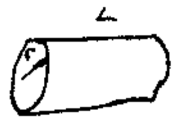
Q9 2000

CONSIDER A THIN CYLINDRICAL LAYER RADIAL THICKNESS dr AND TEMP. DIFFERENCE dT

FOURIER'S LAW $\dot{Q} = -kA\frac{dT}{dr}$ $A = 2\pi r \times$ Length L



$\dot{Q} = -k \times 2\pi r L \frac{dT}{dr}$

$2\pi k L \, dT = -\dot{Q}\frac{dr}{r}$

$2\pi k L \int_{T_1}^{T_2} dT = -\dot{Q}\int_{R_1}^{R_2} \frac{dr}{r}$ $\dot{Q}$ SAME AT ALL RADII

$2\pi k L (T_1 - T_2) = -\dot{Q} \ln R_1/R_2 = +\dot{Q} \ln R_2/R_1$

$\dot{Q} = \frac{2\pi k L (T_1 - T_2)}{\ln R_2/R_1} =$ Constant $(T_1 - T_2)$

THERMAL RESISTANCE $R = \frac{T_1 - T_2}{\dot{Q}}$

$R_1 = \frac{\ln R_2/R_1}{2\pi k L}$ TAKE $L = 1m$

$k = 1.2 \ W/mK$ For Inner Layer

$R_1 = \frac{\ln 70/50}{2\pi \times 1.2} = 0.044626 \ K/W$

$R_2 = \frac{\ln 90/70}{2\pi \times 2.4} = 0.016666 \ K/W$ FOR OUTER LAYER

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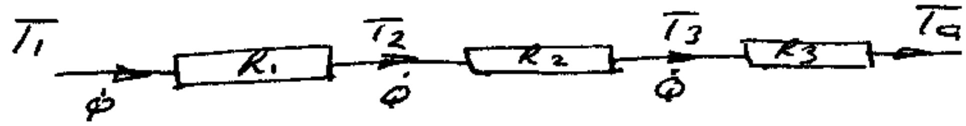
OUTER LAYER CONVECTION

$$\dot{\Phi} = hA(T_a - T_2) = h \times 2\pi r L \, (T_a - T_2)$$

$$\dot{\Phi} = 30 \times 2\pi \times .09 \times 1 \; (T_a - T_2) \qquad r = 90 \text{ mm}$$
$$= 16.96\,(T_a - T_2) \qquad h = 30 \text{ W/m}^2\text{K}$$

THERMAL RESISTANCE $R_3 = \dfrac{T_a - T_2}{\dot{\Phi}} = 0.0589 \dfrac{K}{W}$

ANALOGY 3 RESISTANCES IN SERIES



$$R\,(\text{TOTAL}) = R_1 + R_2 + R_3 = 0.044626 + 0.016666$$
$$+ 0.0589$$

$$R_T = 0.12024 \text{ K/W}$$

$$\dot{\Phi} = \frac{T_1 - T_a}{R_T} = 8.317\,(T_1 - T_a)$$

REVERSING LAYERS

$$R_1 = \frac{\ln 70/50}{2\pi \times 2.4} = 0.022313 \text{ K/W}$$

$$R_2 = \frac{\ln 90/70}{2\pi \times 1.2} = 0.0333 \text{ K/W}$$

$$R_3 = 0.0589 \text{ K/W}$$

$$R_T = 0.1145 \text{ K/W}$$

$$\dot{\Phi} = \frac{T_1 - T_a}{.1145} = 8.73\,(T_1 - T_a)$$

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DIFFERENCE = 8.73 − 8.317
= 0.413

% of 8.73 $\frac{.413}{8.73} \times 100 = 4.7\%$

THIS IS 1/2 THE EXPECTED ANSWER.