POSTAL Book Package 2021

Mechanical Engineering

Objective Practice Sets

Renewable Sources of Energy

Contents

MADE EASY Publications

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CHAPTER

Solar Thermal Energy Collection

Q.1 The absorber coatings are generally used to increase the ....of the collector material
(a) Emissivity (b) Absorptivity
(c) Reflectivity (d) (a) and (b)

Q.2 The wavelength of the radiations emitted by the absorber falls in the range of
(a) 0.3 μm to 2.5 μm (b) 0 to 0.3 μm
(c) 3 to 10 μm (d) none of these

Q.3 The cover of the absorber plate does not allow the transmission of
(a) UV radiation
(b) infrared radiation
(c) short-wavelength radiation
(d) long-wavelength radiation

Q.4 A horizontal flat plate collector is mounted in Chennai (13°N). Find out the tilt factor for reflected radiation and beam radiation on 20th April at 1030 (IST).
(a) 0, 1 (b) 1, 0
(c) 1, 1 (d) 0, 0

Q.5 A flat plate collector is rotated from horizontal position to vertical position at Hyderabad (17.39° N, 78.49°E). Find out the variation in tilt factor of diffused radiation on 30th October 2015 at 1100 h (LAT)
(a) 1.0 (b) 0.75
(c) 0.5 (d) 0.25

Q.6 Find out the total flux falling on a inclined flat plate collector for the following attributes:
Tilt angle β = 30°
Global Radiation falling as surface = 2400 kJ/m^2-h
Beam Radiation Tilt factor = 0.95
Diffused radiation contributes 20% of the global radiation
Ground reflectivity for the given location is 0.18
(a) 1920 kJ/m^2 – h (b) 2280 kJ/m^2 – h
(c) 2300 kJ/m^2 – h (d) 2520 kJ/m^2 – h

Q.7 The experimental investigations were carried out on a flat plate collector system and it is found that the product of transmissivity and absorptivity of the materials is 0.81. If this collector is to be mounted horizontally and global radiation falling on the surface for the sought locations are 1800 kJ/m^2–hr. Find out the total flux falling on the surface and the flux absorbed by the collector system in kJ/m^2–hr.
(a) 1800, 1458 (b) 2222, 1800
(c) 1600, 1296 (d) 1458, 1180

Q.8 A solar thermal energy system of 6 m^2 area has copper absorber plate. The dimensions of absorber plate are 2.9 × 1.95 × 0.01 m^3. The absorber plate is coated with anti-reflective coating such that transmissivity-absorptivity product increase to 0.93. An inventor claimed that he can design insulation for the above systems with zero heat losses to the surrounding. Find out the efficiency of the system according to the claim of inventor
(a) 100% (b) 94%
(c) 88% (d) can't be determined

Q.9 Beam radiation are falling on the transparent cover plate of a collecting system located at Patna (25.59°N, 85.14°E). The collector system is made to follow Sun. On a particular day, incidence angle on the collector is equal to the latitude of the location. Estimate the angle of refraction if refractive index of the material of cover plate with respect to air is 1.48.
(a) 25.6° (b) 39.74°
(c) 16.97° (d) 32.83°

Q.10 A transparent cover plate of refractive index 1.42 is used in solar energy collecting system. Find out transmissivity of the system due to reflection-refraction, if the beam radiation incidence angle is 25°.
(a) 0.92 (b) 0.96
(c) 0.94 (d) 0.90

Q.23 The optimum inclination of a FPC for summer condition is:
(a) ϕ (latitude) (b) $\phi - 15$
(c) $\phi + 15$ (d) None of the above

Q.24 The optimum inclination of a FPC for winter condition is ______.
(a) ϕ (latitude) (b) $\phi + 15$
(c) $\phi - 15$ (d) None of the above

Q.25 The annual optimum inclination of a FPC is:
(a) ϕ (latitude) (b) $\phi + 15$
(c) $\phi - 15$ (d) None of the above

