Table 3.1 Average Velocities for Some Channel and Tube Flows

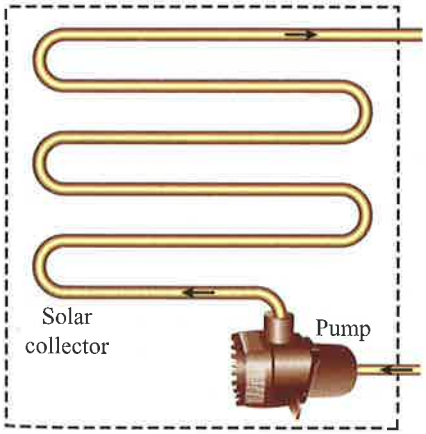
Geometry	Velocity Distribution	Average Velocity
2-D channel with height d	$v(y) = v_{max}\left[1 - 4\left(\frac{y}{d}\right)^2\right]$	$v_{avg} = \frac{2}{3}v_{max}$
Circular tube with radius R	$v(r) = v_{max}\left(1 - \frac{r^2}{R^2}\right)$	$v_{avg} = \frac{1}{2}v_{max}$
Circular tube with radius R	$v(r) = v_{max}\left(1 - \frac{r}{R}\right)^{1/n}$	$v_{avg} = \frac{2n^2}{(n+1)(2n+1)}v_{max}$
	for $n = 6$	$v_{avg} = \frac{72}{91}v_{max} = 0.791v_{max}$
	for $n = 7$	$v_{avg} = \frac{49}{60}v_{max} = 0.817v_{max}$
	for $n = 10$	$v_{avg} = \frac{200}{231}v_{max} = 0.866v_{max}$

Table 3.2 Typical Average Velocities for Selected Pipe Flows*

Fluid	Application	Velocity (m/s)
Steam	Superheated process steam	45–100
	Auxiliary heat steam	30–75
	Saturated and low-pressure steam	30–50
Water	Centrifugal pump suction lines	0.9–1.5
	Feedwater	2.4–4.6
	General service	1.2–3.1
	Potable water	Up to 2.1

*Adapted from Department of the Army, TM 5-810-15, Central Steam Boiler Plants, August 1995.

Example 3.9 Solar-Heated Buildings Application



A solar collector for heating water consists of a 292.6-m length of black EPDM tubing as shown in the sketch. The outside diameter of the tubing is 8.9 mm and the inside diameter is 5.7 mm. Water is pumped through the tubing at a steady volumetric flow rate of 3.9×10^{-5} m^3/s. The water temperature is approximately 365 K. The dimensionless parameter that determines whether the flow is laminar or turbulent, and hence the shape of the velocity profile, is the **Reynolds number**.[4] For flow through pipes and tubes, the Reynolds number is defined as $Re = \rho v_{avg} D/\mu$, where ρ and μ are the fluid density and viscosity, respectively, and D is the diameter of the flow passage. For Reynolds numbers less than about 2300, the flow is generally laminar, whereas

[4] The Reynolds number is a very important parameter in fluid mechanics. Origins of the