Improving Energy Efficiency Systems for Industrial Kitchen Applications

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Abstract

EU countries have agreed on a new 2030 Framework for climate and energy, including EU-wide targets and policy objectives for the period between 2020 and 2030. Targets for 2030, a 40% cut in greenhouse gas emissions compared to 1990 levels, at least a 27% share of renewable energy consumption, at least 27% energy savings compared with the business-as-usual scenario [1,2]. Thus, energy efficiency improvement facilities becoming more and more important. Thermoelectric systems provide significiant contributions to energy efficiency studies. Energy efficiency improvements requires significant research & development (R&D).

Extensive fossil fuel consumption by human activities has led to serious atmospheric and environmental problems. Consequently, global warming, greenhouse gas emission, climate change, ozone layer depletion and acid rain terminologies have started to appear frequently in the literature. To abate the impact of the above disasters, the thermoelectric energy converters is proposed as one of the possible technologies for this aim, which currently gains the most popularity owing to its capability in converting the heat given off from vehicles, electrical instruments, etc., into the electricity [3].

Thermoelectric technology, one of the several green technologies, is reviewed to demonstrate its potential in improving the energy efficiency and point a possible direction of alleviating our energy demand [4]. Thermoelectric systems are receiving a great deal of attention duo to their numerous attractive merits. They are compact and environmentally friendly, and can be operated easily with long life, low maintenance cost [5]. Thermoelectric system is also known Peltier Module. This system is a unique cooling device, in which the electron gas serves as the working fluid [6]. Thermoelectric cooling, commonly referred to as cooling technology using thermoelectric coolers (TECs), has advantages of high reliability, compact in size and light in weight, and no working fluid [7]. In addition, it is inherently noiseless, reliable and environmentally friendly, offer a unique power generation solution because they convert thermal energy into electricity without requiring moving components, fast thermal response (i.e. compared to air cooling fans and liquid heat exchangers) and excellent flexibility [8-13]. Thermoelectric devices include for instance: domestic or automobile industry air-conditioned systems, portable refrigerators, domestic refrigerators, transport of perishable products, vending machines, food display cases etc., where this technology has to compete against traditional vapour compression cooling systems [14].

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Thermal sketch of the thermoelectric refrigerator is shown in Fig. 1.

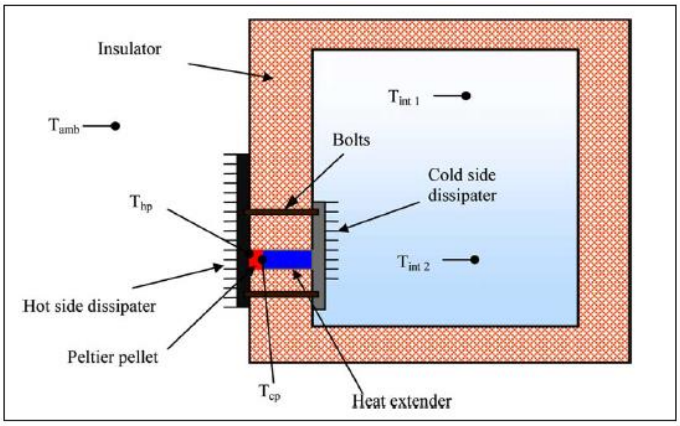

Fig. 1 Thermal sketch of the thermoelectric refrigerator [14].

Fig. 2 shows the history of typical applications of thermoelectric power generation.

