9.3. MODIFYING BATCH AND CONTINUOUS REACTORS

9.3.1. Chemostat with Recycle

Microbial conversions are autocatalytic, and the rate of conversion increases with cell concentration. To keep the cell concentration higher than the normal steady-state level in a chemostat, cells in the effluent can be recycled back to the reactor. Cell recycle increases the rate of conversion (or productivity) and also increases the stability of some systems (e.g., waste-water treatment) by minimizing the effects of process perturbation. Cells in the effluent stream are either centrifuged, filtered, or settled in a conical tank for recycling.

Consider the chemostat system with cell recycle as depicted in Fig. 9.1. A material balance on cell (biomass) concentration around the fermenter yields the following equation:

$$FX_0 + \alpha FCX_1 - (1+\alpha)FX_1 + V\mu_{\text{net}}X_1 = V\frac{dX_1}{dt} \tag{9.8}$$

where α is the recycle ratio based on volumetric flow rates, C is the concentration factor or ratio of cell concentration in the cell recycle stream to the cell concentration in the reactor effluent, F is nutrient flow rate, V is culture volume, X_0 and X_1 are cell concentrations in feed and recycle streams, and X_2 is cell concentration in effluent from the cell separator.

At steady state, and if $dX_1/dt = 0$ and $X_0 = 0$ (that is, sterile feed); then eq. 9.8 becomes

$$\mu_{\text{net}} = (1+\alpha-\alpha C)D = [1+\alpha(1-C)]D \tag{9.9}$$

Since $C > 1$ and $\alpha(1 - C) < 0$, then $\mu_{\text{net}} < D$. That is, *a chemostat can be operated at dilution rates higher than the specific growth rate when cell recycle is used.*

A material balance for growth-limiting substrate around the fermenter yields

$$FS_0 + \alpha FS - V\frac{\mu_g X_1}{Y^M_{X/S}} - (1+\alpha)FS = V\frac{dS}{dt} \tag{9.10}$$

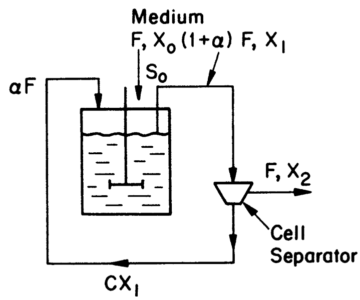

Figure 9.1. Chemostat with cell recycle. The cell separator could be a sedimentation tank, a centrifuge, or a microfiltration device.