POSTAL Book Package 2021

Mechanical Engineering

Objective Practice Sets

Heat Transfer

Contents

MADE EASY Publications

4 CHAPTER Heat Transfer from Extended Surfaces (Fins)

Q.1 Fins are used to increase heat transfer rate from a surface by
1. increasing the temperature difference
2. increasing the effective surface area
3. increasing the convective heat transfer coefficient
4. decreasing the thermal conductivity

Which of the above are true?
(a) 1 and 2 (b) 1, 3 and 4
(c) 2 only (d) 4 only

Q.2 On a heat transfer surface, fins are provided to
(a) increase temperature gradient so as to enhance heat transfer
(b) increase turbulence in flow for enhancing heat transfer.
(c) increase surface area to promote the rate of heat transfer.
(d) decrease the pressure drop of the fluid

Q.3 A cylindrical pin fin of diameter 0.6 cm and length of 3 cm with negligible heat loss from the tip has on efficiency of 0.7. The effectiveness of this fin is
(a) 7 (b) 14
(c) 21 (d) 28

Q.4 Consider the following statements pertaining to heat transfer through fins
1. Fins are equally effective irrespective of whether they are on the hot-side or cold-side of the fluid
2. The temperature along the fin is variable hence the rate of heat transfer varies along the elements of the fin
3. The fins may be made of materials that have a higher thermal conductivity than the material of the wall
4. Fins must be arranged at right angles to the direction of flow of the working fluid

Which of these statements are correct?
(a) 1 and 2 (b) 1 and 3
(c) 2 and 4 (d) 2 and 3

Q.5 Match **List-I** with **List-II** and select the correct answer:

List-I	List-II
A. Heat transfer	1. $1/\sqrt{\left(\frac{hA}{kP}\right)}$
B. Efficiency	2. $\sqrt{hPKA}$
C. Effectiveness	3. $1/\sqrt{\frac{hP}{KA}}$
D. m	4. $\sqrt{\frac{hP}{kA}}$

Codes:

	A	B	C	D
(a)	2	1	3	4
(b)	2	3	1	4
(c)	4	3	1	2
(d)	4	1	3	2

Q.6 The parameter $m = \sqrt{\frac{hP}{KA_C}}$ has been stated to increase in a long fin. If all the parameters are maintained constant, then
(a) temperature profile will remain the same
(b) temperature drop along the length will be at a lower rate
(c) the temperature drop along the length will be steeper
(d) the parameter m influences the heat flow only.

Q.7 For a finned surface, it is considered appropriate that area of cross-section be
(a) maintained constant along the length
(b) increased along the length
(c) reduced along the length
(d) it is considered better to vary the convection coefficient rather than area.

Q.27 A very long copper rod 20 mm in diameter extends horizontally from a plane heated wall maintained at 100°C. The surface of the rod is exposed to an air environment at 20°C with convective heat transfer coefficient of 8.5 W/m^2-deg. If thermal conductivity of copper is 400 W/m-deg the heat loss (in *W*) is ________.

Q.28 A steel rod (K = 30 W/m-deg) 1 cm in diameter and 5 cm long protrudes from a wall which is maintained at 100°C. The rod is insulated at its tip and is exposed to an environment with h = 50 W/m^2-deg and T_∞ = 30°C. The fin efficiency is ________%.

Q.29 A infinitely long copper (k = 400 W/mK) rod of length L and diameter D is attached at one end to a heated wall and transfers heat $\dot{q}_1$ by convection to a cold fluid. If an aluminium (k = 250 W/mK) rod of length L and diameter 0.4D is used in place of copper rod, the heat transfer is $\dot{q}_2$. The ratio $\frac{\dot{q}_1}{\dot{q}_2}$ is ________.

