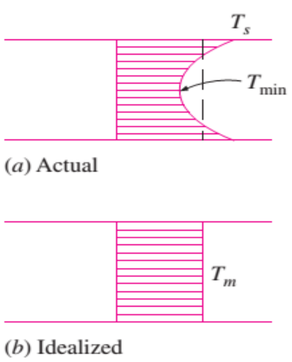
Babylon university /college of materials engineering /department of polymers and petrochemicals engineering
Subject: Heat transfer   Class: Third
Lecture name: Internal force convection
Number of lecture: lecture one
Prepared by :Mr.Qusai AMahdi

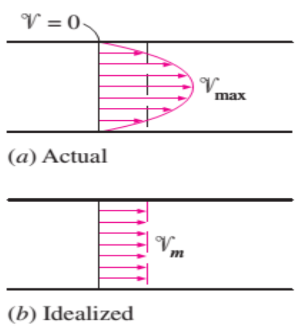
Internal Force Convection:-

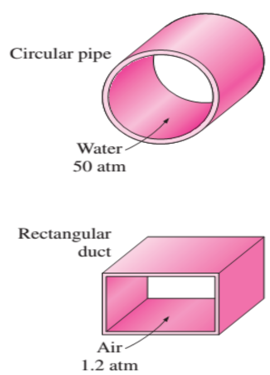
There is a fundamental difference between external and internal flows. In external flow, the fluid has a free surface, and thus the boundary layer over the surface is free to grow indefinitely. In internal flow, however, the fluid is completely confined by the inner surfaces of the tube, and thus there is a limit on how much the boundary layer can grow. in this part defined a general physical description of internal flow, and the mean velocity and mean temperature. We continue with the discussion of the hydrodynamic and thermal entry lengths, developing flow, and fully developed flow. We then obtain the velocity and temperature profiles for fully developed laminar flow, and develop relations for the friction factor and Nusselt number.
Most fluids, especially liquids, are transported in circular pipes. This is because pipes with a circular cross section can withstand large pressure differences between the inside and the outside without undergoing any distortion. Noncircular pipes are usually used in applications such as the heating and cooling systems of buildings where the pressure difference is relatively small

Mean Velocity and Mean Temperature

The fluid velocity in a tube changes from zero at the surface because of the no-slip condition, to a maximum at the tube center. Therefore, it is convenient to work with an average or mean velocity m, which remains constant for incompressible flow when the cross sectional area of the tube is constant.When a fluid is heated or cooled as it flows through a tube, the temperature of the fluid at any cross section changes from Ts at the surface of the wall to some maximum (or minimum in the case of heating) at the tube center. In fluid flow it is convenient to work with an average or mean temperature Tm that remains uniform at a cross section. Unlike the mean velocity, the mean temperature Tm will change in the flow direction whenever the fluid is heated or cooled







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Laminar and Turbulent Flow In Tubes:-

Flow in a tube can be laminar or turbulent, depending on the flow conditions. Fluid flow is streamlined and thus laminar at low velocities, but turns turbulent as the velocity is increased beyond a critical value. Transition from laminar to turbulent flow does not occur suddenly; rather, it occurs over some range of velocity where the flow fluctuates between laminar and turbulent flows before it becomes fully turbulent. Laminar flow is encountered when highly viscous fluids such as oils flow in small diameter tubes or narrow passages.

$$R_e=\frac{\rho u_m D}{\mu}=\frac{u_m D}{\vartheta}$$

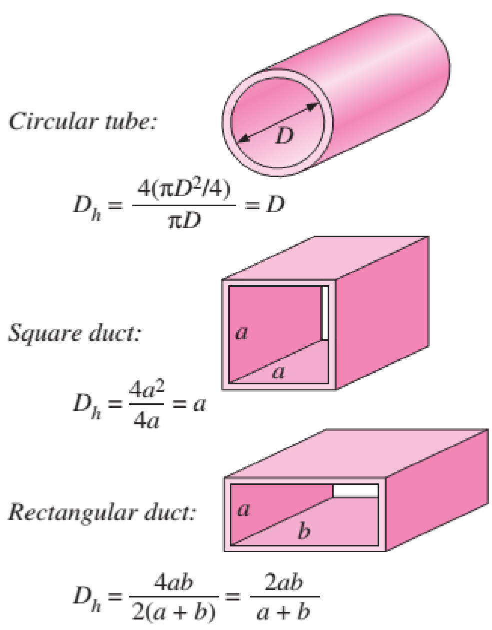
where (u_m) is the mean fluid velocity(m/s)
(D) is the diameter of the tube (m)
And(ϑ)is the kinematic viscosity of the fluid (m^2/s)
For flow through noncircular tubes, the Reynolds number as well as the Nusselt number and the friction factor are based on the hydraulic diameter Dh defined as

$$D_h=\frac{4A_c}{P}$$

In which
A_c: Tube Cross Sectional Area

P: “wetted,” perimeter

Circular tubes: $D_h=\frac{4A_c}{P}=\frac{4\frac{\pi D^2}{4}}{\pi D}=D$



For square tube (Dh=a) ,and for rectangle duct (Dh=4ab/2(a+b))

Under most practical conditions, the flow in a tube is laminar for Re< 2300, turbulent for Re> 10,000, and transitional in between. That is,
(Re< 2300 laminar flow) (2300 ≤Re ≤10,000 transitional flow)
(Re >10,000 turbulent flow)