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Development of a Portable Thermogenerator for Uncontrolled Heat Sources

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This paper presents the development of a portable thermogenerator designed to work on uncontrolled heat sources. Its thermal behavior regarding both steady-state and transient regimens was analytically described and numerically solved by using a lumped capacity model. The ranges of heating power and power increasing rates have been determined to ensure safe operation, or give users advance warning in case of failure. In addition, this model is a useful tool for designing a controller system based on which a feasible thermogenerator can be developed. Experimental tests performed on a prototype based on a commercial BiTe module have demonstrated this goal.

Key words: Thermoelectricity, electrical generator, thermal modeling, numerical simulation, prototype development, lumped capacity thermal model

INTRODUCTION

Thermoelectric (TE) materials have been known for almost two centuries, although up to now they have not been widely applied for electricity generation except by one company within a single niche market. Global Thermoelectric has sold more than 20,000 generators worldwide for small, isolated applications in the oil and gas industry during the last 40 years,[1] based on a proprietary technology of PbBi TE modules that can withstand up to 600°C. However, these TE modules are not available on the open market, in which only standard Peltier TE modules, operable up to 120°C, have traditionally been the single choice for developers of new applications.[2] However, since this temperature level is too low for most large applications (for example, generators working on firewood stoves for rural homes or generators that work with waste exhaust heat to substitute a car's dynamo), up to now the technology of thermogenerators continues to be largely unknown by the general public.[3]

On the other hand, in recent years TEs have emerged as a feasible option within the portfolio of new sustainable energies,[4–6] due to the irruption of independent manufacturers of BiTe thermogenerator modules such as Tellurex from the USA[7] and Thermonamic from China.[8] Tellurex TEs are priced at 4000 USD/kW, lower than photovoltaic panels, and Thermonamic's are even cheaper at 2500 USD/kW.[2] In addition, during the last 2 years both of these manufacturers have launched new TEs that can withstand up to 320°C. These technological and economic improvements have opened an opportunity window for new niche markets.

This paper presents a new portable generator intended to be used as a small battery charger for recreational use, such as when trekking, mountain climbing, and camping. A prototype was tested, and its thermal transients were analytically modeled and numerically studied including the microcontroller's feedback.

DEVELOPMENT OF PROTOTYPE

The prototype was developed as two separate (hot and cold) units linked by electrical and signal wires as illustrated in Fig. 1. The hot unit (shown on the left side of Fig. 1) comprises a G1-54-0557 Tellurex module mounted between two aluminum blocks with a fan cooler on top. The hot-side block is a plate

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