Q.30 A fin has a diameter of 40 mm and length of 200 mm. If this fin has an efficiency of 40%, the effectiveness is ________. (Assume adiabatic tip)

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Answers Heat Transfer from Extended Surfaces (Fins)

1. (c)	2. (c)	3. (b)	4. (d)	5. (b)	6. (c)	7. (c)	8. (a)	9. (a)
10. (d)	11. (b)	12. (d)	13. (b)	14. (d)	15. (b)	16. (d)	17. (c)	18. (d)
19. (a)	20. (d)	21. (d)	22. (a)	23. (d)	24. (134.65)	25. (17)	26. (2.652)	
27. (20.71)	28. (66.57)	29. (5)	30. (7.99)					

Explanations Heat Transfer from Extended Surfaces (Fins)

1. (c)

The fins increase heat transfer rate by increasing the effective area. The heat transfer coefficient remains the same.

2. (c)

Heat transfer α $\sqrt{hpkA}$, so $Q\uparrow$ if $A\uparrow$

3. (b)

$$\eta_{fin} = \left(\frac{\tanh mL}{mL}\right) = 0.7$$

$$\varepsilon_{fin} = \tanh mL\sqrt{\frac{kP}{hA}} = \frac{\tanh mL}{m}\times\frac{P}{A}$$

$$\frac{\varepsilon_{fin}}{\eta_{fin}} = \frac{L\times P}{A}$$

$$\text{Effectiveness} = \frac{3\pi\times 0.6\times 0.7}{\frac{\pi}{4}(0.6)^2} = 14$$

4. (d)

Fins are effective is more effective where the heat transfer coefficient is less. The temperature along the fin varies, the fin material may be different to the base material.

5. (b)

$$m = \sqrt{\frac{hP}{kA}}$$

$$Q = \sqrt{hPkA}\,\theta_0$$

$$\eta = \frac{\tanh(mL)}{mL}\times\frac{1}{m} = \frac{1}{\sqrt{\frac{hP}{kA}}}$$

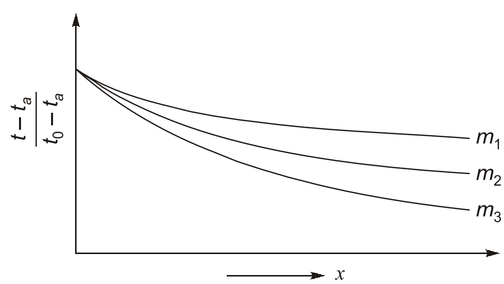
$$\varepsilon = \frac{1}{\sqrt{\frac{hP}{kA}}}$$

6. (c)

For an infinitely long fin,

$$\frac{t-t_a}{t_0-t_a} = e^{-mx}$$

The figure given below shows the dependence of dimensionless temperature $\frac{t-t_a}{t_0-t_a}$ along the length of fin for different values of parameter m ($m_1 < m_2 < m_3$). The plot indicates that the dimensionless temperature falls more with increase in factor m. With fin length extending to infinity, $x \to \infty$, all the curves approach $\frac{t-t_a}{t_0-t_a}$ = 0 asymptotically.



7. (c)

A tapped fin is considered to be a better design as it has more lateral area near the base where the difference is high.

8. (a)

$$Q_{\text{long fin}} = \sqrt{hPkA}\,\theta_0$$

$$= \sqrt{hPKA_C}\,(t_0 - t_\infty)$$

T_∞ = Ambient temperature, T_0 = Wall temperature

9. (a)

If $\frac{h}{mk} > 1$

$\Rightarrow \frac{h}{\sqrt{\frac{hP}{kA}}\cdot k} > 1$

$\Rightarrow \sqrt{\frac{hP}{kA}} > 1$

$\Rightarrow \frac{1}{\varepsilon} > 1$

$\Rightarrow \varepsilon < 1$

Since effective is less than 1.

$\therefore$ Adding on extended surface reduces the rate of heat transfer.

