Application of COMSOL Multiphysics® Software in Transport Phenomena Educational Processes

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Abstract

Introduction
Use of simulation software for solving realistic engineering problems has grown significantly in recent years due to the availability of less expensive but more powerful computers and development of user-friendly yet robust codes. From an educational perspective, students in STEM disciplines can now solve complex problems in a relatively short period of time, which provides new opportunities for strengthening their knowledge of fundamentals, gaining better insight into the interactions between realistic design geometries, problem parameters, and the role of various multiphysics. One key result is an acceleration of their development as technologists, which allows them to ultimately provide greater business impact and leadership in their chosen career. In chemical engineering, teaching of transport phenomena, which is a subject that provides the underpinning of the discipline, is often restricted to cases where analytical solutions can be developed, such as a single space dimension and time. COMSOL Multiphysics® software provides a powerful platform for enhancing student knowledge by first confirming the analytical solutions based upon simplifying assumptions using numerical solutions, and then extending the problem to multi-dimensions with the addition of one or more multiphysics. Although this approach is gaining momentum among some chemical engineering educators, the experiences are not well known or documented.

Objectives
The primary objective of this paper is to illustrate how COMSOL Multiphysics has been used as an instrument for enhancing teaching the principles of transport phenomena to first year chemical engineering graduate students. Another objective is to summarize the techniques used to incorporate it into the course material.
Results and Discussion
Figure 1 shows the temperature distribution for non-isothermal flow over a cylinder for different values of Reynolds number. Students can readily observe how the temperature distribution is affected by changes in the flow pattern from forced to free convection. In addition, they can alter the approach velocity, temperature of the cylinder and bulk fluid, and cylinder radius.
The dependency of temperature and velocity distributions on numerical values of key dimensionless groups (Reynolds, Grashof and Péclet numbers) can be obtained. Other examples will be described along with the pedagogical impact.

Reference

[1] R. Byron Bird, Warren E. Stewart and Edwin N. Lightfoot (2006). Transport Phenomena. New York: John Wiley & Sons. p356.

Figures used in the abstract

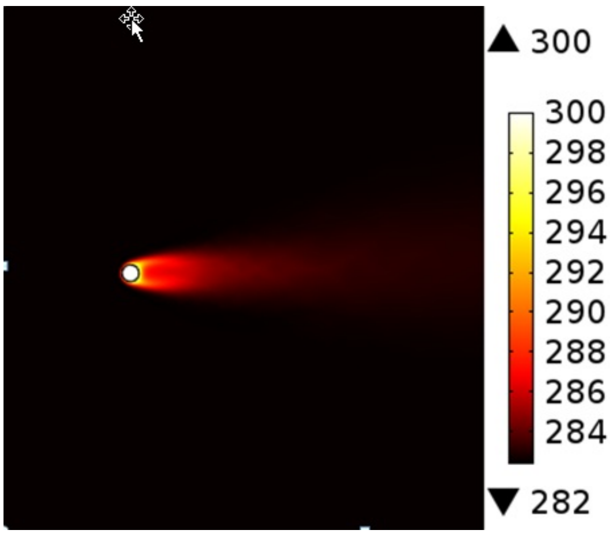

Figure 1: Forced Convection Dominated Flow

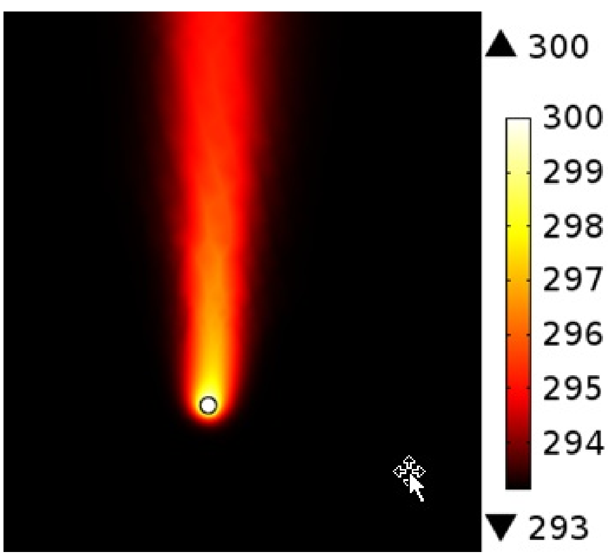

Figure 2: Buoyancy Dominated Flow

Figure 3

Figure 4