Foundational Undergraduate Teaching and Research Tools in Thermoelectrics Using COMSOL Multiphysics®

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Abstract

COMSOL Multiphysics® can play a crucial role in jumpstarting undergraduate research programs in physics and engineering at colleges with limited financial support and small faculty size. The engineering physics program at Ramapo College of NJ has 48 majors and 4 full time faculty with full teaching responsibility, limited research time and financial resources. An attractive experimental and COMSOL Multiphysics® project based on physics topics covered in the curriculum can lead to a rewarding experience for both the students and faculty. One example is the thermoelectric generator. Due to increasing global demand for energy, climate change and a need for sustainable energy solution, thermoelectric generators are considered a very appealing clean option. Despite their relatively low efficiency, recent developments in nanotechnology prove that their response can be improved and therefore a resurgence of research projects are dedicated to increasing their thermopower while reducing the thermal conductivity and increasing the electric conductivity of the electrical contacts. The current project presents a three-component model of a commercial thermoelectric generator with water, heat sink and air-cooling. The electric potential induced by the Seebeck effect was computed for common and novel materials as a function of the temperature of the cold and hot surface temperature and the cooling water. An optimized set of TEG parameters for a practical application is sought. The work presented is the first step in the development of an undergraduate materials science laboratory. It is also used to develop teaching apps for the engineering physics curriculum and to develop COMSOL Multiphysics® modeling skills for faculty and students.

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