10. (d)

$$\eta_{fin} = \frac{\tanh(mL)}{mL} = \frac{\tanh(mL)}{\sqrt{\frac{hP}{kA}}\cdot L}$$

For rectangular fin,

Perimeter, $P = 2(w+b) \approx 2w \quad (\because w >> b)$

Area, $A = wb$

$$\therefore \quad \eta_{fin} = \sqrt{\frac{k \times wb}{h \times 2w}}\,\frac{\tanh(mL)}{L}$$

$$\eta_{fin} = \left(\frac{kb}{2h}\right)^{1/2}\frac{\tanh(mL)}{L}$$

11. (b)

$$Q = \sqrt{hPKA}\,(T_o - T_\infty)$$

$$= \sqrt{300 \times 2\pi \times 1.5 \times 10^{-3} \times 150 \times \frac{\pi}{4}\,(3 \times 10^{-3})^2}\,(140 - 15$$

$$= 6.84 \text{ W}$$

12. (d)

$$m = \sqrt{\frac{hP}{KA}} = \sqrt{\frac{(23.3)\times(\pi d)}{(55.8)\times(\pi d \times 0.0015)}} = 16.7$$

$$\because \left(\frac{T_L - T_\infty}{40 - T_\infty}\right) = \frac{1}{\cos h(16.7 \times 0.12)}$$

$$T_\infty = 100°\text{C}$$

$\therefore$ Measurement error = $T_\infty - T_L$

$= 100°\text{C} - 84°\text{C} = 16°\text{C}$

13. (b)

$$\eta_{fin} = \frac{\tanh(ml)}{ml}$$

where, $m = \sqrt{\frac{hP}{kA}}$

14. (d)

For insulated tip fin,

$$\frac{\theta}{\theta_0} = \frac{T - T_\infty}{T_0 - T_\infty} = \frac{\cosh m(L-x)}{\cosh(mL)}$$

at tip $x = L$

$$\therefore \quad \frac{\theta}{\theta_0} = \frac{\cosh O}{\cosh mL}$$

$$\Rightarrow \quad \theta = \frac{\theta_0}{\cosh(mL)}$$

where, $\theta_0 = T_0 - T_\infty$ and $\theta = T - T_\infty$

29. **(5)**

For infinitely long fin,

$$\dot{q} = \sqrt{hPkA}(T_b - T_\infty)$$

For circular fin, $P = \pi D$

$$A = \frac{\pi}{4}D^2$$

So,

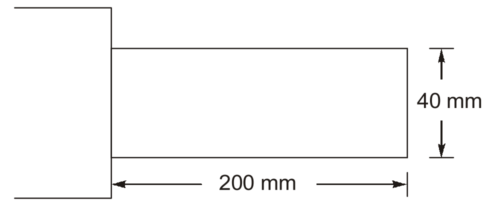
$$\dot{q} = \sqrt{h \times \pi D \times k \times \frac{\pi}{4}D^2}\,(T_b - T_\infty)$$

$$\dot{q} \propto \sqrt{k}D^{3/2}$$

$$\frac{\dot{q}_1}{\dot{q}_2} = \frac{\sqrt{k_1}\,D_1^{3/2}}{\sqrt{k_2}\,D_2^{3/2}}$$

$$= \left(\frac{400}{250}\right)^{1/2}\left(\frac{D}{0.4D}\right)^{3/2} = 5$$

30. **(7.99)**



Efficiency of fin, η_{fin} = 40%

Diameter of fin, d = 40 mm

Cross-sectional area of fin, $A_b = \frac{\pi}{4}d^2$

$$= \frac{\pi}{4} \times 0.04^2$$

$$= 1.2566 \times 10^{-3}\ \text{m}^2$$

Surface area of fin,

$$A_{fin} = \pi d l$$

$$= \pi \times 0.04 \times 0.2 = 0.02513\ \text{m}^2$$

As we know,

Effectiveness of fin,

$$\epsilon_{fin} = \eta_{fin}\frac{A_{fin}}{A_b}$$

$$= 0.4 \times \frac{0.02513}{1.2566 \times 10^{-3}} = 7.99$$

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