Journal of ELECTRONIC MATERIALS, Vol. 42, No. 7, 2013
DOI: 10.1007/s11664-012-2314-0

Design of a Compact, Portable Test System for Thermoelectric Power Generator Modules

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Measurement of fundamental parameters of a thermoelectric generator (TEG) module, including efficiency, internal electrical resistance, thermal resistance, power output, Seebeck coefficient, and figure of merit (Z), is necessary in order to design a thermoelectric-based power generation system. This paper presents a new design for a compact, standalone, portable test system that enables measurement of the main parameters of a TEG over a wide range of temperature differences and compression pressures for a 40 mm × 40 mm specimen. The Seebeck coefficient and figure of merit can also be calculated from the information obtained. In the proposed system, the temperature of each side of the TEG can be set at the desired temperature—the hot side as high as 380°C and the cold side as low as 5°C, with 0.5°C accuracy—utilizing an electrical heating system and a thermoelectric-based compact chilling system. Heating and cooling procedures are under control of two proportional–integral–derivative (PID) temperature controllers. Using a monitored pressure mechanism, the TEG specimen is compressed between a pair of hot and cold aluminum cubes, which maintain the temperature difference across the two sides of the TEG. The compressive load can be varied from 0 kPa to 800 kPa. External electrical loading is applied in the form of a direct-current (DC) electronic load. Data collection and processing are through an Agilent 34972A data logger, a computer, and BenchLink software, with results available as computer output. The input power comes from a 240-V general-purpose power point, and the only sound-generating component is a 4-W cooling fan. Total calculated uncertainty in results is approximately 7%. Comparison between experimental data and the manufacturer's published datasheet for a commercially available specimen shows good agreement. These results obtained from a preliminary experimental setup serve as a good guide for the design of a fully automatic portable test system for operational thermoelectric modules.

Key words: Thermoelectric power generator, test system, portable, compact

Nomenclature

C_p	Specific heat capacity (J/kg/K)
I_{load}	Current flowing through external load (A)
$\dot{m}$	Average mass flow rate (kg/s)
P	Power (W)
Q_{in}	Quantity of energy put into the hot block (W)
R_{ex}	External electrical resistance (Ω)
$R_{ex\text{-}mp}$	Value of R_{ex} at maximum power output of TEG (Ω)
R_{in}	TEG internal electrical resistance (Ω)
T	Temperature (°C, K)
TEC	Thermoelectric cooler
TEG	Thermoelectric generator
T_a	Ambient temperature (K)
T_c	Temperature of cold side of TEG (°C, K)
T_h	Temperature of hot side of TEG (°C, K)

(Received July 6, 2012; accepted October 1, 2012; published online November 10, 2012)