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Performance Evaluation of Multi-Stage and Single-Stage Thermoelectric Coolers for Cooling Wearables

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Extended Abstract

Commercial off the shelves thermoelectric coolers (TECs) are often optimized for use in low thermally resistive environments such as electronics cooling. However, TECs have gained recent interest in applications in high thermally resistive environments such as cooling wearables due to their adjustable cooling capability, in addition to their lightweight and solid-state properties. This led to scientific and industrial attempts at optimizing single-stage TECs to enhance their performance against human skin. In this contribution, we present the use of multi-stage TECs against human skin for cooling wearables. Through experiment and numerical analysis, we find that counter-intuitively, multi-stage TECs perform better than single stage ones when used in a high thermally resistive environment.

In this presentation, we will discuss and compare the performance of multi-stage TECs to their single-stage counterpart through the use of a 1D analytical model, FEA and an experiment setup. Two performance indicators are used throughout this study, the cold side temperature (Tc) and coefficient of performance (CoP). Tc represents the thermal sensation that the TECs can bring for the wearer, while CoP is an important parameter to ensure the efficiency of the power consumption. Commercial TEC1-12703 was used in the experiments for both single-stage and multi-stage configurations. To conduct the experimental study, the single or multi-stage TEC was strapped onto the lower back of a test subject while the skin, TEC cold side, and heat sink temperatures were monitored. The experimental setup was simulated in ANSYS using FEA and the 1D analytical model was setup in MATLAB. All three results pointed to the fact that the multi-stage TEC was able to obtain a lower cold side temperature (Tc) recorded (14.86 °C vs 20.08 °C) and a higher COP (3.26 vs 0.53).

This presentation will highlight the parameters that highly influence the performance of the TECs, as well as the usefulness and limitations of the numerical and analytical model. This information can be useful for future research in thermoelectric or cooling wearables technology.