

Example 11.1.

The following data were obtained in a constant-pressure filtration unit for filtration of a yeast suspension.

t (min)	4	20	48	76	120
V (l filtrate)	115	365	680	850	1130

Characteristics of the filter are as follows:

$$A = 0.28 \text{ m}^2, \quad C = 1920 \text{ kg/m}^3, \quad \mu = 2.9 \times 10^{-3} \text{ kg/m-s}, \quad \alpha = 4 \text{ m/kg}$$

- Determine the pressure drop across the filter.
- Determine the filter medium resistance (r_m).
- Determine the size of filter for the same pressure drop to process 4000 l of cell suspension in 20 min.

Solution

a. V (l)	115	365	680	850	1130
t/V (min/l)	0.035	0.055	0.07	0.089	0.106

A plot of t/V versus V results in a straight line with a slope of 0.67×10^{-4} (min/l²) and an intercept of 0.028 (min/l).

$$\text{slope} = \frac{1}{K} = 0.67 \times 10^{-4}, \quad K = 1.5 \times 10^4 \text{ l}^2/\text{min}$$

$$\Delta p = \frac{K\alpha C\mu}{2A^2 g_c}, \quad g_c = 9.8 \frac{kg_m}{kg_f \cdot s^2}$$

$$\Delta p = 2.3 \times 10^{-4} \text{ N/m}^2$$

$$\text{b. } y \text{ intercept} = \frac{2V_0}{K} = 0.028$$

$$V_0 = 2101$$

$$r_m = \frac{\alpha V_0 C}{A} = 5760 \text{ m}^{-1}$$

- c. $V^2 + 2VV_0 = Kt$, where $K = (2A^2/\alpha C\mu)\Delta pg_c$ and $V_0 = (r_m A/\alpha C)$. By substituting numerical values for V , Δp , and t , we obtain

$$A^2 - 25A - 66.67 = 0$$

The solution to the quadratic equation yields

$$A = 27.43 \text{ m}^2$$

11.2.2. Centrifugation

Centrifugation is used to separate particles of size between 100 and 0.1 μm from liquid by centrifugal forces. The theory of solid–liquid separations in a gravitational field should be clearly understood before centrifugal and gravity separations such as sedimentation are covered. Particle settling in a high-particle-density suspension is known as *hindered settling*, which resembles solid–liquid separations in a centrifugal field.