Ongoing Studies of the Flow in Annular Centrifugal Contactors

Authorship: Kent E. Wardle[11] Chemical Sciences and Engineering Division,
Argonne National Laboratory, Argonne, IL, USA

Abstract

The annular centrifugal contactor is a unique combined mixer/centrifuge device designed for compact liquid-liquid extraction operations as employed in processes for recycling used nuclear fuel. Predictive simulation of mixing and extraction processes in such devices can provide a tool for support of existing contactor installations and lead to improved equipment design for future deployments. Advanced experimental methods are also being used to provide greater insight into multiphase flow phenomena in such contactors as well as data for validation of computational predictions.

Simulation of extraction processes in centrifugal contactors requires advanced models which can account for complex physical phenomena including turbulent free surface flow and liquid-liquid dispersion physics. The use of an open-source CFD framework allows for implementation of advanced models which may not be feasible within the restricted framework of a commercial CFD application. The open-source CFD package OpenFOAM is a promising tool that has simulation capability over a wide range of physical phenomena, shows good parallel performance, is subject to ongoing private development, and has a large and growing user community. This code has been used to simulate the turbulent free-surface flow in the annular centrifugal contactor including simulations of the mixing zone (annular region), the separation zone (rotor interior), as well as coupled mixing/separation zone simulations. These simulations are based on the Volume of Fluid (VOF) methodology along with implicit or explicit Large Eddy Simulation (LES) for turbulence. The results from these simulations compare favorably with previous simulations using a commercial CFD tool and with available experimental data.

A companion experimental effort is also underway to explore multiphase mixing in the annular region of an engineering-scale centrifugal contactor using electrical resistance tomography (ERT) techniques. It is anticipated that this facility will provide valuable insight into flow characteristics specifically related to equipment scale-up and design changes, supporting the on-going experimental studies of larger contactor units at various national laboratories and their deployment at DOE sites such as the units currently being used for cesium extraction from stored liquid waste at the Savannah River Site (Aiken, SC, USA). Moreover, these tools will provide vital experimental data for evaluating and improving computational model predictions.