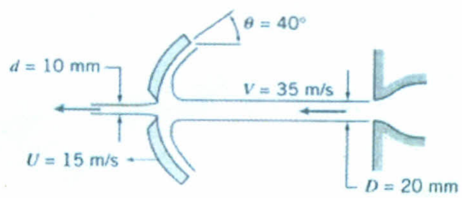
The circular dish in the adjoining figure has an outside diameter of 0.2 m. A water jet with speed of 35 m/s strikes the dish concentrically. The dish moves to the left at 15 m/s. The jet diameter is 20 mm. The dish has a hole at its centre that allows a stream of water, 10 mm in diameter to pass through without resistance. The remainder of the jet is deflected and flows along the dish. Calculate the force required to maintain the dish motion.



Steady flow, horizontal uniform flow, no change in jet speed, incompressible flow.

$$(V-U)\left(-\frac{\pi D^2}{4}+\frac{\pi d^2}{4}+A_{side}\right)=0 . \quad \text{Cont. eq}^n$$

$$A_s = \frac{\pi}{4}(D^2-d^2) = \frac{\pi}{4}\left[(0.02)^2-(0.01)^2\right] m^2 = 2.36\times10^{-4}\, m^2$$

From momentum equation,

$$R_x = u_1\left\{-\rho(V-U)\frac{\pi D^2}{4}\right\} + u_2\left\{+\rho(V-U)\frac{\pi d^2}{4}\right\} + u_3\left\{+\rho(V-U)A_s\right\}$$

$$u_1 = V-U, \quad u_2 = V-U, \quad u_3 = -(V-U)\cos 40^\circ$$

$$R_x = -\rho(V-U)^2\frac{\pi D^2}{4} + \rho(V-U)^2\frac{\pi d^2}{4} - \rho(V-U)^2\frac{\pi}{4}(D^2-d^2)\cos 40$$

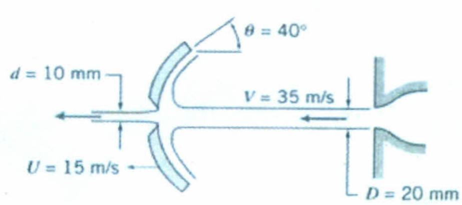
$$= -\rho(V-U)^2\frac{\pi}{4}(D^2-d^2)(1+\cos 40)$$

$$= -10^3\, kg/m^3\,(30-10)^2\,\frac{m^2}{s^2}\times 2.36\times10^{-4}\, m^2\,(1+\cos 40)$$

$$R_x = -167\, N$$

∴ The force must be applied to the right

The circular dish in the adjoining figure has an outside diameter of 0.2 m. A water jet with speed of 35 m/s strikes the dish concentrically. The dish moves to the left at 15 m/s. The jet diameter is 20 mm. The dish has a hole at its centre that allows a stream of water, 10 mm in diameter to pass through without resistance. The remainder of the jet is deflected and flows along the dish. Calculate the force required to maintain the dish motion.



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Steady flow, horizontal uniform flow, no change in jet speed, incompressible flow.

$$(V-U)\left(-\frac{\pi D^2}{4}+\frac{\pi d^2}{4}+A_{side}\right)=0. \quad \text{Cont. eq}^n$$

$$A_s=\frac{\pi}{4}\left(D^2-d^2\right)=\frac{\pi}{4}\left[(0.02)^2-(0.01)^2\right]m^2=2.36\times10^{-4}\,m^2$$

From momentum equation,

$$R_x=u_1\left\{-\rho(V-u)\frac{\pi D^2}{4}\right\}+u_2\left\{+\rho(V-U)\frac{\pi d^2}{4}\right\}+u_3\left\{+\rho(V-u)A_s\right\}$$

$$u_1=V-U, \qquad u_2=V-U, \quad u_3=-(V-U)\cos40^{\circ}$$

$$R_x=-\rho(V-U)^2\frac{\pi D^2}{4}+\rho(V-u)^2\frac{\pi d^2}{4}-\rho(V-u)^2\frac{\pi}{4}\left(D^2-d^2\right)\cos40$$

$$=-\rho(V-U)^2\frac{\pi}{4}\left(D^2-d^2\right)(1+\cos40)$$

$$=-10^3\,kg/m^3\,(30-10)^2\,\frac{m^2}{s^2}\times2.36\times10^{-4}\,m^2(1+\cos40)$$

$$R_x=-167\,N$$

∴ The force must be applied to the right