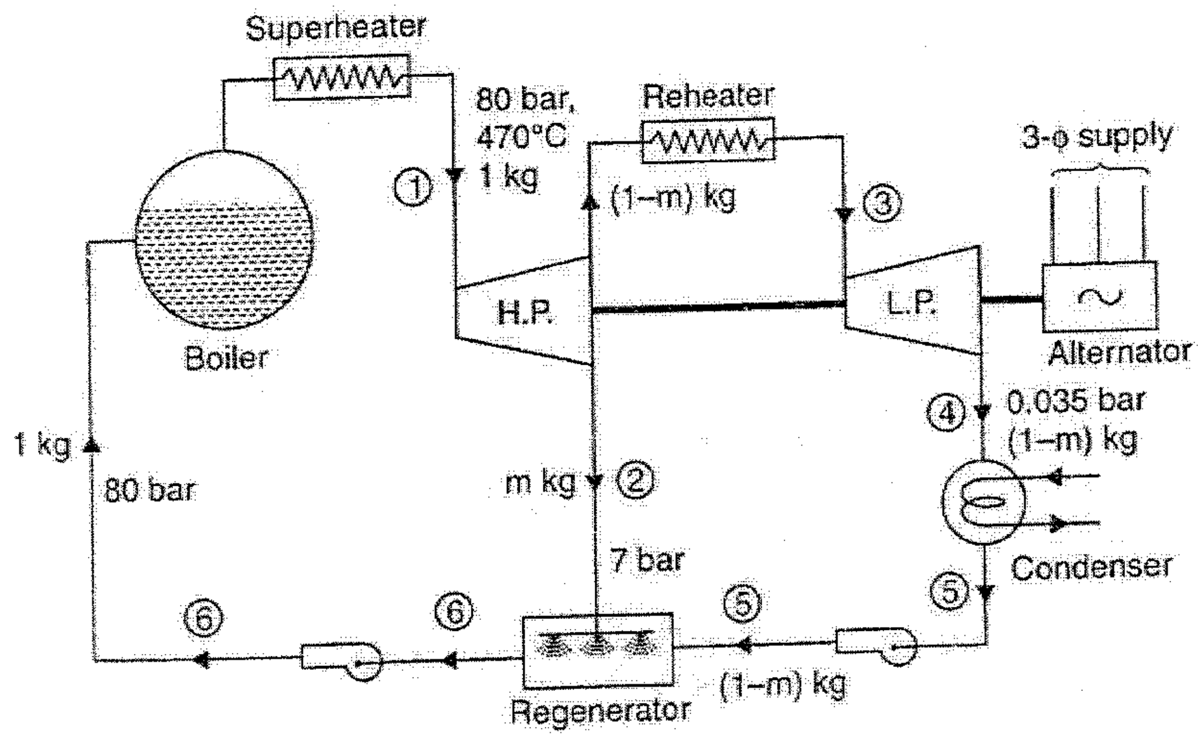

Fig.1

Determine

(i) Amount of steam bled-off for feed heating (ii) Amount of steam supplied to L.P turbine (iii) Heat supplied in the boiler and reheater (iv) Cycle efficiency (v) Power developed by the steam [10 M]

Q.3 In a single stage impulse turbine the mean diameter of the blade ring is 1 metre and the rotational speed is 3000 r.p.m. The steam is issued from the nozzle at 300 m/s and nozzle angle is 20°. The blades are equiangular. If the friction loss in the blade channel is 19% of the kinetic energy corresponding to the relative velocity at the inlet to the blades, what is the power developed in the blading when the axial thrust on the blades is 98N? [8 M]

Q.4 In a boiler trial, the analysis of the coal used is as follows: C= 20 %, H_2 = 4.5 %, O_2 = 7.5 % remainder incombustible matter:

The dry flue gas has the following composition by volume CO_2 = 8.5 %, CO = 1.2 %, N_2 = 80.3 %, O_2 =10%,

Determine: (a) the mass of theoretical air supplied per kg of coal.

(b) Mass of flue gas per kg of fuel (c) the percentage excess air [09M]

Q.5 A power plant is proposed on a river where the available average flow is 70 m^3 / sec and head is 15 m. The Kaplan turbine has to run at constant speed of 200 r.p.m. The efficiency of the turbine is 50%. The best specific speed of the runner at the site is 340.

Diameter of runner in **cm**	143	151	158.5	165	172.5
Unit Power **(kW)**	66.7	74	82.5	87	92
Unit Speed **(RPM)**	53	51	48.5	45.4	42.5

Find a) Total power available at site
b) Power output per turbine,
b) Number of turbines required
c) The unit power and unit speed
c) The diameter of the runner selected from the above data by interpolation. [07 M]

Q.6. A single cylinder oil engine working on four stroke cycle has bore 11 cm and stroke 13 cm and runs at 600 rev/min. The mean effective pressure is 7 bar. It uses 1.17 kg of oil per hour having a Calorific Value of 44520 kJ. The cylinder jacket cooling water enters at a temperature of 18°C and leaves at 60°C. The quantity of water being circulated 95 kg per hour. The effective radius of brake wheel is 43.5 cm. The net load on the brake is 110 Newton.

Calculate IP, BP, FP, Indicated and brake thermal efficiencies and mechanical efficiency. Draw up percentage heat balance sheet assuming that 6% of the heat supply is lost by radiation. Take specific heat of water = 4.187 kJ/kg K [09 M]

Q.7 In a boiler trial the following data were obtained:

Coal consumption = 500 kg

Gross calorific value of coal = 33600 kJ

Moisture content of coal = 2% by mass

Temperature of flue gases = 305°C

The mean specific heat of dry gases	= 1.0 kJ/kg K
The mean specific heat of steam	= 2.1 kJ/kg K
The boiler room temperature	= 16°C
Dry saturated steam pressure from boiler	= 11 bar
Feed water temperature to boiler	= 80°C
Dry steam produced per hour	= 4700 kg
Atmospheric pressure	= 1 bar

The analysis of fuel used is as follows:

Carbon = 85 %, Hydrogen = 5 % and Ash = 10 %

The analysis of dry gases by volume was as follows:

CO_2 = 9.5 %, O_2 = 10 % and N_2 = 80.5 %

Make a complete heat balance sheet for the trial, based on the gross calorific value of 1 kg of dry coal. [10 M]

Q.8 A gas turbine unit has a pressure ratio of 6: 1 and maximum cycle temperature of 610°C. The isentropic efficiencies of the compressor and turbine are 0.80 and 0.82 respectively. Calculate the power output in kilowatts of an electric generator geared to the turbine when the air enters the compressor at 15°C at the rate of 16 kg/s.

Take C_p = 1.005 kJ/kg K and γ = 1.4 for the compression process, and take C_p = 1.11 kJ/kg K and γ = 1.333 for the expansion process. [08M]

Q.9 (a) Give the energy flow diagram (Sankey diagram) of a combined cycle power plant. [03M]

(b) Briefly explain the operation of a spreader stoker with the help of a neat sketch. [05M]

(c) Briefly explain about liquid metal fast breeder reactor (LMFBR) with the help of a neat sketch [05M]

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ANSWERS

Q.1 A power station has the following loads:

	Residential lighting load	Commercial Load	Industrial Load
Maximum demand **(kW)**	1200	2400	6000
Load factor	0.21	0.32	0.82
Diversity between customers	1.32	1. 2	1. 22

Assume overall diversity factor may be taken as 1.42

Determine the following

i) Overall maximum demand on system

ii) Overall daily energy consumption (total)

iii) Overall load factor

iv) Connected load (total) assuming that demand factor for each load is unity

[6 M]

Solution. (i) Maximum demand on system :

$$\text{Group diversity factor} = \frac{\text{Sum of individual maximum demands}}{\text{Actual maximum demand of the group}}$$

$$\therefore \quad 1.42 = \frac{1200 + 2400 + 6000}{\text{Maximum demand on system}}$$

$$\textit{i.e., Maximum demand on system} = \frac{1200 + 2400 + 6000}{1.42} = 6760.5 \text{ kW.} \quad \text{(Ans.)}$$

(*ii*) **Daily energy consumption :**

$$\text{Load factor} = \frac{\text{Average demand}}{\text{Maximum demand}}$$

or $$\text{Average demand} = \text{Maximum demand} \times \text{load factor}$$

$$= 1200 \times 0.21 + 2400 \times 0.32 + 6000 \times 0.82$$

$$= 5940 \text{ kW}$$

$\therefore$ *Daily energy consumption* $= 5940 \times 24 =$ **142560 kWh.** **(Ans.)**

(*iii*) **Overall load factor :**

$$\text{Overall load factor} = \frac{\text{Average demand}}{\text{Maximum demand}}$$

$$= \frac{5940}{6760.5} = \mathbf{0.878.} \quad \textbf{(Ans.)}$$

(*iv*) **Connected load :**

$$\text{Maximum demand} = 1200 \times 1.32 + 2400 \times 1.2 + 6000 \times 1.22 = 11784 \text{ kW}$$

$$\text{Connected load} = \frac{\text{Maximum demand}}{\text{Demand factor}} = \frac{11784}{1}$$

$$= 11784 \text{ kW.} \quad \text{(Ans.)}$$

Q.2 A steam power plant equipped with regenerative as well as reheat arrangement is supplied with steam to the H.P turbine at 80 bar 470°C as shown in Fig.1. For feed heating, a part of steam is extracted at 7 bar and remainder of the steam is reheated at 350°C in a reheater and then expanded in L.P. turbine down to 0.035 bar.

