

Development of Low-Cost Remote-Control Generators Based on BiTe Thermoelectric Modules

LUIS E. JUANICÓ,^{1,2} FABIÁN RINALDE,¹ EDUARDO TAGLIALAVORE,¹
and MARCELO MOLINA¹

1.—National Research Council (Conicet) and Balseiro Institute, Bariloche Atomic Center, 8400 Bariloche, Argentina. 2.—e-mail: juanico@cab.cnea.gov.ar

This paper presents a new thermogenerator based on moderate-temperature (up to 175°C) BiTe modules available on the open market. Despite this handicap relative to commercial thermogenerators based on high-temperature proprietary-technology PbBi modules (up to 560°C), this new design may become economically competitive due to its innovative thermal sink. Our thermal sink is based on a free-convection water loop built with standard tubing and household hot-water radiators, leading to a more practical, modular design. So, the specific cost of about 55,000 USD/kW obtained for this 120-W prototype is improved to 33,000 USD/kW for a 1-kW unit, which represents about half the price of commercial thermogenerators. Moreover, considering recently launched BiTe modules (that withstand up to 320°C), our proposition could have an even more favorable outlook.

Key words: BiTe thermoelectric modules, thermoelectricity, thermogenerator, electrical generators, prototype, thermal-hydraulic design

INTRODUCTION

Up to now there is only a single niche market for thermogenerators (TE) (related to powering remote loads for the oil and gas industry) that can afford prices of about 60,000 USD/kW.¹ Since 1975, this market has only been served by Global Thermoelectric, manufacturing thermogenerators based on its high-temperature (up to 560°C) PbBi modules. This kind of proprietary-technology module allows Global Thermoelectric to design a compact cooling system based on a finned dissipator that works at about 130°C.¹ On the other hand, use of BiTe modules working at moderate temperatures (up to 175°C) that are available on the open market implies a major challenge regarding this small temperature drop, in order to develop a new thermogenerator with competitive costs. Recent studies on BiTe prototypes have proposed the use of vacuum closed loops² or fan-cooled finned dissipators.^{3–5} The former alternative has obtained a modest

improvement (120°C) for the cooling system, whereas the latter implies significant self-consumption of energy (more than 50% of the TE's generation) related to the fan.^{4,5} Therefore, it is necessary to explore new choices in order to develop a competitive TE based on BiTe technology.

In this paper a new thermogenerator is presented, which was developed to solve the lack of a competitive BiTe thermogenerator. The major innovations relate to: (1) a low-cost passive cooling system that works down to 50°C, and (2) a microcontroller system that manages the heating power to ensure safe operation and the possibility of maximizing the power under any conditions. In this way, new thermogenerators based on cheap BiTe modules, such as Tellurex (4,000 USD/kW)⁶ or Thermonamic (2,500 USD/kW), could be obtained.⁷ A first 120-W prototype was built and tested, showing that these goals are achievable.

PROTOTYPE DEVELOPMENT

This prototype was built on 16 G1-54-0557 Tellurex modules mounted between two aluminum

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