TOPIC

Fluids – Section X – Question 10

QUESTION

It is desired to transport 1 kg/s of a viscous liquid (μ = 0.01 kg/m s, ρ= 950 kg/m^3) from one location to another through a round pipe. To not mechanically degrade the fluid, it is desirable to maintain the flow as laminar. In order not to exceed a Reynolds number of 2000, the minimum pipe diameter (m) is most nearly

(A) 0.020
(B) 0.064
(C) 0.24
(D) 2.2

HINTS

- Use the definition of the Reynolds number
- Relate the velocity to the volumetric flow rate and pipe diameter
- Relate the volumetric flow rate to the mass flow rate

SOLUTION

The Reynolds number is defined by:

$$Re = \frac{\rho v D}{\mu}$$

The velocity v is related to the volumetric flow rate Q and the pipe diameter D by:

$$v = \frac{Q}{A}$$
$$= \frac{Q}{\pi D^2/4}$$

Substituting for v in the expression for Re

$$Re = \frac{\rho Q}{(\pi D/4)\mu}$$

The mass flow rate m is related to the volumetric flow rate Q by

$$m = \rho Q$$

So

$$Re = \frac{m}{(\pi D/4)\mu}$$

Solving for diameter$D$

$$D = \frac{m}{(\pi/4)\mu Re}$$

$$= \frac{(1\text{kg/s})}{(\pi/4)(0.01\text{kg/m}\cdot s)(2000)}$$
$$= 0.064m$$

ANSWER
(B)

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