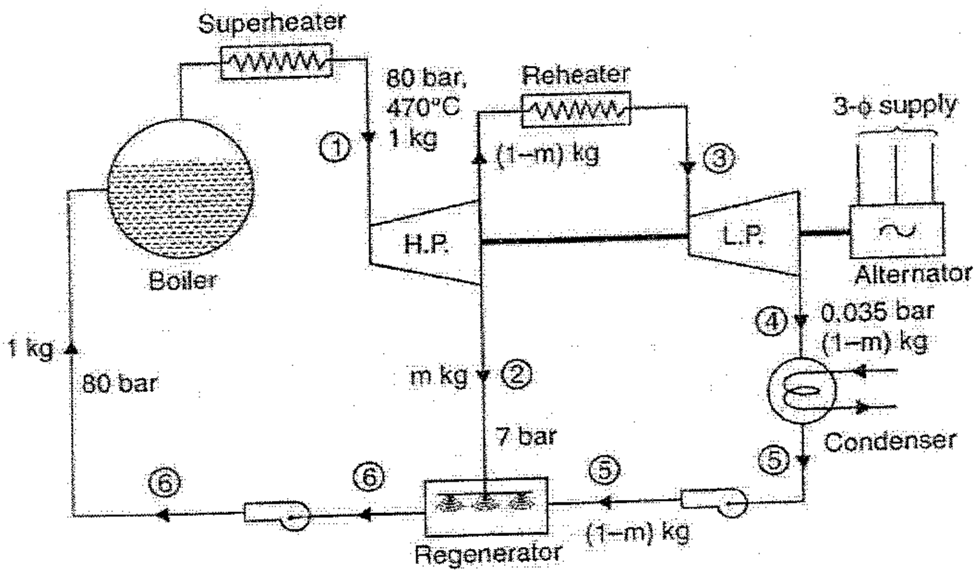


Fig.1

Determine

(i) Amount of steam bled-off for feed heating (ii) Amount of steam supplied to L.P turbine (iii) Heat supplied in the boiler and reheater (iv) Cycle efficiency (v) Power developed by the steam [10 M]

Solution

From h-s chart and steam tables, we have enthalpies at different points as follows :

$h_1 = 3315$ kJ/kg ; $h_2 = 2716$ kJ/kg
$h_3 = 3165$ kJ/kg ; $h_4 = 2236$ kJ/kg } From h-s chart

$h_{f6} = h_{f2} = 697.1$ kJ/kg ; $h_{f5} = h_{f4} = 101.9$ kJ/kg } From steam table.

(*i*) **Amount of steam bled off for feed heating :**

Considering *energy balance at regenerator, we have :*

Heat lost by steam = Heat gained by water

$$m(h_2 - h_{f6}) = (1 - m)(h_{f6} - h_{f5})$$

or $$m(h_2 - h_{f2}) = (1 - m)(h_{f2} - h_{f4}) \qquad [\because h_{f6} = h_{f2} ; h_{f5} = h_{f4}]$$

or $$m(2716 - 697.1) = (1 - m)(697.1 - 111.9)$$

or $$2018.9\,m = 585.2\,(1 - m)$$

∴ $$m = 0.225 \text{ g of steam supplied}$$

Hence amount of **steam bled off is 22.5% of steam generated by the boiler. (Ans.)**

(*ii*) **Amount of steam supplied to L.P. turbine :**

Amount of steam supplied to L.P. turbine

= 100 − 22.5

= **77.5% of the steam generated by the boiler. (Ans.)**

(*iii*) **Heat supplied in the boiler and reheater**

Heat supplied in the *boiler* per kg of steam generated

$= h_1 - h_{f6} = 3315 - 697.1 =$ **2617.9 kJ/kg. (Ans.)** $(\because h_{f6} = h_{f2})$

Heat supplied in the *reheater* per kg of steam generated

$= (1 - m)(h_3 - h_2)$

$= (1 - 0.225)(3165 - 2716) =$ **347.97 kJ/kg. (Ans.)**

Total amount of heat supplied by the boiler and reheater per kg of steam generated,

$$Q_s = 2617.9 + 347.97 = 2965.87 \text{ kJ/kg}$$

(iv) **Cycle efficiency, η_{cycle} :**

Amount of work done by per kg of steam generated by the boiler,

$$W = 1(h_1 - h_2) + (1 - m)(h_3 - h_4), \text{ Neglecting pump work}$$

$$= (3315 - 2716) + (1 - 0.225)(3165 - 2236) \simeq 1319 \text{ kJ/kg}$$

$$\therefore \quad \eta_{cycle} = \frac{W}{Q_s} = \frac{1319}{2965.87} = 0.4447 \quad \text{or} \quad 44.47\% \quad \textbf{(Ans.)}$$

(v) **Power developed by the system :**

Power developed by the system

$$= m_s \times W = 50 \times 1319 \text{ kJ/s} = \frac{50 \times 1319}{1000}$$

$$= 65.95 \text{ MW} \quad \textbf{(Ans.)}$$

Q.3 In a single stage impulse turbine the mean diameter of the blade ring is 1 metre and the rotational speed is 3000 r.p.m. The steam is issued from the nozzle at 300 m/s and nozzle angle is 20°. The blades are equiangular. If the friction loss in the blade channel is 19% of the kinetic energy corresponding to the relative velocity at the inlet to the blades, what is the power developed in the blading when the axial thrust on the blades is 98N? [8 M]

Solution

Solution. Mean diameter of the blade ring, $D = 1$ m

Speed of the turbine, $N = 3000$ r.p.m.

Absolute velocity of steam issuing from the nozzle, $C_1 = 300$ m/s

Nozzle angle, $\alpha = 20°$

Blade angles are equiangular, $\theta = \phi$

Friction loss in the blade channel $= 19\%$

i.e., $C_{r_0} = (1 - 0.19)\, C_{r_1} = 0.81\, C_{r_1}$

Axial thrust on the blades $= 98$ N

Power developed, P :

Blade speed, $C_{bl} = \frac{\pi DN}{60} = \frac{\pi \times 1 \times 3000}{60} = 157.1$ m/s

Also $\theta = \phi$ (given)

Now, velocity diagram is drawn to a suitable scale as shown in Fig. 19.24.

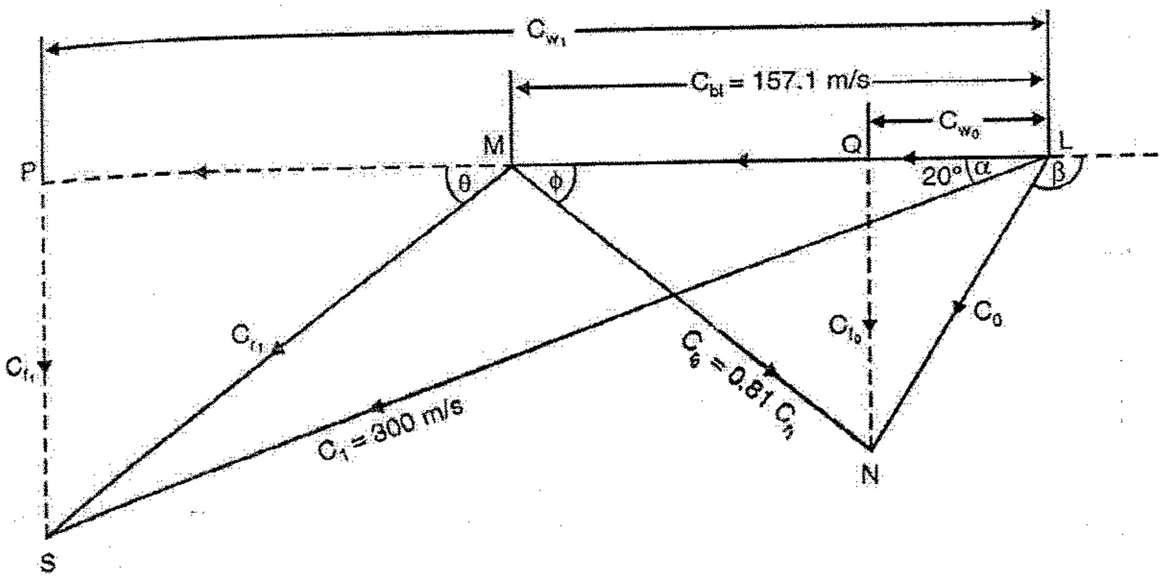


Fig. 19.24

By measurement (from diagram) ;

$C_{w_1} = 283.5$ m/s ; $C_{w_0} = 54$ m/s

$C_{f_1} = 100.5$ m/s

$C_{f_0} = 81$ m/s.

Axial thrust $= \dot{m}_s(C_{f_1} - C_{f_0})$

$98 = \dot{m}_s\ (100.5 - 81)$ or $\dot{m}_s = \frac{98}{100.5 - 81} = 5.025$ kg

Power developed, $P = \frac{\dot{m}_s[C_{w_1} + *(-C_{w_0})]}{1000} C_{bl}$ (*$\beta > 90°$)

$= \frac{5.025\,(283.5 - 54) \times 157.1}{1000} = 181.2$ **kW. (Ans.)**

Q.4 In a boiler trial, the analysis of the coal used is as follows: C= 20 %, H_2 = 4.5 %, O_2 = 7.5 % remainder incombustible matter:

The dry flue gas has the following composition by volume CO_2 = 8.5 %, CO = 1.2 %, N_2 = 80.3 %, O_2 =10%,

Determine: (a) the mass of theoretical air supplied per kg of coal.

(b) Mass of flue gas per kg of fuel (c) the percentage excess air [09M]

Solution.

Constituent	Mass per kg of fuel (a)	O_2 reqd. per kg of constituent (b)	O_2 reqd. per kg fuel (c)
C	0.20	$\frac{8}{3}$	0.533
H_2	0.045	8	0.36
O_2	0.075	—	-0.075
Ash	0.68		—
			$\Sigma C = 0.818$

Oxygen reqd. per kg of fuel $= 0.818$ kg

Minimum mass of air reqd./kg of fuel,

$$= \frac{0.818 \times 100}{23} = 3.56 \text{ kg}$$

In order to find out the mass of flue gas per kg of fuel let us convert the analysis by volume of flue gases to analysis by mass by the tabular method.

