fluid mixing, obviously decrease the rate of heat transfer. Many fermentations will cause solids deposition on coils, greatly decreasing the heat transfer coefficient. In extreme cases, solids deposition can plug spaces between coils, greatly decreasing convective flow by coils and consequently the heat transfer coefficient. Cooling coils are usually placed so that high fluid velocities will strike the coils to promote cleaning. If a reactor is to be maintained as a highly flexible piece of equipment adaptable to a wide range of fermentations, very conservative estimates of the overall heat transfer coefficient must be made.

Example 10.1.

Use the data in Fig 10.5 to estimate k_La from the dynamic method. Also, if the cell dry weight has been measured as 2 g/l, evaluate the specific respiration rate of the culture.

Solution When the aerator is off, we can use the declining part of the curve in Fig 10.5 to estimate OUR. For the straight-line part of the curve (0.5 to 3 min after the aerator is off) we estimate OUR as

$$-dC_L/dt = \text{OUR} = -\frac{2.5 - 0.5 \text{ mg/l}}{0.5 - 3 \text{ min}}$$

$$= 0.8 \text{ mg DO/l-min}$$

To estimate k_La we use the ascending curve formed during reaeration or

$$k_La = \frac{dC_L/dt + \text{OUR}}{C^* - C_L}$$

The best method to estimate k_La is to plot dC_L/dt + OUR versus $(C^* - C_L)^{-1}$, but you can just make use of single points at individual times. In this problem $k_La = 0.16 \text{ min}^{-1}$.

The specific respiration rate is estimated as

$$\text{OUR} = q_{O_2} X$$

or

$$q_{O_2} = \text{OUR}/X$$

$$q_{O_2} = \frac{0.8 \text{ mg DO/l-min}}{2 \text{ g cells/l}}$$

$$q_{O_2} = 0.4 \text{ mg DO/g cells-min}$$

10.2.4. Scale-up

The discussion in the previous sections should have alerted the reader to the complex nature of industrial fermenters. Now we consider how these complexities affect approaches to scaling fermenters.

Generally, fermenters maintain a height-to-diameter ratio of 2 to 1 or 3 to 1. If the height-to-diameter ratio remains constant, then the surface-to-volume ratio decreases dramatically during scale-up. This change decreases the relative contribution of surface aeration to oxygen supply and dissolved-carbon-dioxide removal in comparison to the contribution from sparging. For traditional bacterial fermentations, surface aeration is unimportant, but for shear-sensitive cultures (e.g., animal cells) it can be critical because of restrictions on stirring and sparging.