Using the COMSOL Multiphysics® Software for Simulation of TEGs for Waste Thermal Energy Harvesting

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Abstract

Navy systems, such as turbine engines, produce large quantities of thermal energy. This energy is a byproduct of the work produced by the engine during operation and is typically rejected to its surroundings. The temperature difference between the turbines and the ocean is substantial enough to be a promising application for waste thermal energy harvesting.

Thermoelectric Generators (TEGs) utilize the Seebeck effect to generate an electric current from temperature differences. TEGs could be used to recover this wasted heat and beneficially used in Navy systems. By capturing this wasted heat and recycling it back into the system, it may be possible to increase efficiency, reduce heat signatures, and negate some cooling requirements.

A commercial-off-the-shelf TEG was placed in an ideal environment to determine its performance parameters: voltage, current, and power output for known temperature differences. The temperature range was selected based on observations of heat profiles near the exhaust of a portable generator. This data was inputted into PSPICE, and different parallel and series TEG array arrangements were modeled to map the trade-space and determine the configuration that provides maximum power.

The COMSOL Multiphysics® software was used to simulate the muffler of the portable generator as a source of heat. A prototype system was modeled and simulated in which nine TEGs where placed on aluminum siding on the muffler, between another aluminum sheet cooled by a water block. The modules used were the Heat Transfer and AC/DC products. The Heat Transfer module was used throughout all simulations. The AC/DC module was used in order to test the TEG capabilities and arrangements. The physical reality of the simulation were verified by comparing output to their individual physical counterparts. While the modeling effort is not complete, it is expected that the COMSOL® software will determine the temperature difference between the TEG sidings and therefore be able to predict the voltage and amperage that each TEG or TEG array produces.

Output and intuition gained from the COMSOL® software modeling effort will inform design, construction, and testing of a tabletop TEG array energy harvesting prototype for employment on the generator exhaust. Prototype performance will be compared to the

COMSOL® software output to check the validity of the model, before using it to design a larger-scale version for actual shipboard deployment and testing.

Figures used in the abstract

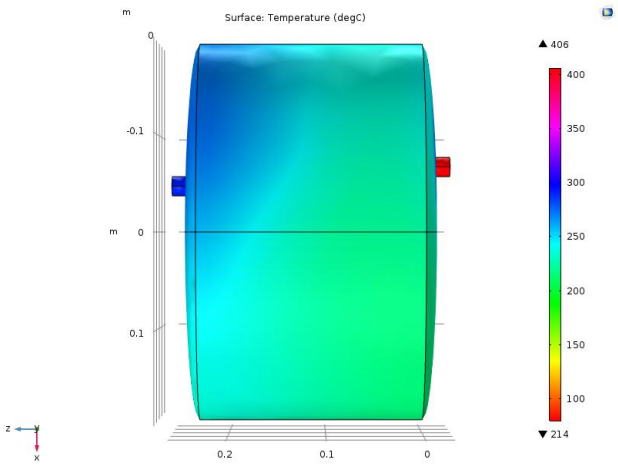

Figure 1: Simulated Muffler Surface Temperature