Name of gas	Vol. per m^3 of flue gas (a)	Molecular mass (b)	Proportional mass $(c) = (a) \times (b)$	Mass per kg flue gas $(d) = \frac{(c)}{\Sigma(c)}$
CO_2	0.085	44	3.740	0.1256
CO	0.012	28	0.336	0.0112
N_2	0.803	28	22.484	0.7556
O_2	0.100	32	3.200	0.1076
			$\Sigma C = 29.76$	

Amount of carbon per kg of flue gas

= amount of carbon in 0.1256 kg of CO_2 + amount of carbon in 0.0112 kg of CO

$$= \frac{3}{11} \times 0.1256 + \frac{3}{7} \times 0.0112 = 0.039 \text{ kg}$$

We are also given that the amount of carbon per kg of fuel = 0.2 kg

Mass of flue gas per kg of fuel, $= \frac{0.2}{0.039} = 5.129$ kg

Mass of excess oxygen per kg of flue gas $= 0.1076 - \frac{4}{7} \times 0.0112 = 0.1012$ kg

(allowing for unburnt carbon monoxide)

Mass of excess O_2 per kg of fuel $= 5.129 \times 0.1012 = 0.519$

$\therefore$ Mass of excess air per kg of fuel $= \frac{0.519 \times 100}{23} = 2.253$

Percentage excess air $= \frac{2.253}{3.56} = 63.2\%$

Q.5 A power plant is proposed on a river where the available average flow is 70 m^3 / sec and head is 15 m. The Kaplan turbine has to run at constant speed of 200 r.p.m. The efficiency of the turbine is 50%. The best specific speed of the runner at the site is 340.

Diameter of runner in **cm**	143	151	158.5	165	172.5
Unit Power **(kW)**	66.7	74	82.5	87	92
Unit Speed **(RPM)**	53	51	48.5	45.4	42.5

Find a) Total power available at site b) Power output per turbine [07 M]

Solution. The given data is as follows.

$Q = 70$ m^3/sec, $H = 15$ m, $N = 200$ r.p.m., $N_s = 340$, $\eta = 90\%$.

(*a*) The type of the runner is Kaplan as the specific speed is 340.

(*b*) The total power available at the site is given by

$$P = \frac{wQH}{1000} \times \eta$$

$$= \frac{1000 \times 9.81 \times 70 \times 15}{1000} \times 0.9 = \mathbf{9270\ kW}$$

The power output per turbine is given by

$$N_s = \frac{N\sqrt{P}}{(H)^{5/4}}$$

$$340 = \frac{200\sqrt{P}}{(15)^{1.25}}$$

$$\sqrt{P} = \frac{340 \times 29.5}{200} = 50$$

$\therefore$ $P = \mathbf{2500\ kW}$

$\therefore$ Number of turbine units required $= \frac{9270}{2500} = 3.7 = 4$

(*c*) The unit power and unit speed are given by,

$$P_u = \frac{P}{(H)^{3/2}} = \frac{2500}{(15)^{1.5}} = 86.2 \text{ kW}$$

$$N_u = \frac{N}{(H)^{1/2}} = \frac{200}{(15)^{0.5}} = \frac{200}{3.87} = 51.7 \text{ r.p.m. m}^{-1/2}$$

For unit power of 86.2 and unit speed of 51.7, the required diameter can be calculated by interpolation from the given data as

$$= 158.5 + \frac{(86.2 - 82.5)}{(87 - 82.5)} \times (165 - 158.5) = 158.5 = \frac{3.7}{4.5} \times 6.5 = \mathbf{163.85\ cm.}$$

Q.6. A single cylinder oil engine working on four stroke cycle has bore 11 cm and stroke 13 cm and runs at 600 rev/min. The mean effective pressure is 7 bar. It uses 1.17 kg of oil per hour having a Calorific Value of 44520 kJ. The cylinder jacket cooling water enters at a temperature of 18°C and leaves at 60°C. The quantity of water being circulated 95 kg per hour. The effective radius of brake wheel is 43.5 cm. The net load on the brake is 110 Newton.

Calculate IP, BP, FP, Indicated and brake thermal efficiencies and mechanical efficiency. Draw up percentage heat balance sheet assuming that 6% of the heat supply is lost by radiation. Take specific heat of water = 4.187 kJ/kg K [09 M]

Solution. $p_m = 7$ bar and $L = 13 \text{ cm} = 0.13 \text{ m}$

$D = 11$ cm and $A = \frac{\pi}{4}(11)^2 = 95 \text{ cm}^2 = 0.0095 \text{ m}^2$

$N = 600$ rev/min ; $n = \frac{N}{2} = 300,\ K = 1$

$$ip = \frac{p_m LAnK}{60} = \frac{7 \times 10^5 \times 0.13 \times 0.0095 \times 300 \times 1}{60 \times 1000}$$

$$ip = 4.32 \text{ kW}$$

Now effective radius of the brake wheel

$$R = \frac{85}{2} + \frac{2}{2} = 42.5 + 1 = 43.5 \text{ cm} = 0.435 \text{ m}$$

$$bp = \frac{(F - S)R \times 2\pi N}{60} = \frac{110 \times 0.435 \times 2\pi \times 600}{60 \times 1000} = 3 \text{ kW} \quad \textbf{Ans.}$$

$$\text{fp} = \text{ip} - \text{bp} = 4.32 - 3.0 = 1.32 \text{ kW}$$

Heat supplied in fuel per minute $= \frac{1.17 \times 44520}{60} = 868$ kJ

Indicated thermal efficiency $= \frac{\text{ip} \times 60}{(\text{Heat supplied in fuel/minute})} \times 100$

$= \frac{4.32 \times 60}{868} \times 100 = 29.86\%$

Brake thermal efficiency $= \frac{\text{bp} \times 60}{(\text{Heat supplied in fuel/minute})} \times 100$

$= \frac{3 \times 60}{868} \times 100 = 20.7\%$ **Ans.**

Mechanical efficiency $= \frac{bp}{ip} \times 100 = \frac{3}{4.32} \times 100 = \mathbf{69.4\%}$ **Ans.**

Heat in bp per minute $= 3 \times 60 = 180$ kJ/min

Percentage of heat in bp $= \frac{180}{868} \times 100 = 20.7\%$

Heat rejected to cooling water per minute $= \frac{95}{60}(60 - 18) \times 4.187 = 278.4$ kJ

Percentage of heat rejected to cooling water $= \frac{278.4}{868} \times 100 = 32.1\%$

Heat lost by radiation (given) $= 6\%$

Total heat accounted for $= 20.7 + 32.1 + 6.0 = 58.8\%$

Heat lost to exhaust gases and other unaccounted for (by difference)

$= 100 - 58.8 = 41.2\%$

The heat balance sheet may now be drawn as follows :

Heat Balance Sheet

Particulars	Percentage
Heat in fuel supplied	100%
Heat equivalent to *bp*	20.7
Heat rejected to cooling water	32.1
Heat lost by radiation (given)	6.0
Heat lost to exhaust gases and other unaccounted for (by difference)	41.2
Total	100%

Q.7 In a boiler trial the following data were obtained:

Coal consumption	= 500 kg
Gross calorific value of coal	= 33600 kJ
Moisture content of coal	= 2% by mass
Temperature of flue gases	= 305°C
The mean specific heat of dry gases	= 1.0 kJ/kg K
The mean specific heat of steam	= 2.1 kJ/kg K
The boiler room temperature	= 16°C
Dry saturated steam pressure from boiler	= 11 bar

Feed water temperature to boiler = 80°C

Dry steam produced per hour = 4700 kg

Atmospheric pressure = 1 bar

The analysis of fuel used is as follows:

Carbon = 85 %, Hydrogen = 5 % and Ash = 10 %

The analysis of dry gases by volume was as follows:

CO_2 = 9.5 %, O_2 = 10 % and N_2 = 80.5 %

Make a complete heat balance sheet for the trial, based on the gross calorific value of 1 kg of dry coal. [10 M]

Solution. Total heat of 1 kg of steam produced = 2782 kJ

Total heat of 1 kg of feed water = 336 kJ

Heat given to steam per kg of dry coal $= \dfrac{(2782 - 336) \times 4700}{500 \times 0.98} = 23460$ kJ.

Dry Flue Gas

Name of gas	Volume per 100 cu m flue gas (*a*)	Molecular mass (*b*)	Proportional mass ($a \times b$)	*C*
CO_2	9.5	44	418	$418 \times \frac{12}{44} = 114$
O_2	10.0	32	320	
N_2	80.5	28	2250	
	100.00		2988	

Mass of dry flue gas $= \dfrac{2988}{114} \times 0.85 = 22.3$ kg/kg of coal

Mass of vapour $= 0.05 \times 9 = 0.45$ kg/kg dry coal

Mass of moisture fired $= \dfrac{0.02}{0.98} = 0.0204$ kg/kg of dry coal

Total mass of vapour in flue gases $= 0.4704$ kg/kg of dry coal

Heat carried away by vapour $= M_a\,[h + C_p\,(t_s - t) - t_r]$

$= 0.4704\,[2680 + 2.1\,(305 - 99.6) - 16 \times 4.187]$

$= 1432$ kJ.

Heat carried away by dry flue gases $= M_f\,C_p\,(t_f - t_a) = 22.3 \times 1.0\,(305 - 16) = 6445$ kJ.

Heat Balance Sheet per kg of Dry Coal

Heat supplied kJ	%age	Heat expenditure kJ		%age
Gross heat supplied = 33600 kJ		Heat supplied in steam formation	= 23460	69.82%
		Heat carried by flue gases	= 6445	19.20%
		Heat lost in evaporating and superheating vapour	= 1432	4.26%
		Heat unaccounted for	= 2263	6.74%
Total : 33600	100		Total : 33600	100

Q.8 A gas turbine unit has a pressure ratio of 6: 1 and maximum cycle temperature of 610°C. The isentropic efficiencies of the compressor and turbine are 0.80 and 0.82 respectively. Calculate the power output in kilowatts of an electric generator geared to the turbine when the air enters the compressor at 15°C at the rate of 16 kg/s.

