SIGNIFICANCE OF REYNOLDS NUMBER IN PIPE FLOW

Reynolds number is the ratio of inertia force to viscous force. The inertia force is proportional
to the mass flow and velocity *i.e.*, ($\rho u.u$). The viscous force is proportional to $\mu(du/dy)$ or $\mu\, u/D$,
dividing

inertia force/viscous force = $\rho u.uD/\ \mu.u$

Viscous force tends to keep the layers moving smoothly one over the other. Inertia forces tend to move the particles away from the layer. When viscous force are sufficiently high so that any disturbance is smoothed down, laminar flow prevails in pipes. When velocity increases, inertia forces increase and particles are pushed upwards out of the smoother path. As long as Reynolds number is below 2,300, laminar flow prevails in pipes. The friction factor in flow is also found to be a function of Reynolds number (in laminar flow, f = 64/Re).

EXAMPLE 6.1

The accepted transition Reynolds number for flow in a circular pipe is $Re_{d,crit}$ _ 2300. For flow
through a 5-cm-diameter pipe, at what velocity will this occur at 20°C for (*a*) airflow(μ=1.80 E-5 kg/(m _ s)),ρ=(1.205 kg/m3) and (*b*) water flow μ =0.001 kg/(m _ s) ρ=(998 kg/m3) ?

Solution

Almost all pipe-flow formulas are based on the *average* velocity *V* _ *Q*/*A*, not centerline or any other point velocity. Thus transition is specified at _*Vd*/_ _ 2300. With *d* known, we introduce the appropriate fluid properties at 20°C from Tables A.3 and A.4:

(*a*) Air: _ _2300 or *V* _ 0.7

(*b*) Water: _ _2300 or *V* _ 0.046

These are very low velocities, so most engineering air and water pipe flows are turbulent, not laminar. We might expect laminar duct flow with more viscous fluids such as lubricating oils or glycerin.

m_s

(998 kg/m3)*V*(0.05 m)

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0.001 kg/(m _ s)

_*Vd*

__

m_s

(1.205 kg/m3)*V*(0.05 m)

___

1.80 E-5 kg/(m _ s)

_*Vd*

__

Zone of flow establishment reservoir

$x/D=0.07\ Re$ **Laminar flow**

$x/D=0.7\ Re^{1/4}$ **Turbulent flow**

Ex/ Estimate length of establishment flow of fluid at 20c in fig 6 , velocity 0,3m/s with 5cm diameter ?if fluid:

1-water

2-crude oil $\rho=856\ kg/m^3$

3-water and partly of boundary layer is laminar

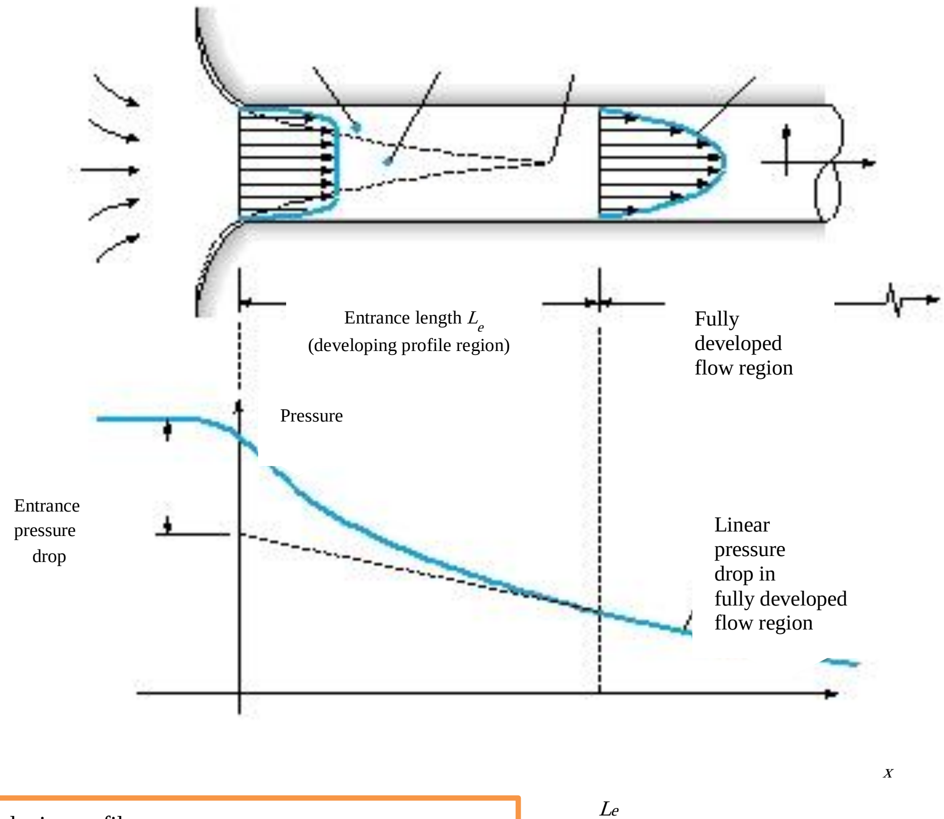

Fig. 6 Developing velocity profiles and pressure changes in the entrance of a duct flow.