Q.26 A cylindrical parabolic concentrator of 3 m width and 12 m length is used in power plant. If the inside and outside diameter of the absorber tube are 60 mm and 65 mm respectively, find out concentration ratio of the collector.
(a) 15.6 (b) 14.4
(c) 58.4 (d) 63.3

Q.27 For a parabolic collector of length 2 m, the angle of acceptance is 18°. Find out the concentration ratio.
(a) 6.4 (b) 3.2
(c) 12.8 (d) 1.6

Q.28 The optical efficiency of concentration (solar thermal energy concentrator) is:
(a) more than the thermal efficiency
(b) equal to thermal efficiency
(c) less than the thermal efficiency
(d) can't be compared

Q.29 The concentration ratio (c) is defined as
(a) Area of absorber plate/area of the aperture
(b) Area of aperture/2
(c) Area of absorber plate / sin θ
(d) Area of aperture to the area of absorber plate

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Answers Solar Thermal Energy Collection

1. (b)	2. (c)	3. (d)	4. (b)	5. (c)	6. (c)	7. (a)	8. (c)	9. (c)
10. (c)	11. (a)	12. (b)	13. (a)	14. (c)	15. (d)	16. (a)	17. (c)	18. (a)
19. (a)	20. (a)	21. (d)	22. (d)	23. (b)	24. (b)	25. (a)	26. (b)	27. (a)
28. (a)	29. (d)							

Explanations Solar Thermal Energy Collection

4. (b)

Tilt factor for reflected radiation

$$r_r = \rho\left(\frac{1-\cos\beta}{2}\right) = \rho\left(\frac{1-\cos 0}{2}\right) = 0$$

Tilt factor for beam radiations

$$= \frac{\cos\theta}{\cos\theta_z}\text{, For horizontal surface}$$

$$= \theta = \theta_z$$

Hence $r_b = 1$

5. (c)

Tilt factor for diffused radiation (r_d)

$$r_d = \frac{1+\cos\beta}{2}$$

β varies from 0° to 90°

$$(r_d)_{0°} = \frac{1+\cos 0°}{2} = 1$$

$$(r_d)_{90°} = \frac{1+\cos 90°}{2} = 0.5$$

variation = 1 – 0.5 = 0.5

6. (c)

Global radiation falling as collector

$$(I_g) = 2400 \text{ kJ/m}^2 - \text{hr}$$

Diffused radiation

$$(I_d) = \frac{20 \times 2400}{100} = 480 \text{ kJ/m}^2\text{hr}$$

Beam radiations

$$(I_b) = I_g - I_d = 2400 - 480$$
$$= 1920 \text{ kJ/m}^2 - \text{hr}$$

Total flux falling (I_T)

$$I_T = I_b r_b + I_d r_d + (I_b + I_d)\text{hr}$$

Now $r_D = 0.95$

$$r_d = \frac{1+\cos\beta}{2} = 0.933$$

$$r_r = \rho\left(\frac{1-\cos\beta}{2}\right)$$

$$= 0.18\left[\frac{1-\cos 30}{2}\right] = 0.0121$$

$\therefore$ $$I_T = 1920 \times 0.95 + 480 \times 0.933 + 0.0121 \times 2400$$
$$= 2300.78 \text{ kJ/m}^2 - \text{hr}$$

7. (a)

Total flux falling are given by (I_T)

$$I_T = I_b r_b + I_d r_d + (I_b + I_d)\, r_r$$

For horizontal surface, $\beta = 0°$ and $\theta = \theta_z$

$\therefore$ $$r_b = \frac{\cos\theta}{\cos\theta_z} = 1$$

$$r_d = \frac{1+\cos\beta}{2} = \frac{1+\cos 0}{2} = 1$$

$$r_r = \rho\left(\frac{1-\cos\beta}{2}\right) = \left(\frac{1-\cos 0}{2}\right)\rho = 0$$

$$I_T = I_b \times 1 + I_d \times 1 + I_g \times 0$$
$$I_T = I_b + I_d$$
$$I_T = I_g = 1800 \text{ kJ/m}^2 - \text{hr}$$