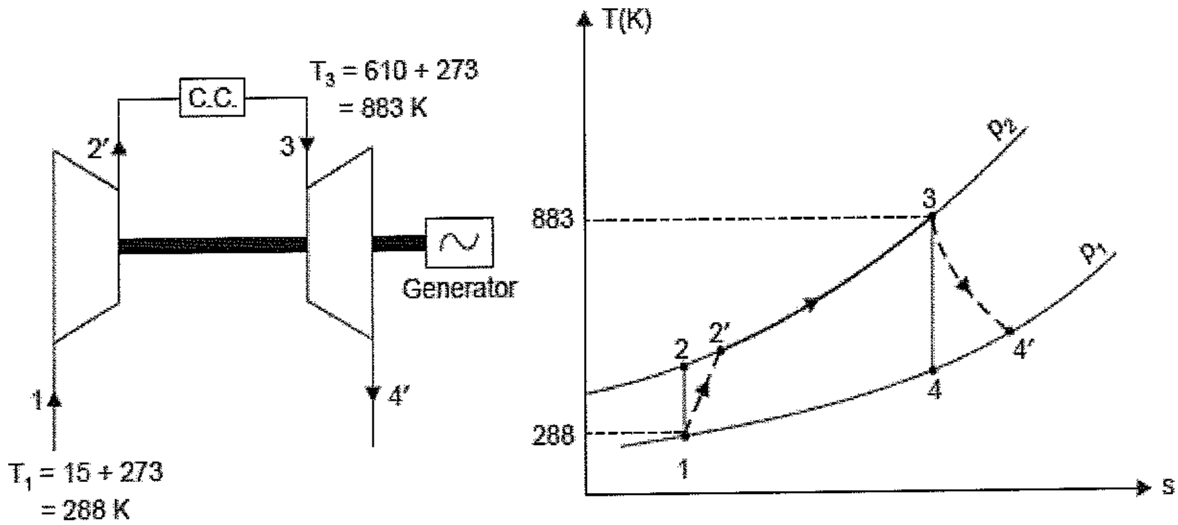
Take C_p = 1.005 kJ/kg K and γ = 1.4 for the compression process, and take C_p = 1.11 kJ/kg K and γ = 1.333 for the expansion process. [08M]

Solution. *Given* : $T_1 = 15 + 273 = 288$ K ; $T_3 = 610 + 273 = 883$ K ; $\frac{p_2}{p_1} = 6$,

$\eta_{compressor} = 0.80$; $\eta_{turbine} = 0.82$; Air flow rate = 16 kg/s

For compression process : $c_p = 1.005$ kJ/kg K, $\gamma = 1.4$

For expansion process : $c_p = 1.11$ kJ/kg K, $\gamma = 1.333$



(a) (b)

For an isentropic process, $\frac{T_2}{T_1} = \left(\frac{p_2}{p_1}\right)^{\frac{\gamma-1}{\gamma}} = (6)^{\frac{14-1}{14}} = 1.67$

$\therefore$ $T_2 = 288 \times 1.67 = 481 \text{ K}$

Also, $\eta_{compressor} = \frac{T_2 - T_1}{T_2' - T_1}$

$$0.8 = \frac{481 - 288}{T_2' - T_1}$$

$\therefore$ $T_2' = \frac{481 - 288}{0.8} + 288 = 529 \text{ K}$

Similarly for the turbine, $\frac{T_3}{T_4} = \left(\frac{p_3}{p_4}\right)^{\frac{\gamma-1}{\gamma}} = \left(\frac{p_2}{p_1}\right)^{\frac{\gamma-1}{\gamma}} = (6)^{\frac{1.333-1}{1.333}} = 1.565$

$\therefore$ $T_4 = \frac{T_3}{1.565} = \frac{883}{1.565} = 564 \text{ K}$

Also, $\eta_{turbine} = \frac{T_3 - T_4'}{T_3 - T_4} = \frac{883 - T_4'}{883 - 564}$

$\therefore$ $0.82 = \frac{883 - T_4'}{883 - 564}$

$\therefore$ $T_4' = 883 - 0.82\,(883 - 564) = 621.4 \text{ K}$

Hence,

Compressor work input, $W_{compressor} = c_p\,(T_2' - T_1)$
$= 1.005\,(529 - 288) = 242.2 \text{ kJ/kg}$

Turbine work output, $W_{turbine} = c_p\,(T_3 - T_4')$
$= 1.11\,(883 - 621.4) = 290.4 \text{ kJ/kg.}$

$\therefore$ Net work output, $W_{net} = W_{turbine} - W_{compressor}$
$= 290.4 - 242.2 = 48.2 \text{ kJ/kg}$

Power in kilowatts $= 48.2 \times 16 =$ **771.2 kW. (Ans.)**

Q.9 (a) Give the energy flow diagram (Sankey diagram) of a combined cycle power plant. [03M]

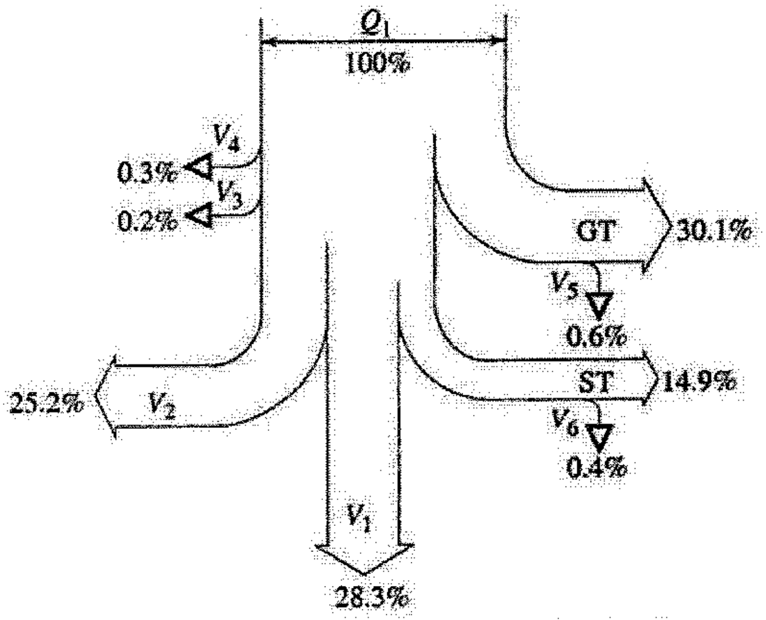


Fig. 3.19 Energy flow diagram of the combined cycle plant with *GT* and *ST* together converting 45% of the input energy (Q_1) into electricity

(b) Briefly explain the operation of a spreader stoker with the help of a neat sketch. [05M]

Refer Class Notes-Theory

(c) Briefly explain about liquid metal fast breeder reactor (LMFBR) with the help of a neat sketch [05M]

Refer Class Notes-Theory

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI, DUBAI CAMPUS

II SEMESTER 2012-2013

Test No.2 (Open Book)

Year : III-MECHANICAL	Date : 28.04.2013	
Course No. : ME C 314	Course Title : POWER PLANT ENGINEERING	
Duration : 50Min	Marks: 40	Weightage : 20 %

Q.1 A fuel **($C_{10}H_{22}$)** is burnt using an air fuel ratio **13:1** by weight. Assuming that the whole amount of hydrogen burns to form water vapour and there is neither any free oxygen nor any free carbon.

Air contains 77 % of nitrogen and 23 % of oxygen by weight. Determine

a) Theoretical weight of air required for complete combustion
b) Deficiency of air-fuel ratio
c) Percentage composition of flue gases from weight analysis to volumetric analysis [16 M]

Q.2 The following data relate to a boiler test:

i. Coal used per hour 6750 kg having moisture content of 2 %
ii. Mass of steam generated 60500 kg per hour, dry saturated at 16.5 bar
iii. Gross calorific value of fuel = 35490 kJ/kg
iv. Ultimate mass analysis of dry coal being C=84%, H_2 = 4 % and ash = 8 %
v. Dry flue gas analysis by volume, CO_2 = 9.5%, O_2 = 10.48 % and N_2 = 80.02 %.
vi. Temperature of flue gas = 305^{o}C
vii. Ambient temperature 32^{o}C
viii. Specific heat of flue gas 1.0 kJ/kg- ^{o}C
ix. Partial pressure of dry steam going with flue gas = 1bar
x. Specific heat of super heat steam due to moisture in flue gas 2 kJ/kg- ^{o}C

Draw up a heat balance sheet per kg of dry coal, given that air contains 23 percent by mass of O_2 [18 M]

Q.3 The following data are provided for two boilers:

Steam pressure in bar		**Quality of Steam**	**Rate of evaporation**
Boiler A	10 bar	0.91	8.5 kg / kg of coal
Boiler B	16 bar	Superheated to 275^{0}C	6.95 kg / kg of coal

Both the boilers are supplied with feed water at 30^{0}C. Select the boiler which has higher rate of heat utilization per kg of coal fired. Take Specific heat of superheated steam C_p = 2.184 kJ/kg- ^{o}C [6 M]

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI, DUBAI CAMPUS

II SEMESTER 2012-2013

Test No.2 (Open Book)

Year : III-MECHANICAL	**Date : 28.04.2013**	
Course No. : ME C 314	**Course Title : POWER PLANT ENGINEERING**	
Duration : 50Min	**Marks: 40**	**Weightage : 20 %**

ANSWER [KEY]

Q.1 A fuel **($C_{10}H_{22}$)** is burnt using an air fuel ratio **13:1** by weight. Assuming that the whole amount of hydrogen burns to form water vapour and there is neither any free oxygen nor any free carbon.

Air contains 77 % of nitrogen and 23 % of oxygen by weight. Determine

a) Theoretical weight of air required for complete combustion
b) Deficiency of air-fuel ratio
c) Percentage composition of flue gases from weight analysis to volumetric analysis [16 M]

Solution

Solution. Combustion equation is :

$$2C_{10}H_{22} + 31O_2 = 20CO_2 + 22H_2O$$

$$2 \times 142 + 31 \times 32 = 20 \times 44 + 22 \times 18$$

or $$284 + 992 = 880 + 396$$

∴ Air required for complete combustion

$$= \frac{992 \times 100}{284 \times 23} = 15.2 \text{ kg/kg of fuel}$$

Air actually supplied = 13 kg/kg of fuel

∴ Deficiency of air = 15.2 − 13 = 2.2 kg/kg of fuel

Also 1 kg of C requires $\frac{4}{3} \times \frac{100}{23} = 5.8$ kg of less air to burn to CO instead of CO_2.

Hence $\frac{2.2}{5.8} = 0.379$ kg C is burnt to CO ;

and $\left(\frac{12 \times 10}{142}\right) - 0.379 = 0.466$ kg of C is burnt to CO_2.

