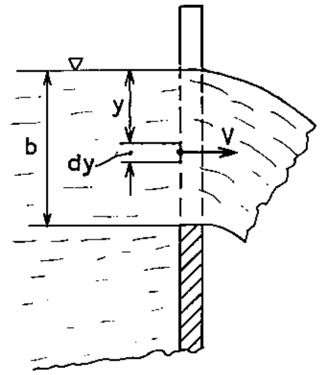

Figure 1.26 Overflow in notch

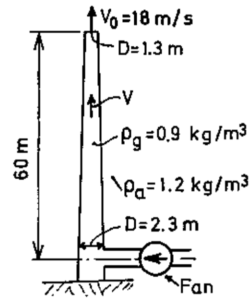

Figure 1.27 A conical stack

With 24 notches, the rate of flow per notch is

$$0.35/(3600)(24) = 0.00406b^{3/2},$$

$$b = 0.01 \text{ m} \quad \text{or} \quad 10 \text{ mm}.$$

EXAMPLE 1.6. PRESSURE DROP IN A STACK

To reduce pollution at ground level, 86,000 m^3/h hot flue gases are to be exhausted 60 m above the ground at a velocity V_0 = 18 m/s, through a conical stack with inner diameter 2.3 m at ground level and diameter 1.3 m at the top (Figure 1.27). Density of flue gas, ρ_g, is 0.9 kg/m^3 and density of ambient air, ρ_a, is 1.2 kg/m^3. The pressure drop due to friction is assumed to be one velocity head per length $L_e = 50D$.

(*a*) Calculate the exit loss in mm water gauge.

(*b*) Calculate the friction loss in the stack in mm water gauge.

(*c*) Calculate the total head (static head and velocity head) after the fan. The pressure drop from the fan to the bottom of the stack is estimated to be 6 mm water gauge.

Solution

(*a*) The exit loss is $\rho \dfrac{V^2}{2} = 0.9 \dfrac{18^2}{2}$

$$= 146 \text{ N/m}^2$$

or

$$146/g = 146/9.82 = 15 \text{ mm water gauge.}$$

(*b*) The velocity, $V = V_0\left(\dfrac{D_0}{D}\right)^2 = 18\left(\dfrac{1.3}{D}\right)^2 = \dfrac{30.4}{D^2}$ m/s.

The stack diameter,

$$D = 2.3 - (2.3 - 1.3)L/60,$$

$$L = 138 - 60D.$$

These values are inserted in equation (1.12),

$$\Delta p_f = \frac{138 - 60D}{50D} 0.9 \frac{30.4^2}{2D^4} = 1148D^{-5} - 499D^{-4}$$

$$\frac{d\Delta p_f}{dD} = (-5)(1148)D^{-6} - (-4)(499)D^{-5}$$

$$\Delta p_f = -5740 \int_{2.3}^{1.3} D^{-6}\, dD + 1996 \int_{2.3}^{1.3} D^{-5}\, dD = 134 \text{ N/m}^2$$

134/9.82 = 14 mm water gauge.

(*c*)	Total loss, 15 + 14 + 6 =	35 mm water gauge
	Natural draft, $60(1.2 - 0.9)g/g$ =	18 mm water gauge
	Total head of the fan	27 mm water gauge.

EXAMPLE 1.7. PRESSURE DROP IN A GRANULAR BED (CATALYST)

Calculate the pressure drop in a 0.5 m thick catalyst bed consisting of cylinders, 6 mm diameter and 8 mm long. A sample of the catalyst gives a void fraction $\epsilon = 0.32$ and gas velocity referred to the total cross section, $V_0 = 0.8$ m/s. The gas density is assumed to be a constant, $\rho = 0.49$ kg/m^3, and the gas viscosity, $\mu = 0.034$ cP.

Solution

Calculate the shape factor Φ_s [equation (1.19)]. A sphere with the same volume has the diameter D_p,

$$\frac{1}{6}\pi D_p^3 = \frac{\pi}{4}(0.6)^2(0.8),$$

$$D_p = 0.756 \text{ cm}.$$

Shape factor,

$$\Phi_s = \frac{\pi 0.756^2}{2\left(\frac{\pi}{4}0.6^2\right) + \pi(0.6)(0.8)} = 0.870.$$

Artificial Reynolds number according to equation (1.20),

$$\mathrm{Re_e} = \frac{(0.49)(0.8)(0.00756)}{(0.034)(10^{-3})} = 87$$

which gives (Figure 1.15) an exponent $n = 1.28$ and friction factor f_m = 2.0–3 0. These values inserted in equation (1.18) give

$$\Delta p_f = \frac{2f_m(0.49)(0.8^2)(0.5)(1 - 0.32)^{1.28}}{(0.00756)(0.870^{1.28})(0.32^3)} = 923 f_m \text{ N/m}^2.$$