Flux absorbed by the collector systems is given by:

$$S = (\tau\alpha)\, I_T = 0.81 \times 1800$$
$$S = 1458 \text{ kJ/m}^2 - \text{hr}$$

8. (c)

Collector efficiency is given by:

$$\eta_c = \frac{q_u}{A_c I_T}$$

Useful heat gain (q_u) = Total heat gain – heat losses

$$q_u = q_T - q_l$$

As $q_l = 0$

$\therefore$ $$q_u = q_T$$

Total heat gain $q_T = (\tau\alpha)\, I_T \times A_P$

where I_T is total flux falling on the collector

A_P is area of absorber plate

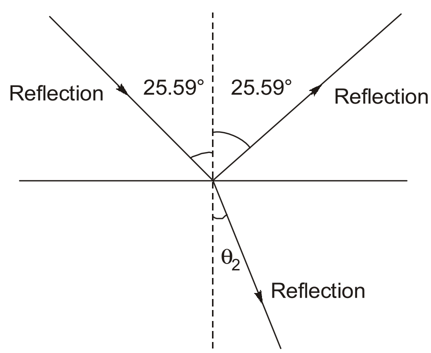
A_C is area of collector system

$\therefore$ $$\eta_c = \frac{(\tau\alpha) A_P I_T}{A_C I_T}$$

$$= \frac{(0.93) \times 2.9 \times 1.95}{6} = 0.8765$$

$$= 87.65\%$$

9. (c)



Refraction angle can be determined with Snell's law i.e.

$$\frac{\sin\theta}{\sin\theta_2} = \frac{n_1}{n_2}$$

$$\Rightarrow \quad \frac{\sin 25.59°}{\sin\theta_2} = 1.48$$

$$\Rightarrow \quad \theta_2 = 16.97°$$

10. (c)

Incidence angle (θ) = 25°

Beam refraction angle can be obtained from Snell's law i.e. $\dfrac{\sin\theta}{\sin\theta_2} = \dfrac{n_1}{n_2}$

$$\Rightarrow \quad \frac{\sin 25}{\sin\theta_2} = 1.42$$

$$\Rightarrow \quad \theta_2 = 17.31°$$

Now reflectivity of the system is given by

$$\rho_I = \frac{\sin^2(\theta_2 - \theta)}{\sin^2(\theta_2 + \theta)}$$

$$\rho_{II} = \frac{\tan^2(\theta_2 - \theta)}{\tan^2(\theta_2 + \theta)}$$

$\therefore$ $$\rho_I = \frac{\sin^2(25 - 17.31)}{\sin^2(25 + 17.31)} = 0.04$$

17. (c)

Bond resistance is given by:

$$R_b = \frac{k_b \times b}{r} = \frac{250 \times 25}{0.5} = 25000$$

Bond conductance (C_b)

$$C_b = \frac{1}{R_b} = \frac{1}{25000} = 4 \times 10^{-5}\,\text{W/m°C}$$

18. (a)

Thermal resistance offered by tubes is given by:

$$\frac{1}{h_{f1}\,\pi D_i} = \frac{1}{200 \times \pi \times 10 \times 10^{-3}}$$

$$= 0.159\ (\text{W/m°C})^{-1}$$

26. (b)

Concentration ratio

$$= \frac{W - D_0}{\pi D_0} = \frac{3000 - 65}{\pi \times 65} = 14.37$$

27. (a)

Concentration ratio (CR)

$$= \frac{1}{\sin\theta_{max}}$$

Now $\theta_{max} = \dfrac{\text{angle of acceptance}}{2}$

$$= \frac{18}{2} = 9°$$

$\therefore$ $CR = \dfrac{1}{\sin 9°} = 6.39$

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