Weight of CO_2 formed $= 0.466 \times \frac{11}{3} = 1.708$ kg

Weight of CO formed $= 0.379 \times \frac{7}{3} = 0.884$ kg

Weight of H_2O formed $= \left(\frac{22}{142}\right) \times 9 = 1.394$ kg

Weight of N_2 from air $= 13 \times 0.77 = 10.01$ kg.

The percentage composition of products of combustion

Products of combustion	Weight x	Molecular weight y	Proportional volume $z = \frac{x}{y}$	Percentage $= \frac{z}{\Sigma z} \times 100$
CO_2	1.708	44	0.0388	7.678 per cent (Ans.)
CO	0.884	28	0.0316	6.254 per cent (Ans.)
H_2O	1.394	18	0.0774	15.317 per cent (Ans.)
N_2	10.01	28	0.3575	70.750 per cent (Ans.)
			$\Sigma z = 0.5053$	

Q.2 The following data relate to a boiler test:

i. Coal used per hour 6750 kg having moisture content of 2 %
ii. Mass of steam generated 60500 kg per hour, dry saturated at 16.5 bar
iii. Gross calorific value of fuel = 35490 kJ/kg
iv. Ultimate mass analysis of dry coal being C=84%, H_2 = 4 % and ash = 8 %
v. Dry flue gas analysis by volume, CO_2 = 9.5%, O_2 = 10.48 % and N_2 = 80.02 %.
vi. Temperature of flue gas = 305°C
vii. Ambient temperature 32°C
viii. Specific heat of flue gas 1.0 kJ/kg- °C
ix. Partial pressure of dry steam going with flue gas = 1bar
x. Specific heat of super heat steam due to moisture in flue gas 2 kJ/kg- °C

Draw up a heat balance sheet per kg of dry coal, given that air contains 23 percent by mass of O_2 [18 M]

Solution

Name of gas	Volume per 100 cu m of flue gas (a)	Molecular mass (b)	Proportional mass $(a)\times(b)$	C
CO_2	9.5	44	418	$418 \times \frac{12}{44} = 114$ $C + O_2 \rightarrow CO_2$ $12 + 32 \rightarrow 44$ $\frac{12\ C}{44\ CO_2} \times 418\ CO_2 = 114$
O_2	10.48	32	335	
N_2	80.02	28	2240	
	100.00		2993	

Dry flue gas per kg of dry coal $= \frac{2993}{114} \times 0.84 = 22$ kg

Mass of vapour $= (0.04 \times 9) + \frac{0.02}{0.98}$

$= 0.36 + 0.0204 = 0.3804$ kg/kg of dry coal

Total mass of wet gases $= 22.3804$ kg/kg of dry coal

Mass of air supplied $= 22.3804 - (\text{fuel} + \text{moisture} - \text{ash})$

$= 22.3804 - (1 + 0.0204 - 0.08)$

$= 21.44$ kg/kg dry coal.

Air required for correct combustion

$$\left[\left(0.84 \times \frac{32}{12}\right) + (0.04 \times 8) - 0.04\right]\frac{1}{0.231} = 10.9 \text{ kg.}$$

$\therefore$ Excess air $= 21.44 - 10.9 = 10.54$ kg/kg dry coal.

Mass of dry gas from combustion with correct air

$= 22 - 10.54 = 11.46$ klg/kg dry coal.

Heat carried away by correct dry gases

$= 1.0 \times 11.49 \times (305 - 32) = 1.0 \times 11.49 \times 273$

$= 3136$ kJ/kg of dry coal.

Heat carried away by excess air $= 1.0 \times 10.54 \times (305 - 32) = 2877$ kJ/kg of dry coal.

Heat carried away by the vapour

$M_v\,[h_f + h_{fg} + C_p\,(t_s - t_{sat}) - h_{f1}] = M_v\,[h + C_p\,(t_s - t_{sat}) - h_{f1}]$

$= 0.3804\,[2675 + 2.0\,(305 - 99.6) - 133]$

$= 1123$ kJ/kg of coal

Heat in steam above, $32°C = \frac{60500\,(2797 - 133)}{6750 \times 0.98}$

$= 24365$ kJ/kg of dry coal.

Heat in feed water $= \frac{60500\,(47 - 32) \times 4.187}{6750 \times 0.98}$

$= \frac{60500 \times 15 \times 4.187}{6750 \times 0.98} = 573.62$ kJ/kg of dry coal.

Heat Balance Sheet per kg of Dry Coal 32°C Datum.

Heat supplied kJ	Percentage	Heat expenditure kJ	Percentage
Gross heat of kg of dry coal = 35490	98.40	Heat utilised in steam formation = 24365	67.61
Heat in feed water = 573.6	1.60	Heat carried away by correct dry gases = 3136	8.70
		Heat carried away by excess air = 2877	7.98
		Heat carried away by the vapour = 1123	3.12
		Heat lost due to radiation etc. = 4535.6	12.59
Total : 36063.6	100	Total : 36063.6	100

Q.3 The following data are provided for two boilers:

Steam pressure in bar		Quality of Steam	Rate of evaporation
Boiler A	10 bar	0.91	8.5 kg / kg of coal
Boiler B	16 bar	Superheated to 275°C	6.95 kg / kg of coal

Both the boilers are supplied with feed water at 30°C. Select the boiler which has higher rate of heat utilization per kg of coal fired. Take Specific heat of superheated steam $C_p = 2.184$ kJ/kg-°C [6 M]

Solution:

Enthalpy of 0.91 dry steam at 10 bar

$$h_A = 762.6 + 2013.6 \times 0.91$$

$$= 2595 \text{ kJ/kg}$$

Enthalpy of steam at 16 bar and 275°C

$$h_B = 2791.7 + 2.184(275 - 201.4)$$

$$= 2952.4 \text{ kJ/kg}$$

Heat Utilization of coal for boiler 'A'

$$\frac{h_A - h_{f1}}{2258} \times 8.5 = \frac{(2595 - 125.7) \times 8.5}{2258}$$

$$= 9.3 \text{ kg/kg of coal}$$

Heat Utilization of coal for boiler 'B'

$$\frac{h_B - h_{f_1}}{2258} \times 6.95 = \frac{(2952.4 - 125.7) \times 6.95}{2258}$$

$$= 8.70 \text{ kg/kg of coal.}$$

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI, DUBAI CAMPUS

II SEMESTER 2012-2013

Test No.1 (Closed Book)

Year : III-MECHANICAL	**Date : 10.03.2013**	
Course No. : ME C 314	**Course Title : POWER PLANT ENGINEERING**	
Duration : 50Min	**Marks: 25**	**Weightage : 25 %**

Notes: (i) *answer all the questions* (ii) *Draw neat sketches wherever necessary*

(iii) *Make suitable assumptions if required and clearly state them (iv) Steam table will be provided*

(v) Graph sheet is printed in 3rd page for plot the load curve.

---

1 In a single heater regenerative cycle the dry and saturated steam is supplied to turbine at **32 bar** and condenser pressure is **0.05 bar** as shown in Figure.1. The steam bled from the turbine at **2.8 bar** and mixed with direct contact type feed water heater. Neglect the pump work. Find (i) the quantity of steam bleed (ii) Work done by the Turbine in kJ/kg (iii) Rankine cycle efficiency with regeneration and without regeneration

If the power plant capacity is **500 kW** (iv) find mass flow rate of steam in kg/s (v) mass flow rate of cooling water circulation in the condenser if the rise in temperature is limited to (ΔT) **5^{0}C**. Assume specific heat of water **4.2 kJ/kg-k** [12 M]

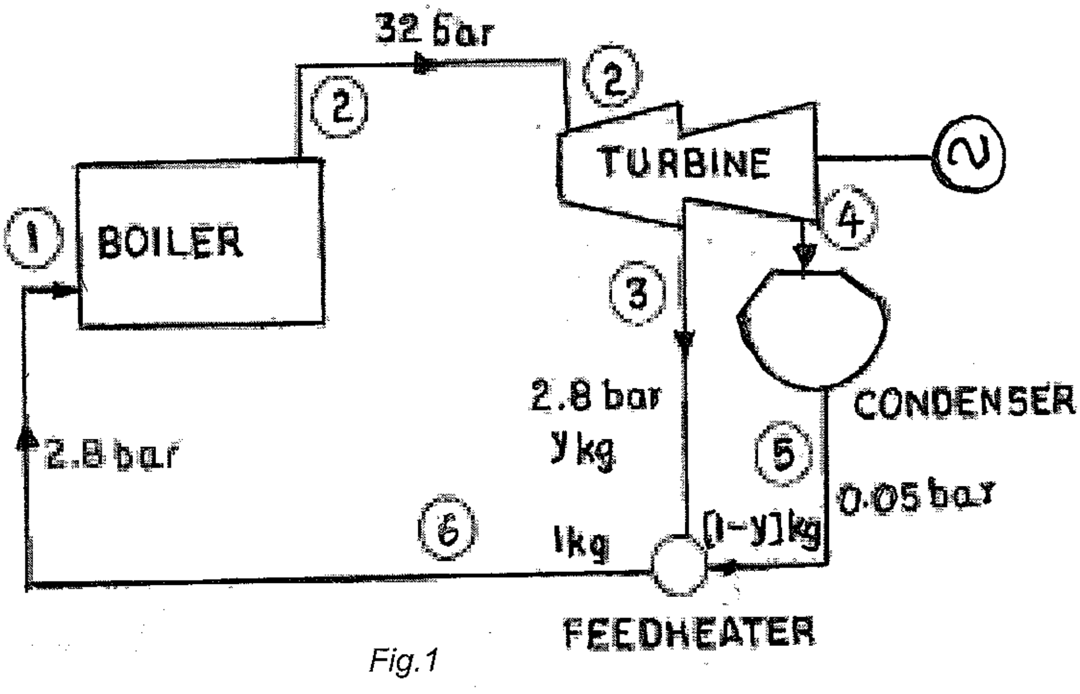


Fig.1

Q.2 An electrical power system experiences linear changes in load such its daily load curves is defined as follows.

