flocculants. If the product is biomass, then separation of solids is the major step in product recovery, which results in a significant volume reduction. If the product is a soluble compound, solids need to be separated from liquid before the liquid is further treated to recover and purify the soluble product. For the recovery of intracellular products, the cells need to be disrupted and other cellular products need to be separated from the desired product. The major methods used for the separation of cellular material (biomass) are (1) filtration (both rotary vacuum filtration and micro- or ultrafiltration), (2) centrifugation, and (3) coagulation and flocculation.

11.2.1. Filtration

Filtration is probably the most cost-effective method for the separation of large solid particles and cells from fermentation broth. Fermentation broth is passed through a filter medium, and a filter cake is formed as a result of deposition of solids on the filter surface. Continuous rotary filters or *rotary vacuum precoat filters* are the most widely used types in the fermentation industry. The drum is covered with a layer of precoat, usually of diatomaceous earth, prior to filtration. A small amount of coagulating agent or filter aid is added to the broth before it is pumped into the filter. As the drum rotates under vacuum, a thin layer of cells adhere to the drum. The thickness of the cell layer increases in the section designed for forming the cake. The layer of solids is washed and dewatered during its passage to the discharge point, where a knife blade cuts off the cake. A vacuum maintained in the drum provides the driving force for liquid and air flow. A schematic diagram of a continuous rotary vacuum filter is shown in Fig. 11.3.

Filtration is commonly used for separating mycelium from fermentation broth in antibiotic fermentations. It is also commonly used in waste-water treatment facilities.

The rate of filtration (the flow of filtrate) for a constant-pressure (vacuum) filtration operation is determined primarily by the resistance of the cake and filter medium:

$$\frac{dV}{dt} = \frac{g_c \Delta p A}{(r_m + r_c)\mu} \tag{11.1}$$

where V is the volume of filtrate, A is the surface area of the filter, Δp is the pressure drop through the cake and filter medium, μ is the viscosity of the filtrate, r_m is the resistance of

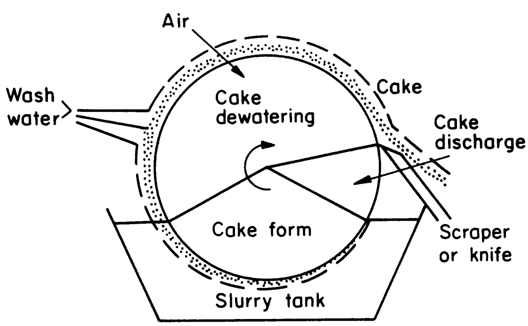

Figure 11.3. Schematic of a continuous rotary vacuum filter. A vacuum (subatmospheric pressure) is maintained within the drum, causing the pressure-driven flow of liquid (during cake formation) and air (during dewatering).