The effect of off-wall clearance of a side-entry impeller on mixing of pulp suspension in a cylindrical stock chest.

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Abstract

Axial flow impellers having hydrofoil blade design are commonly used for agitation of pulp suspensions in stock chests employed in Pulp and Paper Industry. A pulp fibre suspension is a non-Newtonian fluid exhibiting a yield stress. In mixing operations, a 'cavern' (region of active motion and mixing) is created around the impeller, with the size of the cavern affecting the quality of mixing attained. For side-entry mixers, the cavern size is also a function of impeller clearance (E) from the rear-wall which is characterized by E/D where D is impeller diameter. The cavern size in batch operation was measured in C_m = 2, 3 and 4% (mass concentration or consistency) hardwood pulp suspensions using electrical resistance tomography (ERT). For continuous operation at Q = 7 L/min, dynamic mixing (tracer-response) tests were carried out to identify the mixing model and hence the well-mixed volume. Both batch and continuous operation at impeller speed, N = 550 rpm, gave comparable cavern size. The cavern size was seen to increase with an increase in E/D until it leveled off above E/D = 0.55 for the agitation of C_m = 3% hardwood pulp suspension. At E/D = 0.14, throttling of the impeller-induced flow occurred due to limitation on the available area for impeller suction, considerably reducing the cavern size. The pumping capacity of an axial flow impeller is significantly smaller in non-Newtonian fluids and further performance degradation occurred at lower E/D for all suspension consistencies. CFD simulations for steady state operation using Multiple Reference Frame approach under-predicted the cavern size, but correctly captured the trend in cavern size variation with E/D. When impeller throttling was absent, the measured cavern volumes compared well with the predictions of an axial force model that accounted for interaction between the cavern and the vessel walls.