Time hours	**12PM**	**2AM**	**6AM**	**8AM**	**12AM**	**12.30AM**	**1 PM**	**5PM**	**6PM**	**12PM**
Load (MW)	**24**	**12**	**12**	**60**	**60**	**48**	**60**	**60**	**84**	**24**

(I) Plot the load curve for the system

(II) Find the load Factor

(III) What is the utilization factor of the plant serving this load if its capacity is **120MW?**

[9 M]

Q.3 In what respects Reheat cycle differs from that of Regenerative Rankine cycle in steam power plant? Mention at least 5 points.

[4 M]

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BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI, DUBAI CAMPUS

II SEMESTER 2012-2013

Test No.1 (Closed Book)

Year : III-MECHANICAL	**Date : 10.03.2013**
Course No. : ME C 314	**Course Title : POWER PLANT ENGINEERING**
Duration : 50Min	**Marks: 25** **Weightage : 25 %**

ANSWER [KEY]

Q.1 In a single heater regenerative cycle the dry and saturated steam is supplied to turbine at **32 bar** and condenser pressure is **0.05 bar** as shown in Figure.1. The steam bled from the turbine at **2.8 bar** and mixed with direct contact type feed water heater. Neglect the pump work. Find (i) The quantity of steam bleed (ii) Work done by the Turbine in kJ/kg (iv) Rankine cycle efficiency with regeneration and without regeneration

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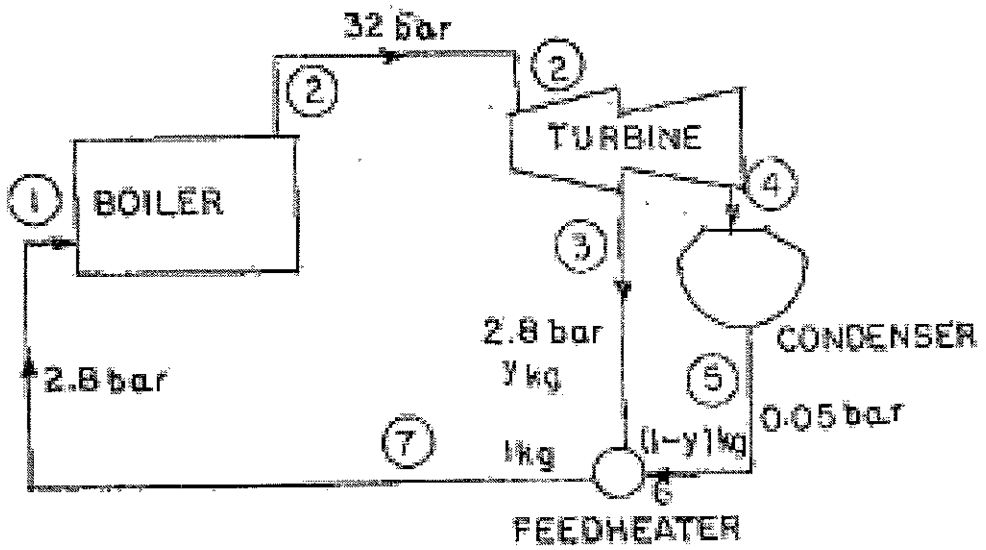


FIG.1

Solution

$$1 \times h_{f_7} = y \times h_3 + (1-y)\, h_{f_5}$$

∴ $$y = \frac{h_{f_7} - h_{f_5}}{h_3 - h_{f_5}}$$

h_{f_7} = liquid enthalpy at 2.8 bar = 551.5 kJ/kg

h_{f_5} = liquid enthalpy at 0.05 bar = 121 kJ/kg

h_3 = enthalpy of wet steam at 2.8 bar.

For this, entropy of dry and saturated steam at 32 bar

= entropy of wet steam at 2.8 bar.

$$6.159 = 1.647 + x \times 5.367$$

∴ $$x = 0.841$$

∴ Enthalpy $$h_3 = 551.5 + 0.841 \times 2170.0 = 2376.5 \text{ kJ/kg}$$

∴ $$y = \frac{551.5 - 121}{2376.5 - 121} = 0.1909 \text{ kg}$$ (Ans)

Also for isentropic expansion of steam to 0.05 bar entropy of dry and saturated steam at 32 bar

= entropy of wet steam at 0.05 bar.

$$6.159 = 0.476 + x \times 7.920 \quad \text{and} \quad x = 0.718$$

Enthalpy of 0.718 dry steam at 0.05 bar,

$$h_4 = 137.8 + 0.718 \times 2423.8 = 1878 \text{ kJ/kg}$$

The heat transferred in the boiler = enthalpy of saturated steam at 32 bar − enthalpy of water at 2.8 bar

$$= h_2 - h_{f_7} = 2802.3 - 551.5 = 2350.8 \text{ kJ/kg}$$

Turbine work $$= (h_2 - h_3) \times 1 + (h_3 - h_4) \times (1 - y)$$

$$= (2802.3 - 2376.5) \times 1 + (2376.5 - 1878) \times (1 - 0.1909)$$

$$= 425.8 + 403.3 = 829.1 \text{ kJ/kg}$$ (Ans)

(*b*) Cycle efficiency $$= \frac{\text{Turbine work}}{\text{Heat supplied}} = \frac{829.1}{2350.8} = 0.3527 \quad i.e. \quad 35.27\%$$ (Ans)

(iv) Rankine cycle efficiency without Regeneration

$$\eta_R = \frac{h_2 - h_4}{h_2 - h_5} = \frac{2802.3 - 1878}{2802.3 - 137.8}$$

$$= 34.6\ \%$$ (Ans)

Increase in cycle efficiency due to Regeneration

$$35.27 - 34.6 = 0.67\ \%$$ (Ans)

(V) Mass flow rate of Steam

$$\dot{m}_s \times W_T = 500 \text{ kW}$$

$$\dot{m}_s \times 829.1 = 500 \text{ kW}$$

$$\dot{m}_s = \frac{500 \text{ kW}}{829.1} = 0.6030 \text{ kg/s}$$

$$= 2171 \text{ kg/hr. (Ans)}$$

(VI) Mass flow rate of Cooling water circulation.

Heat gained by water = Heat lost by steam in Condenser

$$\dot{m}_w \times 4.2 \times 5 = \dot{m}_s (1-y)(h_4 - h_{f5})$$

$$21\, \dot{m}_w = \dot{m}_s (1-0.1909)(1878-137.8)$$

$$21\, \dot{m}_w = 849.02$$

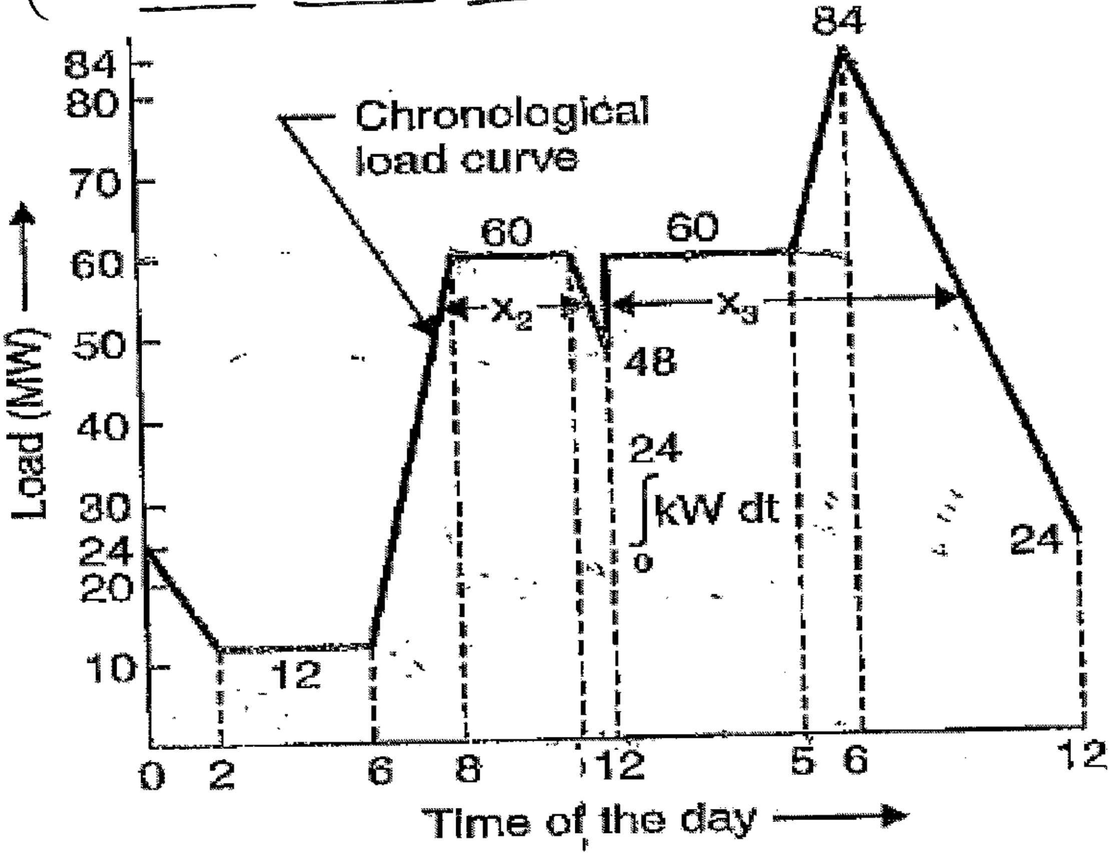
$$\dot{m}_w = \frac{849.02}{21} = 40.4 \text{ kg/s. (Ans)}$$

Q.2 An electrical system experiences linear changes in load such its daily load curves is defined as follows.

