5.26 Air at standard conditions enters the compressor shown in Fig. P5.26 at a rate of 10 ft³/s. It leaves the tank through a 1.2-in.-diameter pipe with a density of 0.0035 slugs/ft³ and a uniform speed of 700 ft/s. **(a)** Determine the rate (slugs/s) at which the mass of air in the tank is increasing or decreasing. **(b)** Determine the average time rate of change of air density within the tank.
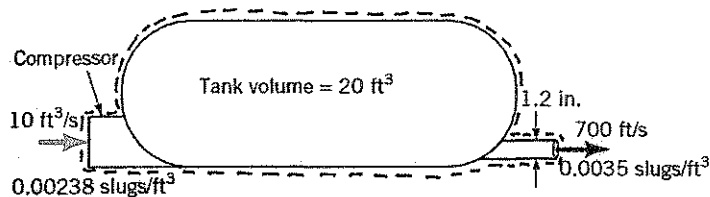

Compressor

Tank volume = 20 ft³

1.2 in.

10 ft³/s

700 ft/s

0.00238 slugs/ft³

0.0035 slugs/ft³

■ FIGURE P5.26

use the control volume within the broken lines.

(a) From the conservation of mass principle we get

$$\frac{D M_{sys}}{Dt} = \dot{m}_{in} - \dot{m}_{out} = \rho_{in} Q_{in} - \rho_{out} A_{out} V_{out}$$

$$\frac{D M_{sys}}{Dt} = \left(0.00238 \frac{slug}{ft^3}\right)\left(10 \frac{ft^3}{s}\right) - \left(0.0035 \frac{slug}{ft^3}\right) \frac{\pi (1.2 \, in.)^2}{\left(144 \frac{in^2}{ft^2}\right)}\left(700 \frac{ft}{s}\right)$$

$$\frac{D M_{sys}}{Dt} = 0.00456 \frac{slug}{s} \quad increasing$$

(b) $$\frac{D M_{sys}}{Dt} = \frac{D(\rho V_{sys})}{Dt} = V_{sys} \frac{D\rho}{Dt} = 0.00456 \frac{slug}{s}$$

so

$$\frac{D\rho}{Dt} = \frac{0.00456 \frac{slug}{s}}{V_{sys}} = \frac{0.00456 \frac{slug}{s}}{20 \, ft^3} = 2.28 \times 10^{-4} \frac{slug}{ft^3 \, s}$$

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