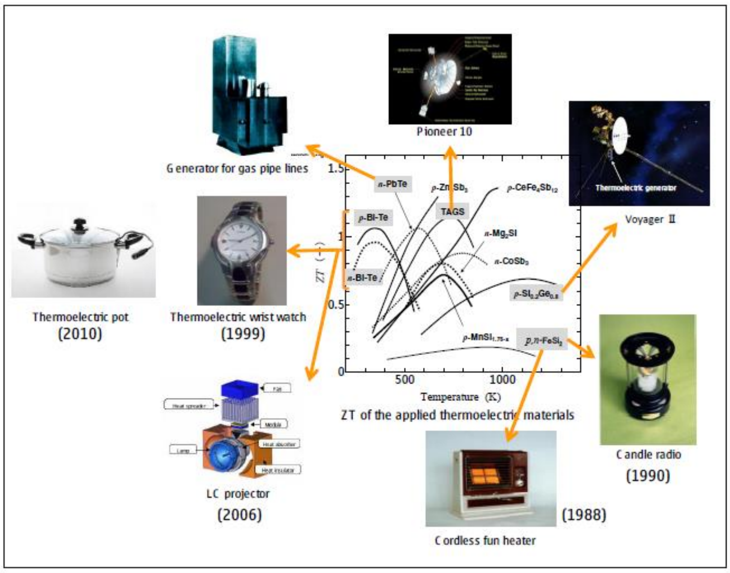

Fig. 2 History of typical applications of thermoelectric power generation [15].

In this project, we investigated the effect of thermoelectric system and improving energy efficiency for industrial kitchen applications. Banquet trolleys are widely used in industrial kitchen to ensure the food inside in cold or hot conditions. In this study, numerical models have been developed for thermoelectric system based on different formulations and boundary conditions. In order to find the ideal Peltier position, the Peltier module was placed at a certain distance from the top to the bottom of banquet trolley, and different analyzes were made for each position. Obtained results are shown in Figs. 3 and 4.

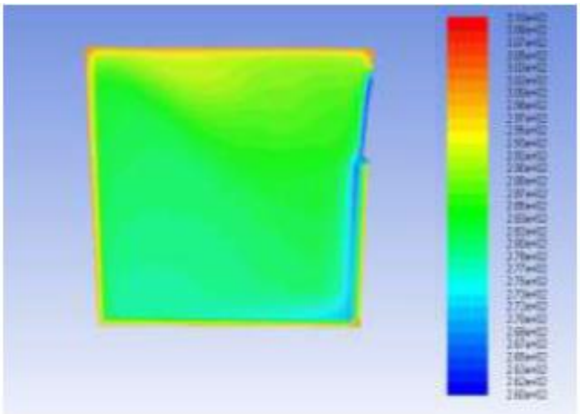

Fig. 3 Temperature distribution of Peltier power (200 W)

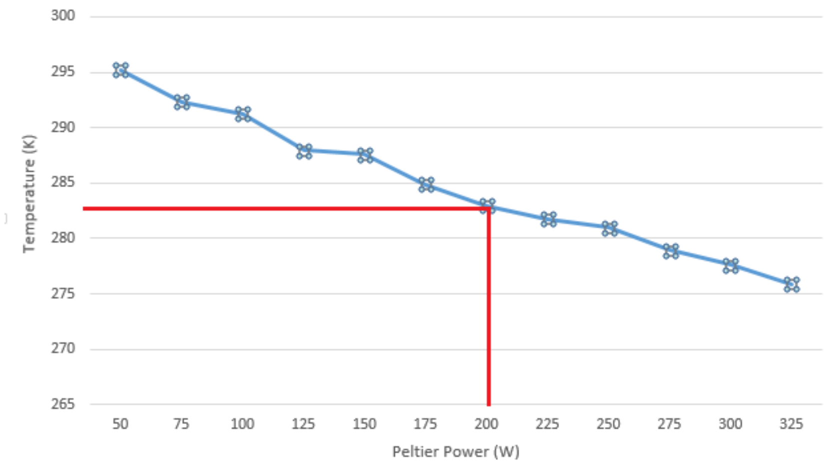

Fig. 4 Optimal temperature distribution associated with Peltier power.

The effect of hot zone to cold zone temperature difference is discussed and the thermal resistances at both hot and cold zones are also analyzed within given performance parameters.

The result indicates that the most suitable Peltier power (200W) for the temperature (+2 /+10°C) is in the cooling zone. Based on the measured data, it has been demonstrated that the thermoelectric system can be successfully installed as a cooling zone in banquet trolley prototype. We also observed that it is better to work with low voltage values for the cooling zone. For different cases, the operating range of thermoelectric system, temperature distribution (hot and cold zones for banquet trolley) and energy efficiency datas were also obtained. Comparisons between simulation results and experimental observations were in a good agreement.

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