Time hours	12PM	2AM	6AM	8AM	12AM	12.30AM	1 PM	5PM	6PM	12PM
Load (MW)	24	12	12	60	60	48	60	60	84	24

(I) Plot the load curve for the system (ii) Find the load Factor (iii) what is the utilization factor of the plant serving this load if its capacity is **120MW.** [9 M]

Solution (i) Load duration Curve



(ii) Load factor :

$$\frac{\left[(12\times2)+\frac{1}{2}(2\times12)\right]+[12\times4]+\left[(12\times2)+\frac{1}{2}(2\times48)\right]+[4\times60]+\left[[0.5\times48]+\frac{1}{2}(0.5\times12)\right]+[4.50\times60]+\left[(1\times60)+\frac{1}{2}(24\times1)\right]+\left[(6\times24)+\frac{1}{2}(6\times60)\right]}{24\text{ hrs}}$$

$$= \frac{36+48+72+240+27+270+72+324}{24\text{ hrs}}$$

$$= \frac{1089}{24} = 45.375\text{ MW} \quad \text{(Ans)}$$

(iii) Utilisation factor :

$$\text{Utilisation factor} = \frac{\text{Maximum Load}}{\text{Rated capacity of the plant}}$$

$$= \frac{84}{120}$$

$$= \underline{\underline{70\%}} \quad \text{(Ans)}$$

Q.3 Distinguish between Reheat-Regenerative Rankine cycle [4 M]

Solution: Class Notes

VERSION: A

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI, DUBAI CAMPUS

II SEMESTER 2012-2013

QUIZ-2 (Closed Book)

Year : III-MECHANICAL	**Date : 15.05.2013**	
Course No. : ME C314	**Course Title : POWER PLANT ENGINEERING**	
Duration : 50Min	**Marks: 21**	**Weightage : 7 %**

1. In case of non-condensing turbines the back pressure is

   (A) atmospheric (B) below atmospheric pressure

   (C) above atmospheric pressure (D) depends on the size of turbine.

2. An impulse turbine produces 50 kW of power when the blade mean speed is 400 m/s. What is the rate of change of momentum tangential to the rotor?

   (a) 200 N (b) 175 N (c) 150 N (d) 125 N

3. As compared to steam at entry to the turbine, which of the following will be larger at exit ?

   (A) Pressure (B) Flow rate (C) Specific volume (D) Specific enthalpy.

4. In hydro power plants

   (A) Initial cost is high and operating cost is low

   (B) Initial cost as well as operating costs are high

   (C) Initial cost is low and operating cost is high

   (D) Initial cost as well as operating cost is low.

5. A single-stage impulse turbine with a diameter of 120 cm runs at 3000 rpm. If the blade speed ratio is 0.42 then, the inlet velocity of steam will be

   (a) 79 m/s (b) 188m/s (c) 450 m/s (d) 900 m/s

6. A Francis turbine is

   (A) Inward flow reaction turbine (B) Inward flow impulse turbine

   (C) Outward flow reaction turbine (D) Outward flow impulse turbine.

7. A Kaplan turbine is

(A) a high head mixed flow turbine (B) an impulse turbine, inward flow type

(C) an reaction turbine, outward flow type (D) low head axial flow turbine.

8. In pumped storage

(A) Power is produced by means of pumps

(B) Water is stored by pumping to high pressures

(C) Downstream water is pumped up-stream during off load periods

(D) Water is re circulated through turbine.

9. In a hydro-electric plant a conduct system for taking water from the intake works to the turbine is known as

(A) Dam (B) Reservoir (C) Penstock (D) Surge tank.

10. A Pelton wheel is

(A) inward flow impulse turbine (B) Outward flow impulse turbine

(C) Inward flow reaction turbine (D) Axial flow impulse turbine.

11. An impulse turbine

(A) always operates submerged (B) makes use of a draft tube

(C) is most suited for low head installations

(D) operates by initial complete conversion to kinetic energy.

12. In an impulse turbine

(A) water must be admitted over the whole circumference of the wheel

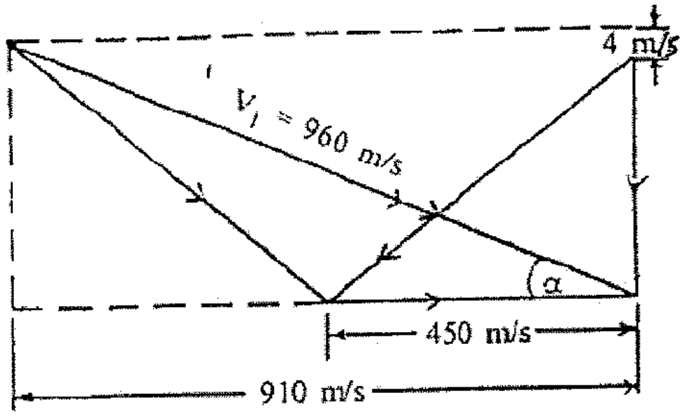
(B) it is net possible to regulate the flow without loss

(C) wheel must run full and be-kept entirely submerged in water below the tail race

(D) the pressure in the driving fluid as it moves over the vane, is atmospheric.

13. Velocity diagram shown above is for an impulse turbine stage. What is the, tangential force and axial thrust per kg/s of steam, respectively?

(a) 450 N, 8 N
(b) 560 N, 8 N
(c) 680 N, 4 N
(d) 910 N, 4 N



14. Pelton wheels are installed on

(A) run of river plants with pondage

(B) run of river plants without pondage

(C) base load plant

(D) high head plants.

15. In hydro power plants

(A) Initial cost is high and operating cost is low

(B) Initial cost as well as operating costs are high

(C) Initial cost is low and operating cost is high

(D) Initial cost as well as operating cost is low.

16. In axial flow turbines

(A)only part of the available head is converted into velocity before the water enters the wheel

(B) water is admitted over part of the circumference

(C) it is possible that the wheel may run full

(D) it is possible to regulate the flow.

17. Steam enters a De Laval steam turbine with an inlet velocity of 30 m/s and leaves with an outlet velocity of 10 m/s. The work done by 1kg of steam is

(a) 400 Nm (b) 600 Nm (c) 800 Nm (d) 1200Nm

18. Consider the following statements:

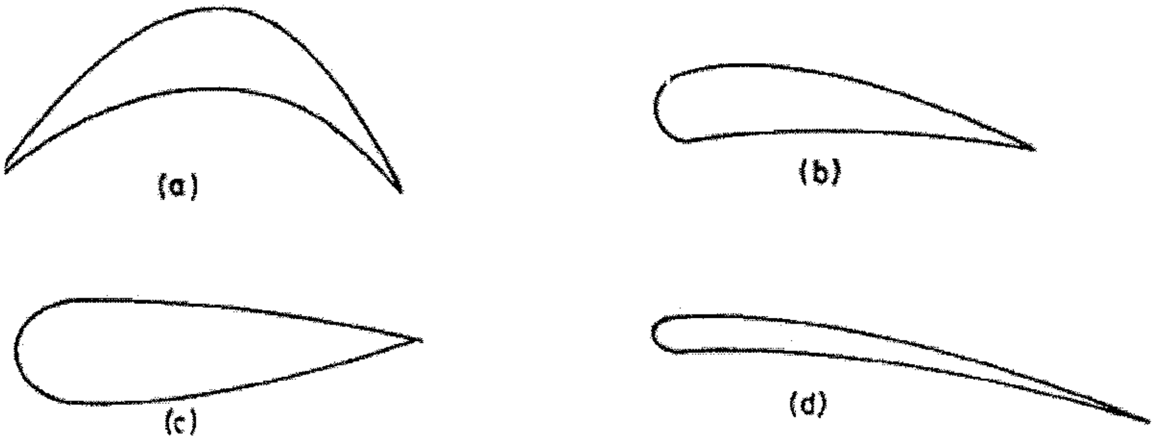
In an impulse turbine,

1. the relative velocity of steam at inlet and outlet of moving blades are equal.
2. the moving blades are symmetrical.
3. the outlet area of the moving blades is smaller than the inlet area.

Of these statements:

(a) 1, 2 and 3 are correct (b) 2 and 3 are correct
(c) 1 and 2 are correct (d) 1 and 3 are correct

19. Which one of the following sketches represents an impulse turbine blade?



20. The blade friction in the impulse turbine reduces the velocity of steam by _________ while it passes over the blades.

a) 10 to 15 % (b) 15 to 20 %
C) 20 to 30 % (D) 30 to 40 %

21. The maximum efficiency of a De-Laval turbine is

a) $\mathrm{Sin}^2 \alpha$
b) $\cos^2 \alpha$
c) $\tan^2 \alpha$
d) $\cot^2 \alpha$

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BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI, DUBAI CAMPUS

II SEMESTER 2012-2013

QUIZ-2 (Closed Book)

Course No: ME C314 **Subject: Power plant Engineering**

Max. Marks: 24 **QUIZ -1** **Weightage : 7 %**

ANSWERS

Qns	1	2	3	4	5	6	7	8	9	10	11	12
Ans	C	D	C	A	C	A	D	C	C	D	D	D

Qns	13	14	15	16	17	18	19	20	21
Ans	D	D	A	C	A	C	A	A	B

1. In case of non-condensing turbines the back pressure is

   (A) atmospheric (B) below atmospheric pressure

   (C) above atmospheric pressure (D) depends on the size of turbine.

2. An impulse turbine produces 50 kW of power when the blade mean speed is 400 m/s. What is the rate of change of momentum tangential to the rotor?

   (a) 200 N (b) 175 N (c) 150 N (d) 125 N

3. As compared to steam at entry to the turbine, which of the following will be larger at exit ?

   (A) Pressure (B) Flow rate (C) Specific volume (D) Specific enthalpy.

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5. A single-stage impulse turbine with a diameter of 120 cm runs at 3000 rpm. If the blade speed ratio is 0.42 then, the inlet velocity of steam will be

(a) 79 m/s (b) 188m/s (c) 450 m/s (d) 900 m/s

6. A Francis turbine is

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8. In pumped storage

(A) Power is produced by means of pumps

(B) Water is stored by pumping to high pressures

(C) Downstream water is pumped up-stream during off load periods

(D) Water is re circulated through turbine.

9. In a hydro-electric plant a conduct system for taking water from the intake works to the turbine is known as

(A) Dam (B) Reservoir (C) Penstock (D) Surge tank.

10. A Pelton wheel is

(A) inward flow impulse turbine (B) Outward flow impulse turbine

(C) Inward flow reaction turbine (D) Axial flow impulse turbine.

11. An impulse turbine

(A) always operates submerged (B) makes use of a draft tube

(C) is most suited for low head installations

(D) operates by initial complete conversion to kinetic energy.

