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Prototype Combined Heater/Thermoelectric Power Generator for Remote Applications

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This study presents a prototype thermoelectric generator (TEG) developed for remote applications in villages that are not connected to the electrical power grid. For ecological and economic reasons, there is growing interest in harvesting waste heat from biomass stoves to produce some electricity. Because regular maintenance is not required, TEGs are an attractive choice for small-scale power generation in inaccessible areas. The prototype developed in our laboratory is especially designed to be implemented in stoves that are also used for domestic hot water heating. The aim of this system is to provide a few watts to householders, so they have the ability to charge cellular phones and radios, and to get some light at night. A complete prototype TEG using commercial (bismuth telluride) thermoelectric modules has been built, including system integration with an electric DC/DC converter. The DC/DC converter has a maximum power point tracker (MPPT) driven by an MC9SO8 microcontroller, which optimizes the electrical energy stored in a valve-regulated lead–acid battery. Physical models were used to study the behavior of the thermoelectric system and to optimize the performance of the MPPT. Experiments using a hot gas generator to simulate the exhaust of the combustion chamber of a stove are used to evaluate the system. Additionally, potential uses of such generators are presented.

Key words: Thermoelectric generator, maximum power point, MPPT, power generation, biomass stove

INTRODUCTION

According to the International Energy Agency,[1,2] 1.4 billion people live without electricity, most of them in developing countries. They rely on biomass such as wood, charcoal, agricultural waste, and animal dung to meet their energy needs for cooking. Biomass is burned in an open fire, making an important contribution to household air pollution. According to the World Health Organization, use of wood fuel and dung for cooking and heating causes over 400,000 premature deaths in India annually, mostly women and children; For example, the concentration of airborne particulate matter in Indian household air using biomass is over 2000 μg per cubic meter, compared with the US limit of 150.[3–5]

To avoid this air pollution, the first thing to do is to use a stove instead of an open fire. To be efficient, stoves need tall flues to generate adequate draw. These flues are expensive and time-consuming to build. In some countries, with flat roofs, people do not have the technology to build chimneys going through the roof.

The possibility of adding an electric fan dramatically increases the widespread use of stoves. Addition of a fan greatly improves the overall performance of cooking stoves: it improves the air-to-fuel ratio,

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