Novel Approach for Teaching Microchemical Systems Analysis to Chemical Engineering Students Using Interactive Graphical User Interfaces (GUIs)

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Abstract

Chemicals are an integrated part of our daily life. While chemicals are significant contributor to a nation's economy, sound management of chemical production is essential for environmentally friendly operation without maximizing operational costs. Next generation technologies must be developed that potentially change the chemical plants and process engineering giving rise to safe, compact, flexible, eco-friendly, energy efficient processes and plants. Though these changes are rather obvious in the industry the same is not true for the academia. Hence, there is a need for the students to be exposed to these new emerging technologies.

Microchemical systems are one such key emerging technology with applications ranging from discovery research through commercial processes. To introduce this technology to students the Department of Chemical Engineering at Texas A&M - Kingsville (TAMUK) developed learning module called Interlinked Curriculum Component (ICC) on Microchemical Systems as a part of the Undergraduate curriculum reform funded by NSF in 20081.

The ICC connects the organizing principles of molecular transformations, multi-scale analysis, and a systems approach. This is accomplished by first providing a qualitative overview of specific microprocess systems and then focusing on quantitative aspects of key microprocess components. The module utilizes the latest tools for 2-D and 3-D imaging, animation, and modeling so the concepts and processes being studied are represented in visualized form. The module enables students to work through a series of exercises that start from basic principles and concepts to more complex situations where opportunities exist for both critical thinking and creativity.

COMSOL Multiphysics® software was used as the numerical engine to simulate various microprocess system components involving fluid flow, heat transfer, and species transport, such as micro-scale fluidics and fluid micromixers, micro heat exchangers, and micro reactors. A library of various models was also created so that students can readily explore the effect of various model parameters on the physical system without worrying about numerical solution details. This approach allows them to focus on developing better insight and understanding of the system physics, which helps to reinforce the fundamentals that are taught in required courses on fluid mechanics, heat transfer, and mass transfer.

To provide a more direct connection between the model equations and the calculated results, a Graphical User Interface (GUI) was created using COMSOL Multiphysics with MATLAB®

Guide that provides either a 2-D and 3-D visualization of the model simulations where the effect of various model parameters can be explored.
The primary objective of this study is to use COMSOL Application Builder to create the user interface that allows user to change selected input parameters. The application created will be then compared with the user interfaces developed using COMSOL with MATLAB® Guide to evaluate advantages and limitations of Application builder.
Many microreaction technology (MRT) systems involve fluid transport through small capillary tubes and ducts. The geometry of a 2-D micro conduit is illustrated in Figure 1. Figure 2 shows the graphical user interface developed for the COMSOL model to obtain velocity profile illustrated in Figure 3.

Reference

1. P.L. Mills et al., Development Of A Web Based Self Teaching And Assessment Module For Chemical Engineering Microchemical Systems, American Society for Engineering Education Conference Proceedings (2010).

Figures used in the abstract

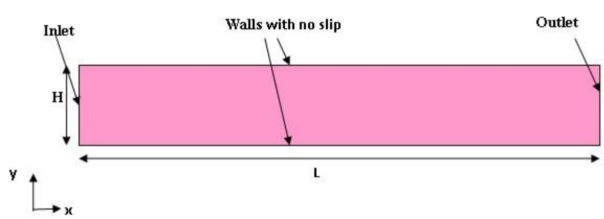

Figure 1: Geometry Model for 2-D Pressure Driven Flow

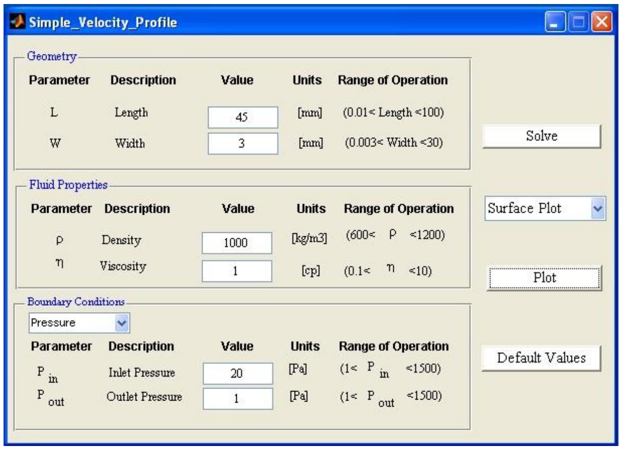

Figure 2: GUI Showing Parameter Entry

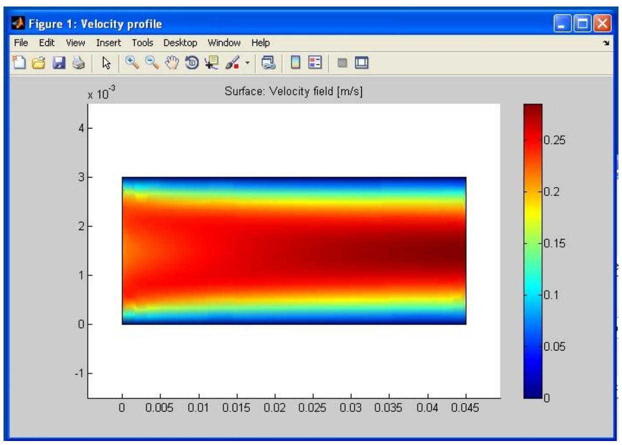

Figure 3: Velocity Profile Surface Plot

Figure 4