Variation in $k_a$ Values for Various Curved Blade Impeller Designs in Bioreactor

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Abstract

Standard six curved blade impeller (6SCB) is widely used to retrofit Rushton Turbine (6RT) in bioreactors due to its power stability in gassed conditions. The power stability offers better volumetric mass transfer coefficient per unit power for 6SCB compared to 6RT. However, most of the previous work on curved blades only focused on standard six semi-circle blades with central blade measuring 3/4 of the impeller diameter. Absence in the literature are information with regard to the effect of number of blades (four, eight and twelve), size of central disc (without disc and 1/3 and 1/4 of the impeller diameter), length and shape (semi-circle, 140° and 160°) on mass transfer performances. In this work, effect of all these variation on gas-liquid volumetric mass transfer, $k_a$ were investigated for power input, superficial gas velocity, $v_g$ and solid concentration that are typically employed in small laboratory size bioreactors (< 0.1 m³). A stirred tank of 40 cm diameter with power input of 0.5 kW/m³, $v_g$ of 4.0 mm/s (compressed air) and solid (inert ballotini particles) concentration of 10% was selected for this purpose. The volumetric mass transfer was measured using dissolved oxygen (DO) probe. The results proved that impeller with six semi-circular curved blades with the central disc size of 3/4 of impeller diameter is the most optimum impeller with regard to $k_a$ values at typical condition in a bioreactor.

1 Introduction

Aerobic fermentation processes in stirred tank bioreactors requires efficient mixing procedures to perform the tasks of dispersing gas in liquid for oxygen dissolution and suspending cells in the medium for optimum nutrient utilization. This is usually achieved by the use of an impeller in the bioreactors to maintain reasonably high power input as the mass transfer coefficient, $k_a$ is directly proportional to the impeller power input. Generally, the optimum impeller is considered as one that would achieve the dispersion and suspension functions with minimal power demand. For constant rate operations, Rushton Turbine is widely used for many chemical and biological reactors. It is also the most studied impeller and therefore design work involving Rushton Turbine is relatively simpler.

For dynamic systems where the gas flow rates varies, Rushton Turbine poses weakness by causing reduction in power input due to formation of cavities behind the blades. When reduction in power intake occurs, the dispersion of gas and suspension of solid phases is also affected, thus lowering mass transfer capabilities of the system. Many type of impellers are being introduced to improve gas dispersion characteristics which may improve mass transfer coefficient. One of the attempt is to modify 6RT itself to improve the power reduction under gassed conditions. This was done by modifying the flat blades into semi-circle blades. The new design is called curved blade impeller. Since its introduction, the curved blade impeller was studied by number of researchers with most of them concluding favorably compared to Rushton Turbine for its superior mass transfer capability. It

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