Principles of

Heat Transfer

FRANK KREITH

Professor of
Mechanical Engineering

UNIVERSITY OF COLORADO

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practical application. l checking of the units ess numbers is a pre- gested that a common- nal result. The order typical conditions in

-transfer coefficient in wing examples. It is ples independently in s equations presented

velocity of 10 fps through e, steam is condensing at . The tube is clean, and inner surface. Using the conductance between the Fig. 8–9, and compare the ution is 68 F and neglect

vity	Specific Heat (Btu/lb F)
	0.50
	0.53
	0.56

ermine whether the flow lk temperature we get

ft³) / tipoise) = 15,600

temperature according

10 F

ken at T_f. The Prandtl , is

0 sec/hr) = 61.5

n from Appendix II.] .4. Using Eq. 8–20 to arrangement,

456 Btu/hr sq ft F

From Fig. 8–9 at Pr = 61.5 and Re_D = 15,600 we find

$$\mathrm{St}\left(\frac{\mu_s}{\mu_b}\right)^n = 2.7 \times 10^{-4}$$

For heating liquids $n = 0.36$ and the viscosity correction factor is

$$\left(\frac{\mu_b}{\mu_s}\right)^n = \left(\frac{5.1}{0.6}\right)^{0.36} = 2.16$$

Using Eq. 8–22 to evaluate $\bar{h}_c$ we get

$$\bar{h}_c = \frac{0.100 \text{ Btu/hr sq ft (F/ft)}}{1/12 \text{ ft}} (15{,}600)(61.5)(2.16)(2.7 \times 10^{-4})$$

$$= 670 \text{ Btu/hr sq ft F} \qquad \textit{Ans.}$$

We note that, for the example which represents unusually large viscosity variations ($\mu_b/\mu_s = 8.5$), Deissler's analysis predicts a value of $\bar{h}_c$ which is 32 per cent larger than the value predicted by McAdams' empirical equation. This sort of discrepancy between different methods is not unusual in convective heat transfer.

Example 8–2. Determine the unit thermal convective conductance for water flowing at a velocity of 10 fps in an annulus formed between a 1-in.-OD tube and a 1½-in.-ID tube. The water is at 180 F and is being cooled. The temperature of the inner wall is 100 F, and the outer wall of the annulus is insulated. Neglect entrance effects and compare the results of Eqs. 8–20 and 8–22. The properties of water are given in the accompanying tabulation.

T (F)	μ ($\mathrm{lb_m}$/hr ft)	k (Btu/hr ft F)	ρ ($\mathrm{lb_m}$/cu ft)	c (Btu/$\mathrm{lb_m}$ F)
100	1.67	0.36	62.0	1.0
140	1.14	0.38	61.3	1.0
180	0.75	0.39	60.8	1.0

Solution: The hydraulic diameter D_H for this geometry is 0.5 in. The Reynolds number based on the hydraulic diameter and the bulk temperature properties is

$$\mathrm{Re}_{Db} = \frac{VD_H\rho}{\mu} = \frac{(10 \text{ ft/sec})(0.5/12 \text{ ft})(62 \text{ lb}_m\text{/cu ft})(3600 \text{ sec/hr})}{0.75 \text{ lb}_m\text{/hr ft}}$$

$$= 125{,}000$$

Based on the mean film temperature T_f, the Reynolds number is Re_{Df} = 82,000. The Prandtl number at the bulk temperature is

$$\mathrm{Pr}_b = \frac{c\mu}{k} = \frac{(1.0 \text{ Btu/lb}_m \text{ F})(0.75 \text{ lb}_m\text{/hr ft})}{0.39 \text{ Btu/hr ft F}} = 1.92$$

and at T_f, we find that $\mathrm{Pr}_f = 3.0$. According to Eq. 8–20 we have

$$\mathrm{St} = \frac{\bar{h}_c}{c\rho V} = 0.023\, \mathrm{Re}_{Df}^{-0.2}\, \mathrm{Pr}_f^{-2/3}$$

$$= 0.023/(9.6 \times 2.08) = 0.00115$$