King Saud University
College of Engineering
Chemical Engineering Dept.

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CHE 313 , 3rd Mid. (s)

Heat Transfer Operations

Good Luck Prof. Dr. Anis H. Fakeeha

Student Name: [illegible] Ideal Solution Student Num= Section

Question One : **(30 Points)**

Answer By either True or False for the following statmets:

1- Combustion gases reduced amount of heat transfer by radiation

2- Black body reflect part of received heat by radiation

3- Nitrogen gas absorb part of heat transfer by radiation pass through it

4- Most of engineering bodies allow radiation to pass through them

5- Natural convection transfer heat more than forced convection

6- In natural convection $N_{Nu} = f(N_{Re} \ \& \ N_{Pr})$

7- Circulation in natural convection is due to external velocity.

8- Gray body is the ideal body.

9- Smooth surfaces emissivity is lower than rough surfaces.

10- Rate of heat transfer by radiation proportional to T^4.

11- Heat transfer coefficient represent conductance of heat

12- Heat transfer coefficient in natural convection depend on orientation of heating surface.

13- Heat transfer coefficient in forced convection depend on fluid velocity only

14- Heat transfer coefficient inversely proportional to boundary layer thickness .

15- Heat transfer coefficient in forced convection is proportional to Reynold number at constant Prandtl number

لا تكتب في هذا الهامش

$T_f = \frac{250+350}{2} = \frac{600}{2} = 300\,k$

from table $\rho = 1.1774\ kg/m^3$

$\mu = 1.8462\times10^{-5}\ kg/m.s$

$C_p = 1.0057\ \frac{kJ}{kg\,k}$

$k = 0.02624\ W/m\,k = 0.02624\times10^{-3}\ kJ/m\,k$

$P_r = 0.708$

$N_{Re} = \frac{\rho v L}{\mu} = \frac{1.1774\times3.05\times0.305}{1.8462\times10^{-5}}$

$= 59326 = 5.9\times10^{4}$

$N_{Pr} = \frac{C_p\mu}{k} = 0.708 = \frac{1.0057\times1.8462\times10^{-5}}{0.02624\times10^{-3}}$

$N_{Nu} = \frac{hL}{k} = 0.664(59326)^{0.5}(0.708)^{0.33}$

$= 0.664\times243.57\times0.892$

$= 144.312$

(1) $h = \frac{144.312\times0.02624}{0.305} = 12.416\ \frac{W}{m^2k}$

(2) $q = hA\Delta T = 12.416(0.305\times1)\times(350-250)$

$= 378.675\ W$

(3) $N_{Re} = \frac{1.1774\times30.5\times0.305}{1.8462\times10^{-5}} = 5.9326\times10^{5}$

$N_{Nu} = 0.0366(5.93\times10^{5})^{0.8}(0.708)^{0.33}$

$= 0.0366\times41552.39\times0.892 = 1356.57$

$h = \frac{1356.57\times0.02624}{0.305} = 116.71$

$$T_f = \frac{T_W + T_b}{2} = \frac{239 + 15}{2} = \frac{254}{2} = 127^\circ C = 400 K.$$

physical properties of air at 400 K.

$\rho = 0.8826$ kg/m³

$\mu = 2.286 \times 10^{-5}$ kg/m.s

$k = 0.03365$ W/m.K

$P_r = 0.689$

$$\beta = \frac{1}{T_f} = \frac{1}{400} = 0.0025$$

$$Gr.P_r = \frac{\rho^2 . L^3 g \beta (T_W - T_b)}{\mu^2} . P_r$$

$$= \frac{(0.8826)^2 (0.3)^3 (9.81)(0.0025)(239-15)}{(2.286 \times 10^{-5})^2} (0.689)$$

$$= 1.52 \times 10^8$$

$$Nu = C (Gr.P_r)^m$$

from table at Gr-Pr in the range $10^4 - 10^9$

$C = 0.53$ and $m = \frac{1}{4}$

$$\therefore Nu = 0.53 (1.52 \times 10^8)^{1/4} = 58.85$$

but $Nu = \frac{h.d}{k} \Rightarrow h = Nu . \frac{k}{d} = \frac{58.85 (0.03365)}{0.3}$

$$= 6.6 \text{ W/m}^2.K$$

$$q_{conv.} = h A . \Delta T = h . \pi d L (T_w - T_b)$$

$$\therefore \frac{q}{L} = h . \pi d (T_W - T_b)$$

$$= 6.6 \pi (0.3)(239-15) = 1393.4 \text{ W/m}$$

$$= 1.39 \frac{kW}{m}$$

$q_{rad.} = \sigma \varepsilon . A \left(T_1^4 - T_2^4\right)$

$T_1 = 239°C = 239 + 273 = 512\ K$

$T_2 = 15°C = 15 + 273 = 288\ K$

$\therefore \frac{q_{rad}}{L} = (5.676 \times 10^{-8})(0.9)(\pi(0.3)) \left[512^4 - 288^4\right]$

$= 2977.3\ \frac{W}{m} = \underline{\underline{2.977\ \frac{kW}{m}}}$

$q_{total} = q_{rad.} + q_{conv.}$

$= 2977.3 + 1393.4 = 4370.7\ \frac{W}{m}$

$= \underline{\underline{4.37\ \frac{kW}{m}}}$