Cankaya University
Faculty of Engineering
Mechanical Engineering Department
ME 313 Heat Transfer

Chapter 8
Internal Flow Examples
Fall 2016

Laminar Flow

Example -1 Consider the heating of atmospheric air flowing with a velocity of $V = 0.5$ m/s inside a thin-walled tube 2.5 cm in diameter in the hydrodynamically and thermally developed region. Heating can be done either by condensing steam on the outer surface of the tube, thus maintaining a uniform surface temperature, or by electric resistance heating, thus maintaining a uniform surface heat flux. Calculate the heat transfer coefficient for both of these heating conditions by assuming air properties can be evaluated at 350 K.

Example -2 Air at atmospheric pressure and with a mean velocity of $V = 0.5$ m/s flows inside thin-walled, square cross-section ducts of sides $b = 2.5$ cm. The air is heated from the walls of the duct, which are maintained at a uniform temperature by condensing steam on the outside surface. Calculate the friction factor and the heat transfer coefficient in the hydrodynamically and thermally developed region. Air properties can be evaluated at 350 K.

Example -3 Determine the hydrodynamic and the thermal entrance lengths in terms of the tube inside diameter D for flow at a mean temperature $T_m = 60°C$ and $Re = 200$ inside a circular tube for mercury, air, water, ethylene glycol, and engine oil, under constant wall heat flux boundary condition.

Example -4 Ethylene glycol at 60°C, with a velocity of $V = 4$ cm/s, enters the 6-m-long, heated section of a thin-walled, 2.5-cm-ID tube, after passing through an isothermal calming section. In the heated part, the tube wall is maintained at a uniform temperature $T_w = 100°C$ by condensing steam on the outer surface of the tube. Calculate the exit temperature of ethylene glycol.

Example -5 Engine oil is cooled from T_{mi}= 120°C to T_{mo} = 80°C while it is flowing with a mean velocity of V = 0.04 m/s through a circular tube of inside diameter 2.5 cm. The tube wall is maintained at a uniform temperature T_w = 40°C. As soon as the enine oil enters the tube, cooling begins. Determine length L.

Turbulent Flow

Example -6 Water flows with a mean velocity of V = 2 m/s inside a circular pipe of inside diameter D = 5 cm. The pipe is of commercial steel, and its wall is maintained at a uniform temperature T_w = 100°C by condensing steam on its outer surface. At a location where the fluid is hydrodynamically and thermally developed, the bulk mean temperature of water is T_b = 60°C. Calculate the heat transfer coefficient h.

Example 7: Water flows with a mean velocity of V=2 m/s inside a circular pipe of inside diameter D=5 cm. The pipe is smooth pipe and its wall is maintained at a uniform temperature $T_w = 100\,^0C$ by condensing steam on its outer surface. At a location where fluid is hydrodynamically and thermally fully developed, the bulk temperature of water is $T_m = 60\,^0C$ .Calculate the heat transfer coefficient.