Centre for Energy Studies
INDIAN INSTITUTE OF TECHNOLOGY DELHI

ESL 340: Non-Conventional Sources of Energy

Time: Two Hours ***Major Test*** ***Maximum Marks: 75***

1. A flat plate solar collector uses a 4mm thick glass cover (refractive index of 1.5 and extinction coefficient of 30 m^{-1}). Calculate the energy losses (i) due to reflection at the air-glass interface and (ii) due to absorption in the glass, for normal incidence of solar radiation. **[4]**

2. Calculate the bottom heat loss coefficient of a flat plate solar collector using 10 cm thick insulation of thermal conductivity 0.5 W/m°C. Assume the resistance of convective and radiative heat transfer from the outer surface of the bottom of the collector to be negligibly small. **[3]**

3. On 'No Load' testing of a box type solar cooker the stagnation plate temperature was found to be 114°C with a corresponding values of ambient temperature of 24°C and solar radiation intensity of 800 W/m^2. Determine the first figure of merit (F_1) of the cooker. What will be the stagnation temperature of the cooker for an insolation of 900 W/m^2 and ambient temperature of 35°C? **[4]**

4. For safe medium term storage of an agricultural product its moisture content (on wet basis) is to be reduced from 85% to 15%. Calculate the amount of moisture to be removed for each kilogram of the dried product. **[4]**

5. During the cooling curve experiment of a 1 kg metallic cooking pot (with mass 1 kg and surface area 0.20 m^2) initially containing 2kg water, it was observed that difference between the water temperature and the ambient temperature became $(1/e)^{th}$ of its initial value in 4700 seconds. Estimate the heat loss factor ($F'U_L$) for the cooking pot if the specific heat of the material of the cooking pot is 1.0 kJ/kg °C and that of water is 4.2 kJ/kg °C. **[4]**

6. For an OTEC plant the cold water at 5°C is being obtained from 1000m deep ocean layer. Calculate the percentage gain in the conversion efficiency of an ideal carnot cycle if the temperature of warm surface ocean water is found to increase from 27°C to 37°C (values of other parameters assumed to be the same). What would be the fractional change in the volume flow rate of warm water required for the same power output? **[4]**

7. A wind turbine is experiencing a wind speed of 10m/s. Show that an infinitesimal change in the wind speed would change its mechanical power output by 30%. **[4]**

8. The daily useful energy requirement of 10 MJ for domestic cooking is presently being met with a traditional cookstove (efficiency of fuel utilization=10%). Estimate the annual amount of expected fuelwood savings if the household switches over to an improved cookstove with a fuelwood utilization efficiency of 30%. Assume a calorific value of 15 MJ/kg for the fuelwood. **[5]**

9. The dependence of the power coefficient (C_p) of a wind turbine on its tip speed ratio (TSR) is given by

$$C_p = 0.45 - 0.03\,(TSR-5)^2 \qquad \text{for } 2 \leq TSR \leq 8$$

Determine the optimum value of TSR for achieving maximum value of C_p. Also calculate the maximum power delivered by such a turbine at a wind speed of 10m/s. **[4]**

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10. A 10,000 metric tonne rock is cooled from 225°C to 105°C. Estimate the amount of heat extracted if the average value of the specific heat for the material of the rock is 2.1 kJ/kg °C. If the cooling is achieved in 1000 hours and the overall thermal to electrical energy conversion efficiency is 12%, determine the rate of power delivery. **[4]**

11. Determine solar time at Bhopal (longitude 72° 30′ East) at 12.30 hours Indian Standard Time for September 23, 2006. In India standard time is based on 82° 30′ East longitude and equation of time for September is +8 minutes. **[3]**

12. Explain the relevance of
    (a) selective coatings in solar thermal collection devices.
    (b) moisture trap in biogas delivery network.
    (c) binary fluid in a geothermal power plant.
    (d) controller in a PV home lighting system. **[8]**

13. Estimate
    (a) the maximum likely value of daily distillate output of a single basin type solar still. **[2]**

    (b) the maximum stagnation temperature of a black absorber plate exposed to solar radiation. **[2]**

    (c) the maximum transmittance of the glass cover of a flat plate solar collector. **[2]**

    (d) the maximum extractable power density from a wind turbine at a wind speed of 10 m/s. **[2]**

    (e) the maximum conversion efficiency of an OTEC system. **[2]**

    (f) the maximum gasholder size of a 2 m^3 biogas plant. **[2]**

    Explicitly mention the assumptions used in estimating the values in each case.

14. What are the differences in the design of a box type solar cooker and a flat plate solar collector. Discuss the relevance and implications of the changes made in the design of the box type solar cooker as compared to the design of a flat plate solar collector. **[4]**

15. (a) Discuss the merits and limitations of biomass as an energy source. **[2]**

    (b) Explain the likely implications of selecting a particular value of rated wind speed of a wind turbine on the possible values of its cut-in and cut-out wind speeds. **[2]**

    (c) Discuss the advantages of photovoltaic conversion of solar radiation to produce electricity. What are the factors which limit the conversion efficiency of solar cells? **[4]**