

CSM – 55/16
Mechanical Engineering
Paper – II

Time : 3 hours

Full Marks : 300

The figures in the right-hand margin indicate marks.

Candidates should attempt Q. No. 1 from

Section – A and Q. No. 5 from Section – B

*which are compulsory and **three** of the remaining questions, selecting at least **one** from each Section.*

If any data is considered insufficient, assume suitable value and indicate the same clearly.

SECTION – A

1. Answer any **three** of the following : **[20×3 = 60]**

(a) A Rankine cycle based power plant is designated with superheat and reheat :

(i) Sketch T-S, h-S and p-v diagram.

- (ii) If the condenser pressure is increased or decreased what will be the effect on power output of power plant.
- (iii) If the boiler pressure is increased or decreased, what will be the effect on the power output of power plant.
- (b) Make a comparative study of the main pollutants emitted by petrol, diesel and CNG based engines. Discuss their effect on human and biological life.
- (c) In an air compressor of reciprocating type, the ratio of heat transfer to work transfer is $\frac{1}{4}$ if the compressor follows, $PV^n = \text{constant}$, what is the value of n ? In such a compression process the work required is 200 KJ/kg, and specific heat at constant volume is 0.75 KJ/kgK, what rise of temperature is expected at the end of compression process ?
- (d) Do you think that velocity boundary layer and thermal boundary layer depend on Prandtl

number? If yes, explain properly. Also explain, with the help of neat sketches, the significance of relative thickness of velocity boundary layer and thermal boundary layer for the following :

(i) Liquid metals

(ii) Oils

2. (a) What factors motivate the use of Ethyl Alcohol as a fuel in internal combustion engine? Explain. Express your views for making India a zero petroleum import country. [30]

(b) For a pure substance changing the phase, develop the Clapeyron equation. Hence find the enthalpy of evaporation for R-22 at -10°C and compare the same with the tabulated value. What percentage error involved? [30]

$T(^{\circ}\text{C})$	$P(\text{KPa})$	$V_f(\text{lit/kg})$	$V_g(\text{m}^3/\text{kg})$	$h_{fg}(\text{KJ/kg})$
20	244.72	0.7409	0.0929	220.331
-10	354.16	0.7587	0.0654	213.136
0	497.41	0.7783	0.0472	205.369

3. (a) (i) Derive an expression for specific speed of a turbine in terms of its speed N , output power P and head H . [15]

(ii) At a hydroelectric station, the available head is 60m and it is anticipated that $32.3 \text{ m}^3/\text{s}$ of water will be available.

Francis turbines of specific speed of 190 are to be installed and to be run at 500 r. p. m. with an overall efficiency of 82%. Determine the maximum power available from the turbines and the number of turbine required. [15]

(b) The engine of a truck which is four cylinder has been converted to run on propane fuel. A dry analysis of the engine exhaust gives the following volumetric percentages :

$\text{CO}_2 - 4.90$, $\text{CO} - 9.79$ and $\text{O}_2 - 2.45$.

Calculate the equivalence ratio at which the engine is operating. [30]

4. (a) (i) Air coolers can be used only in some geographical locations, whereas mechanical air conditioning can be used in all geographical locations. Explain why. Show the processes involved in both these equipments. [15]

(ii) Explain why it is thermodynamically advantageous to employ a heat pump rather than employing a direct electrical heater for a room air heating application. [15]

(b) A two stroke engine when tested on full load gives the following result : [30]

Speed = 350 rpm

Net Brake load = 590 N

Mean effective pressure = 2.8 bar

Fuel oil consumption = 4.3 kg/hr

Cooling water required = 500 kg/hr

Rise in cooling water temperature = 25°C

Air used per kg of fuel = 33 kg

Room temperature = 25°C

Exhaust gas temperature = 400°C

Cylinder diameter = 220 mm

Stroke length = 280 mm

Effective brake diameter = 1 m

CV of fuel oil = 43900 KJ/kg

Mean specific heat of exhaust gases = 1.0

KJ/kg-k

Specific heat of steam = 2.09 KJ/kg-k

Proportion of hydrogen in fuel = 15%

Calculate the following :

(i) Indicated Power

(ii) Brake Power

(iii) Draw heat balance sheet on the basis
of KJ/min

SECTION - B

5. Answer any **three** of the following :

(a) Briefly explain the following statement :

[5×4 = 20]

(i) S. I. engines are generally not
supercharged

- (ii) As the engine speed increases, the ignition timing should be advanced.
- (iii) COP of refrigeration system is increases when water cooled condenser is used in place of air cooled condenser.
- (iv) For low sensible heat factor applications, re-heat is necessary.

(b) During summer to cool water for drinking purpose 2 kg of Ice at -3°C in an insulated container which is subjected to atmospheric pressure of 1 bar. Assume specific heat of ice is $2.093 \text{ KJ/kg} - \text{k}$ and latent heat of ice is 335 KJ/kg . Work out the following :

[10×2 = 20]

- (i) Temperature of mixture.
 - (ii) The change of entropy for instantaneous process.
- (c) Show that the effectiveness of a parallel flow heat exchanger is given as : **[20]**

$$\epsilon = \frac{1 - \exp[-NTU(1 + C_r)]}{1 + C_r},$$

where notations have their usual meanings.

(d) Define and discuss the physical significance of the following : [20]

(i) Stanton number

(ii) Nusselt number

(iii) Reynold number

What is meant by fully developed flow in pipe ?

6. (a) A power generating station has a maximum demand of 20 MW. The daily load on the station is as follows : [40]

Time	Load MW
8 A. M. to 12 P. M.	16
12 P. M. to 1 P. M.	6
1 P. M. to 5 P. M.	15
6 P. M. to 7 P. M.	17
7 P. M. to 9 P. M.	20
9 P. M. to 11 P. M.	9
11 P. M. to 6 A. M.	4
6 A. M. to 8 P. M.	7

- (i) Draw the load curve and load duration curve of the plant.
- (ii) Decide the capacity and number of units.
- (iii) Prepare the operating schedule of the units.
- (b) (i) Discuss, in brief, the advantages of using multi point fuel injection system in place of conventional carburettor.
- (ii) Explain the necessary modifications that have to be made to convert a car running on petrol fuel to Compressed Natural Gas (C. N. G). **[20]**

7. (a) Define and discuss 'availability' with regard to a system. What is other term by which this property is also referred to ? Also derive an expression for availability (A) for a reversible cycle in which heat (Q) is rejected. The cycle works between temperature T and T_0 ($T > T_0$). **[20]**

- (b) With usual nations, develop an expression for the efficiency of a fin of uniform cross-section when the heat loss from the tip is considered negligible. **[40]**

8. (a) (i) Briefly explain the phenomenon of surge and choking in centrifugal compressor. **[10]**

- (ii) Distinguish between "open cycle" and "closed cycle" gas turbines. Why is gas turbines not used commercially as prime movers for automobiles while they have replaced IC engines in aircraft applications ? **[10]**

- (b) Air enters a diffuser with a velocity of 250 m/s and a temperature of 30°C . It leaves with a velocity of 90 m/s. Neglecting friction and heat transfer determine : **[40]**

- (i) Exit temperature

(ii) Exit pressure if the inlet pressure is 125 KPa.

(iii) Area ration between the exit and entrance. Will your answer change if there is friction present ? Explain how.



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