Understanding Transport Phenomena Concepts in Chemical Engineering with COMSOL Multiphysics®

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Abstract

Transport Phenomena in Chemical Engineering involves three key aspects: Momentum, Heat and Mass Transport. These areas are described by differential equations which are solved for a particular problem using independent or a set of combined equations (e.g., water flowing in a heated pipe). At an undergraduate level class, the advanced mathematics of partial differential equations, tensors and the specific applications of conservations laws for a differential element are challenging concepts to understand. Nonetheless, Transport phenomena represent the basis of Chemical Engineering fundamentals. For example, fluid velocity distribution, temperature distribution, and fluxes (momentum flux, heat flux, and Mass/Molar Fluxes) are core concepts in Chemical Engineering.
Although analytical solutions exist for very simplified problems that are solved in class using mathematics, the students are usually eager to understand the effect of velocity change in more than one dimension and/or with respect to time. In this work, a unique approach is presented to develop an applied Transport Phenomena course that involves simulations using COMSOL Multiphysics ®. The specific models from the applications library used for enhancing students learning are (a) tubular reactor, (b) shell and tube heat exchanger, and (c) flow past a cylinder. Additionally, laminar/turbulent flow in a pipe is explained using a combination of modules, including dilute chemical species transport. As an outcome, it is expected that a combination of analytical solutions and their representation in COMSOL Multiphysics ® can be utilized to enhance students learning. The ultimate goal is to develop a project-based course so that the students can obtain a practical understanding of Transport Phenomena and connect the importance of computational tools in many Chemical Engineering processes.
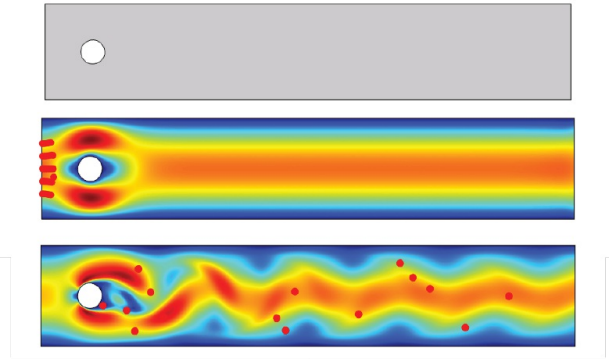
Figures used in the abstract

Figure 1: Fluid flow past a cylinder at different average velocities