I SEMESTER M.TECH. (THERMAL SCIENCES AND ENERGY SYSTEMS)

END SEMESTER EXAMINATIONS, NOV/DEC 2017

SUBJECT: SOLAR THERMAL ENERGY SYSTEMS [MME 5143]

REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ANY FIVE FULL** questions.
- Missing data may be suitably assumed.

1A. List the various driving forces of world energy supply and demand. Explain how they are interrelated. **06**

1B. What are the water-related challenges that the energy sector is facing and what are the solutions for it using current technology **04**

2A. Find the angle of incidence of beam radiation on a surface tilted to horizontal plane by 44^0 at 1-30 pm on 15th November. The plain is pointing 25^0 west of south. The latitude and longitude of the place are 19.20^0 N and 72.84^0 E respectively. Take standard longitude as 81.76^0. The following general equation for incident angle can be used. **05**

$$\cos\theta_i = \sin\phi\left[\sin\delta\cos\beta + \cos\delta\sin\beta\cos\theta_A\cos\omega\right] +$$
$$\cos\phi\left[\cos\delta\cos\beta\cos\omega - \sin\delta\sin\beta\cos\theta_A\right] +$$
$$\cos\delta\sin\theta_A\sin\omega\sin\beta$$

2B. A flat plate solar water heater has 12 copper tubes, each of 2.5 cm outer diameter and soldered to the underside of the absorber plate made of copper. The collector is 3m x 2m in size and its average surface temperature is 75^0C. Water flows in the tube at the velocity of 1.3 m/min at a temp of 62^0C. Find the exit temperature of water and radiation heat flux on the collector. Assume transmissivity of glass cover is 0.9 and absorptivity of absorber plate is 0.95. Use the following properties of water **05**
Density = 983.3 kg/m^3, Absolute viscosity = 4.7 x 10^{-4} kg/m-s, Specific heat = 4.2 kJ/kg ^{0}C, Pr = 3.01, k = 0.65 W/m – K
If the flow is laminar, use the equation Nu = 1.86[Re Pr D/L]$^{0.33}$ otherwise, use Nu = 0.0196 (Re)$^{0.8}$ (Pr D/L)$^{0.33}$

3A. Explain the significance of efficiency factor in the performance of flat plate collector. Prove that for an integrated tube flat plate collector, the efficiency factor is given by **05**

$$F' = \frac{1/U_L}{W\left[\frac{1}{U_L\left[D+(W-D)F\right]} + \frac{1}{C_b} + \frac{1}{\pi D_i h_{fi}}\right]}$$

3B. Calculate the collector plate efficiency factor and heat removal factor for solar air collector of 1 m wide and 4 m long when the following data is given
Air flow rate = 0.6 m^3/min/m^2 surface area
Gap through which air is flowing = 1.6 cm
Take the following properties of air at mean temp
Density= 1.1 kg/m^3, viscosity= 17.9 x 10-6 kg/m-s, k = 0.024 W/m -^{0}C, Pr= 0.72
Overall heat transfer coefficient from the plate = 5 W/m^2 ^{0}C
The heat transfer coefficient between the flowing air and plate is given by **05**

$$Nu = \frac{h_p L_c}{k_a} = \frac{0.0192(\mathrm{Re})^{0.75}(\mathrm{Pr})}{1+1.22(\mathrm{Re})^{-0.125}(\mathrm{Pr})^{-2}}$$

4A. Explain the significance of "Acceptance angle" of a concentrating collector. Obtain expression for it in case of parabolic and paraboloid concentrator **04**

4B. A cylindrical parabolic collector having 2 m width and 8 m long is used to heat fluid entering at 160^{0}C with a flow rate of 7 kg/min (C_p= 1.25 kJ/kg-^{0}C). The diameter of the absorber tube is 6 cm which is covered with glass tube. The incident radiation is 760 W/m^2. Ambient temp is 30^{0}C. The optical properties of the collector are Transmissivity-absorptivity product is 0.8, reflectivity of surface 0.93 and transmissivity of glass is 0.85, Collector efficiency factor is 0.85, heat loss coefficient is 8 W/m^2-^{0}C. Tilt factor is 1 and intercept factor is also 1. Find; **06**

i) Useful heat gain and exit temperature of the fluid

ii) Collector efficiency

5A. Discuss the merits and demerits of solid-sensible heat storage system. Obtain an expression for temperature of this storage system stating clearly the assumptions made **04**

5B. A cylindrical water tank of 1.5 m diameter and 2 m high is made of steel (Density = 7800 kg/m^3, Sp heat = 460 J/kg-^{0}C) and 5 mm thick. The initial temperature of water in the tank is 50^{0}C at 7 am and the variation of useful heat gain with temperature for 3 hrs is as follows

Time	7-8 am	8-9 am	9-10 am
Q_u (kJ/hr)	14500	32500	54000
T_a (^{0}C)	17	19	24

The energy is withdrawn at a constant rate of 14000 kJ/hr from 7 am onwards. Heat loss coefficient is 2.8 W/m^2C. Assuming the temperature of water in the tank is same throughout, calculate the variation in temperature in the tank water from 7 to 10 am **06**