Seminar

Institute for Plasma Research

Title : CFD Based Analysis of Flow Phenomena in Disc and Doughnut Pulsed Column and Stirred Tank Photobioreactor

Speaker: Dr. Raj Kumar Saini
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Date : 12th February 2019 (Tuesday)

Time : 03.30 PM

Venue : Committee Room 3, (New Building), IPR

Abstract :

Fluid flow patterns play crucial role in deciding the performance of many process equipments, such as solvent extraction units and stirred tank reactors. In case of solvent extraction columns, the mass transfer efficiency depends largely on the interfacial area, so the dispersion of aqueous and organic phases is important. The performance of stirred tank reactors also depends on the extent of mixing of the reactants in the reactor. In both cases, understanding of the fluid flow coupled with either heat or mass transfer or both is important from the design perspective. In recent years, computational fluid dynamics (CFD) techniques have emerged as powerful tools for analysis and design of process equipments.

The objective of the present work is to investigate the pulsatile flow of single and two immiscible liquids in a disc and doughnut pulsed column using CFD techniques. Numerical simulations are performed to study the effect of the operating conditions such as frequency and amplitude of the pulsation on deformation, coalescence and breakage of the droplets and hold-up distribution of the dispersed phase. In the present simulations, the dynamic contact angle model is implemented. The effect of turbulence on the continuous phase is captured using low Reynolds number k-ε model. Based on the turbulent kinetic energy distribution, the drop size is to be estimated for single phase flow. The estimated droplet size is used in the simulations of two immiscible fluids in a pulsed column using continuum approach, where both the phases are considered to be interpenetrating continua. Sensitivity analysis is carried out to study the effect of drop size on hold-up distribution of dispersed phase. Average stage wise hold up is found to be significantly dependent on the droplet size of the dispersed phase.

Numerical simulations are performed to investigate the hydrodynamic parameters such as frequency of cross-over of the cell particles and the impeller speed on the growth of microalgae and cyanobacteria in stirred tank photobioreactor (STR). STR is divided into the light and dark zones based on the light intensity profiles within the photobioreactor. The light intensity distribution is obtained from the CFD simulations for different concentration of the microorganisms in the photobioreactor. The average light intensity is determined in the reactor for different cell concentrations in the culture. Individual cell particles (microalgae) are tracked. The fractional time spent by the cell particle in the light zone and the average cross over frequency is determined between the zones. The photosynthetic rate is determined using the average light intensity in the reactor for different initial cell concentrations. The critical impeller speed is compared against the experimental observation reported in the literature for the maximum cell growth.

Keywords - Solvent extraction, pulsatile flow, CFD, surface tension, microorganism, light intensity.