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Continuing Education Course #119
Convection Heat Transfer Coefficient Estimation

- Newton's Law of Cooling can be used for which of the following types of convection calculations?
 - for only forced convection
 - for only natural convection
 - for both forced convection and natural convection
- Calculate the heat transfer coefficient (in $\text{Btu/hr-ft}^2\text{-}^\circ\text{F}$) for natural convection from a 1 ft diameter, 20 ft long horizontal cylinder with surface temperature of 130°F to air at 75°F , if the rate of heat loss from the pipe is 3100 Btu/hr.
 - 0.75
 - 0.80
 - 0.90
 - 1.10
- Which of the following are the dimensionless numbers typically used for forced convection heat transfer coefficient correlations?
 - Nusselt, Reynolds, and Prandtl numbers
 - Nusselt, Grashof, and Prandtl numbers
 - Grashof, Prandtl, and Rayleigh numbers
 - Rayleigh, Prandtl, and Nusselt numbers
- Which of the following are the dimensionless numbers typically used for natural convection heat transfer correlations?
 - Nusselt, Reynolds, and Prandtl numbers
 - Nusselt, Reynolds, and Grashof numbers
 - Nusselt, Prandtl, Grashof, and Rayleigh numbers
 - Prandtl, Grashof, and Reynolds numbers
- Which of the turbulent pipe flow correlations requires a different exponent on Pr for heating than for cooling of the fluid?
 - the Dittus-Boelter correlation
 - the Sieder-Tate correlation
 - the Petukhov correlation
 - the Gnielinsky correlation
- Calculate the Reynolds number for flow of water at 85°F at a velocity of 2.5 ft/sec in a 3 inch diameter pipe.
 - 35,300
 - 55,100
 - 73,500
 - 94,200

7. Calculate the convective heat transfer coefficient, h , (in $\text{Btu/hr-ft}^2\text{-}^\circ\text{F}$) for water at 85°F flowing through a 2.5 inch diameter pipe if the Nusselt number is 202.
- a. 320
 - b. 381
 - c. 356
 - d. 497
8. The factor to be used to correct for variation in fluid properties with the Gnielinsky correlation is different than that used in the Sieder-Tate correlation.
- a. true
 - b. false
9. The equation for the Nusselt number for fully developed laminar flow in a pipe is the same for uniform wall heat flux as for uniform wall temperature.
- a. true
 - b. false
10. The velocity profile remains constant within the entrance length, L_e , for flow in a pipe.
- a. true
 - b. false
11. What is the Nusselt number for flow of water at 75°F , through a 3" diameter pipe with Reynolds number equal to 1800, if the length of the pipe is significantly greater than the entrance length for this flow and the inside pipe surface is at a constant temperature?
- a. 1.86
 - b. 3.66
 - c. 4.36
 - d. 12.7
12. What would be the characteristic length to use in calculating the convection heat transfer coefficient for turbulent flow of water through a circular annulus with inner diameter = 2 inches and outer diameter = 5 inches?
- a. 2 inches
 - b. 3 inches
 - c. 5 inches
 - d. 8 inches
13. The characteristic velocity to be used when calculating the Reynolds number for estimating the forced convection heat transfer coefficient for flow across a horizontal cylinder is the approach velocity, V_∞ .
- a. true
 - b. false
14. The critical length, X_c , for flow parallel to a flat plate is the distance from the leading edge of the plate to the point at which _____.
- a. the velocity in the boundary layer reaches its critical value
 - b. the velocity profile becomes constant
 - c. the end of the plate is reached
 - d. the flow in the boundary layer changes from laminar to turbulent
15. Will air at 103°F flowing parallel to a 10 ft long flat plate, be flowing in laminar or in turbulent flow at the end of the plate if the approach velocity of the air is 2.5 ft/sec? You may use $0.00221 \text{ slugs/ft}^3$ as the density and $3.94 \times 10^{-7} \text{ lb-sec/ft}^2$ as the viscosity of the air at 103°F . Use a critical Reynolds number of 3×10^5 .

- a. It will be laminar flow.
- b. It will be turbulent flow.
- c. There's not enough information to determine whether it's laminar or turbulent flow.

16. Which one of the following temperatures should be used for the fluid properties in the dimensionless numbers, Pr, Nu, Gr, & Ra, for natural convection heat transfer coefficient estimation from a vertical plate?

- a. the film temperature, $T_f = (T_\infty + T_w)/2$
- b. the temperature of the fluid far from the vertical wall, T_∞
- c. the temperature of the vertical wall, T_w
- d. the difference between the fluid temperature and the wall temperature, $T_w - T_\infty$

17. What is the value of thermal expansion coefficient, β (in $^\circ\text{R}^{-1}$), to be used for natural convection from a vertical wall at 220°F to air at 120°F?

- a. 0.00027
- b. 0.00159
- c. 0.00454
- d. 0.00588

18. The same equation can be used to calculate the heat transfer coefficient for natural convection from a horizontal plate whether the fluid is being heated from the upper surface of the plate or from the lower surface of the plate.

- a. true
- b. false

19. Calculate the Nusselt number for natural convection heating of air above a horizontal plate the air will be heated from the upper surface of the plate if the Prandtl number is 0.74 and the Grashof number is 7.4×10^7 .

- a. 23.2
- b. 46.4
- c. 57.0
- d. 73.4

20. To calculate the natural convection heat transfer coefficient for a surface inclined at the angle, θ , from vertical, the factor "g" should be replaced with "g sin θ " in the expression for natural convection from a vertical surface.

- a. true
- b. false

21. The maximum angle, θ , from the vertical for use of the correlation given in this course for natural convection from an inclined surface is _____.

- a. 20°
- b. 30°
- c. 60°
- d. 80°

22. The length of a long horizontal cylinder, L, is used as the characteristic length in which of the following dimensionless numbers for natural convection heat transfer?

- a. L is used in Gr only.
- b. L is used in Nu only.
- c. L is used in both Gr and Nu.
- d. L is not used in any of the dimensionless numbers for natural convection heat transfer from a long horizontal cylinder.

23. Calculate the Nusselt number for natural convection heat transfer from a 4 ft diameter sphere with $Gr = 6.3 \times 10^9$, $Pr = 0.76$, and $Ra = 4.79 \times 10^9$.

- a. 27
- b. 64
- c. 122
- d. 243

24. All of the natural convection heat transfer correlations given in this course for calculating Nu from known values of Pr and Ra remain the same in either U.S. units or S.I. units.

- a. true
- b. false

NOTE: The following question was revised on 22 June 2018

25. Which of the following is the correct expression for the hydraulic diameter for flow through a circular annulus with outer pipe diameter of D_o and inner pipe diameter of D_i ?

- a. $D_o - D_i$
- b. D_o/D_i
- c. $(D_o)(D_i)$
- d. D_i/D_o

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