12. In an impulse turbine

(A) water must be admitted over the whole circumference of the wheel

(B) it is net possible to regulate the flow without loss

(C) wheel must run full and be-kept entirely submerged in water below the tail race

(D) the pressure in the driving fluid as it moves over the vane, is atmospheric.

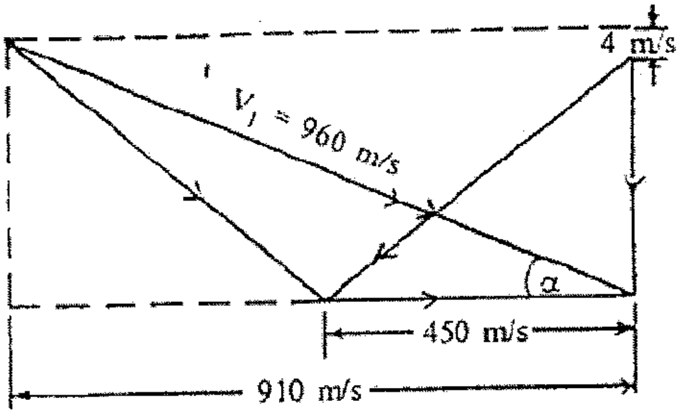
13. Velocity diagram shown above is for an impulse turbine stage. What is the, tangential force and axial thrust per kg/s of steam, respectively?

(a) 450 N, 8 N

(b) 560 N, 8 N

(c) 680 N, 4 N

(d) 910 N, 4 N



14. Pelton wheels are installed on

(A) run of river plants with pondage

(B) run of river plants without pondage

(C) base load plant

(D) high head plants.

15. In hydro power plants

(A) Initial cost is high and operating cost is low

(B) Initial cost as well as operating costs are high

(C) Initial cost is low and operating cost is high

(D) Initial cost as well as operating cost is low.

16. In axial flow turbines

(A)only part of the available head is converted into velocity before the water enters the wheel

(B) water is admitted over part of the circumference

(C) it is possible that the wheel may run full

(D) it is possible to regulate the flow.

17. Steam enters a De Laval steam turbine with an inlet velocity of 30 m/s and leaves with an outlet velocity of 10 m/s. The work done by 1kg of steam is

(a) 400 Nm (b) 600 Nm (c) 800 Nm (d) 1200Nm

18. Consider the following statements:

In an impulse turbine,

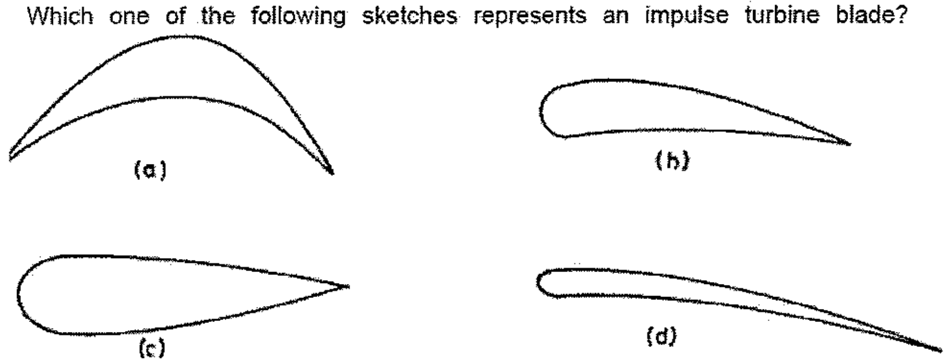
1. the relative velocity of steam at inlet and outlet of moving blades are equal.
2. the moving blades are symmetrical.
3. the outlet area of the moving blades is smaller than the inlet area.

Of these statements:

(a) 1, 2 and 3 are correct (b) 2 and 3 are correct

(c) 1 and 2 are correct (d) 1 and 3 are correct

19. Which one of the following sketches represents an impulse turbine blade?



20. The blade friction in the impulse turbine reduces the velocity of steam by _________ while it passes over the blades.

a) 10 to 15 % (b) 15 to 20 % (C)20 to 30 % (D) 30 to 40 %

21. The maximum efficiency of a De-Laval turbine is

a) $\text{Sin}^2 \alpha$
b) $\cos^2 \alpha$
c) $\tan^2 \alpha$
d) $\cot^2 \alpha$

VERSION: A

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI, DUBAI CAMPUS

II SEMESTER 2012-2013

QUIZ-1 (Closed Book)

Year : III-MECHANICAL	**Date : 27.03.2013**	
Course No. : ME C314	**Course Title : POWER PLANT ENGINEERING**	
Duration : 50Min	**Marks:**	**Weightage : 8 %**

STUDENT NAME:---I.D No:----------------------------

Qns	1	2	3	4	5	6	7	8	9	10	11	12
Ans												

Qns	13	14	15	16	17	18	19	20
Ans								

1. Which of the following has the highest calorific value? (1 M)

   [A] Peat **[B]** Lignite **[C]** Bituminous coal **[D]** Anthracite coal

2. The fuel mostly used in cement industry and in metallurgical processes is (1 M)

   [A] wood charcoal **[B]** Bituminous coal **[C]** pulverized coal **[D]** coke

3. When coal is first dried and then crushed to a fine powder by pulverizing machine, the resulting fuel is called (1 M)

   [A] wood charcoal **[B]** Bituminous coal **[C]** briquetted coal **[D]** none of these

4. When the finely ground coal is moulded under pressure with or without a binding material, the resulting fuel is called briquetted coal (1 M)

   [A] yes **[B]** No

5. The ultimate analysis of coal consists of the determination of the percentage of (1 M)

[A] carbon **[B]** hydrogen and nitrogen **[C]** sulphur and ash

[D] all of these

6. Weight percentage of which one of the following is determined by Proximate analysis of coal? (1M)

[A] Fixed carbon, volatile matter, moisture and ash

[B] All solid and gaseous components

[C] All solid & gaseous components except volatile matter

[D] Fixed carbon and volatile matter

7. In combustion process, the effect of dissociation is to (1M)

[A] Reduce the flame temperature

[B] Separate the products of combustion

[C] Reduce the proportion of carbon monoxide in gases

[D] Reduce the use of excess air

8. The amount of CO_2 produced by 1 kg of carbon on complete combustion is (1M)

[A] 3/11 kg **[B]** 3/8 kg **[C]** 8/3 kg **[D]** 11/3 kg

9. One kg of carbon requires 4/3 kg of oxygen and produces ____________ kg of carbon monoxide (1 M)

[A] 8/3 **[B]** 11/3 **[C]** 17/3 **[D]** 7/3

10. One kg of carbon monoxide requires 4/7 kg of oxygen and produces (1 M)

[A] 11/3 kg of carbon dioxide gas **[B]** 7/3 kg of carbon monoxide gas

[C] 11/7 kg of carbon dioxide gas **[D]** 8/3 kg of carbon monoxide gas

11. One kg of sulphur requires 1 kg of oxygen for complete combustion and produces 2 kg of sulphur dioxide (1 M)

[A] true **[B]** false

12. Methane burns with stoichiometric quantity of air. The air / fuel ratio by weight is (1M)

[A] 4 **[B]** 14.7 **[C]** 15 **[D]** 17.16

13. One kg of ethylene (C_2H_4) requires 2 kg of oxygen and produces 22/7 kg of carbondioxide and ______________ kg of water and steam (1 M)

[A] 9/7 **[B]** 11/7 **[C]** 7/4 **[D]** 11/4

14. The minimum weight of air required per kg of fuel for complete combustion of a fuel is given by (1M)

[A] $11.6C + 34.8\left(H - \frac{O}{8}\right) + 4.35S$ **[B]** $11.6C + 34.8\left(H + \frac{O}{8}\right) + 4.35S$

[C] $11.6C - 34.8\left(H - \frac{O}{8}\right) + 4.35S$ **[D]** $11.6C - 34.8\left(H + \frac{O}{8}\right) + 4.35S$

15. The mass of carbon per kg of flue gas is given by (1 M)

[A] $\frac{11}{3}CO_2 + \frac{3}{7}\,CO$ **[B]** $\frac{3}{7}CO_2 + \frac{11}{3}\,CO$ **[C]** $\frac{7}{3}CO_2 + \frac{3}{11}\,CO$

[D] $\frac{3}{11}CO_2 + \frac{7}{3}\,CO$

16. The mass of excess air supplied is equal to (1 M)

[A] $\frac{23}{100} \times mass\ of\ excess\ carbon$ **[B]** $\frac{23}{100} \times mass\ of\ excess\ oxygen$

[C] $\frac{100}{23} \times mass\ of\ excess\ carbon$ **[D]** $\frac{100}{23} \times mass\ of\ excess\ oxygen$

17. To ensure complete and rapid combustion of a fuel, some quantity of air, in excess of the theoretical air is supplied (1 M)

[A] yes **[B]** No

18. Bomb calorimeter is used to determine (1 M)

[A] calorific value of solid or liquid fuels

[B] calorific values of gaseous fuels

[C] ash content of solid fuels

[D] incombustible matter in solid fuel

19. Amount of oxygen needed to completely burn 1k g of methane (CH_4) is (1M)

[A] 2 kg **[B]** 4 kg **[C]** 16 kg **[D]** 22 kg

20. Which of the following constituents of a fuel does not contribute to its calorific value on combustion? (1 M)

[A] carbon **[B]** hydrogen **[C]** sulphur **[D]** nitrogen

21. Match the correct answer from Group B for the average calorific value of the fuels given in Group A (4 M)

Group A	Group B	Answer (Write down the value)
a) Wood	A) 33,500 kJ/kg	**Ans**________________
b) Peat	B) 19,700 kJ/kg	**Ans**________________
c) Lignite coal	C) 25,000 kJ/kg	**Ans**________________
d) Bituminous coal	D) 23,000 kJ/kg	**Ans**________________

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI, DUBAI CAMPUS

Course No: ME C314 **Subject: Power plant Engineering**

Max. Marks: 24 **QUIZ -1** **Weightage : 8 %**

ANSWERS

Qns	1	2	3	4	5	6	7	8	9	10	11	12
Ans	A	C	D	A	D	A	A	D	D	C	A	D

Qns	13	14	15	16	17	18	19	20
Ans	A	A	A	D	A	A	B	D

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