Answer on Question #77247, Physics / Other

A liquid of density 1.8 g/cm^3 flows through into a pipe with an input velocity of 3m/s. the input radius of the pipe is 5m.

Calculate :

(a)the volume of liquid flowing into the pipe and out of the pipe per second,

(b) the mass of liquid flowing into and out of the pipe per second,

(c) the output radius of the pipe if the desired output speed is 6m/s.

Solution:

Given:

$\rho = 1.8\ g/cm^3 = 1800\ kg/m^3$,

$v_i = 3\ m/s$,

$R_i = 5\ m$,

$v_o = 6\ m/s$,

(a)

Since volume flow rate measures the amount of volume that passes through an area per time, the equation for the volume flow rate looks like this:

$$Q = \frac{V}{t} = \frac{Volume}{time}$$

The volume of a portion of the fluid in a pipe can be written as

$$V = Ad$$

where A is the cross sectional area of the fluid and d is the width of that portion of fluid.

So,

$$Q = \frac{V}{t} = \frac{Ad}{t} = Av$$

where *v* is the speed of the fluid.

$$A = \pi R_i^2$$

So,

$$Q = \pi R_i^2 v = \pi \times (5\ m)^2 \times (3\ m/s) = 235.6\ m^3/s$$

(b) The mass rate is

$$\dot{m} = \rho Q = (1800\ kg/m^3) \times (235.6\ m^3/s) = 424115\ kg/s$$

(c) The equation of continuity for incompressible fluids says that the value of Av has a constant value throughout the pipe

$$A_i v_i = A_o v_o$$

So,

$$A_o = A_i \frac{v_i}{v_o}$$

$$R_o^2 = R_i^2 \frac{v_i}{v_o}$$

$$R_o = R_i \sqrt{\frac{v_i}{v_o}} = 5 \times \sqrt{\frac{3}{6}} = 3.54\, m$$

Answer: (a) $Q = 235.6\, m^3/s$; (b) $\dot{m} = 424115\, kg/s$; (c) $R_o = 3.54\, m$.