World Academy of Science, Engineering and Technology
International Journal of Mathematical and Computational Sciences
Vol:14, No:12, 2020

Investigation of Turbulent Flow in a Bubble Column Photobioreactor and Consequent Effects on Microalgae Cultivation Using Computational Fluid Dynamic Simulation

Authors : Geetanjali Yadav, Arpit Mishra, Parthsarathi Ghosh, Ramkrishna Sen

Abstract : The world is facing problems of increasing global CO2 emissions, climate change and fuel crisis. Therefore, several renewable and sustainable energy alternatives should be investigated to replace non-renewable fuels in future. Algae presents itself a versatile feedstock for the production of variety of fuels (biodiesel, bioethanol, bio-hydrogen etc.) and high value compounds for food, fodder, cosmetics and pharmaceuticals. Microalgae are simple microorganisms that require water, light, CO2 and nutrients for growth by the process of photosynthesis and can grow in extreme environments, utilize waste gas (flue gas) and waste waters. Mixing, however, is a crucial parameter within the culture system for the uniform distribution of light, nutrients and gaseous exchange in addition to preventing settling/sedimentation, creation of dark zones etc. The overarching goal of the present study is to improve photobioreactor (PBR) design for enhancing dissolution of CO2 from ambient air (0.039%, v/v), pure CO2 and coal-fired flue gas (10 ± 2%) into microalgal PBRs. Computational fluid dynamics (CFD), a state-of-the-art technique has been used to solve partial differential equations with turbulence closure which represents the dynamics of fluid in a photobioreactor. In this paper, the hydrodynamic performance of the PBR has been characterized and compared with that of the conventional bubble column PBR using CFD. Parameters such as flow rate (Q), mean velocity (u), mean turbulent kinetic energy (TKE) were characterized for each experiment that was tested across different aeration schemes. The results showed that the modified PBR design had superior liquid circulation properties and gas-liquid transfer that resulted in creation of uniform environment inside PBR as compared to conventional bubble column PBR. The CFD technique has shown to be promising to successfully design and paves path for a future research in order to develop PBRs which can be commercially available for scale-up microalgal production.

Keywords : computational fluid dynamics, microalgae, bubble column photbioreactor, flue gas, simulation
Conference Title : ICSRD 2020 : International Conference on Scientific Research and Development
Conference Location : Chicago, United States
Conference Dates : December 12-13, 2020