INDIAN INSTITUTE OF ENGINEERING SCIENCE AND TECHNOLOGY, SHIBPUR

M.E. (Mech) 2nd Semester Examination, 2014

Solar Thermal Engineering (ME-1005)

Full Marks: 70 **Time: 3 hrs**

Answer any FOUR questions.

All question carry equal marks.

Symbols have their usual meanings.

Missing data, if any, may be assumed appropriately.

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1. a) Describe the following angles with respect to sun earth geometry: i) Surface azimuth angle ii) solar azimuth angle iii) Declination angle iv) Hour angle v) Latitude

b) Calculate the day's solar radiation on a horizontal surface in the absence of the atmosphere at latitude 43^0N on April 15 between the hours of 10 and 11.

2. What are the main advantages and limitations of solar air heaters over liquid flat plate collectors? Derive an expression for collector efficiency factor and collector heat removal factor of a conventional solar air heater.

3. a) Describe in brief the effects of the following parameters on the performance of flat plate collector: i) Selective surfaces ii) Number of covers iii) Fluid inlet temperature iv) Dust on the top cover

b) Describe with a neat sketch the testing procedure of a flat plate collector.

4. a) A solar water heater has an array of flat plate collectors with an area of 30 m^2 installed in a factory. It costs Rs 150000 and is set up with an initial down payment of 20 percent of the investment. The balance 80 percent is taken as bank loan which needs to be repaid in equal installments over a period of 10 years at an interest rate of 16%. The cost of the conventional fuel saved in the first year is Rs 21000 and this cost increases at a rate of 4% every year. The maintenance cost is Rs 6600 in the first year which increases at the rate of 5% every year. Tax deductions are permissible only on depreciation, which is at the rate of 25% every year. The company income tax rate is 55%. If the market discount rate is 10 percent, calculate the cumulative solar savings (CSS) of the heater for a period of 15 years.

b) Derive an expression for the collector efficiency factor for a liquid flat plate collector.

5. A flat plate collector is made up of GI absorber plate, GI tubes being fixed on the underside and there are two glass covers. The following data is given:

Length of absorber plate: 1.5 m

Width of absorber plate: 1.0 m

Thermal conductivity of plate material: 35 W/m^0C

Plate thickness: 1.3 mm

Plate absorptivity/emissivity: 0.95

Outer tube diameter: 18 mm

Inner tube diameter: 14 mm

Tube centre to centre distance: 12 cm

$(\tau\ \alpha)_b = 0.727$

$(\tau\ \alpha)_d = 0.642$ (same for the reflected component of radiation)

Overall loss coefficient (U_l): 4.0 $W/m^2\ ^0C$

Location of collector = 18^0 32' N, 73^0 51'E

Date: 15 May

Hour angle (ω) = 23^0

Collector tilt =latitude angle

Surface azimuth angle= 0^0

Intensity of beam and diffused radiation: 665 W/m^2 and 230 W/m^2 respectively

Adhesive resistance: Negligible

Fluid to tube heat transfer coefficient: 205 $W/m^{20}C$

Flow rate of water = 70 kg/h

Inlet temperature of water: 60^0C

Ambient temperature: 25^0C

Determine the incident solar flux absorbed by the absorber plate, collector efficiency factor, collector heat removal factor and the useful heat gain. Also, compute the outlet temperature of water from the collector and the instantaneous efficiency.

6. Write short notes on the following:

a) Solar constant b) Latent heat storage c) Pyrheliometer d) Collector stagnation temperature