Project Title:	Thermoelectric Cooling for the Construction of Solid-State Air Conditioner in Lift
Principal Investigator:	Dr AL Roy VELLAISAMY
Project ID:	CICR/02/16
Research Institution:	City University of Hong Kong
Subject Area:	Environment and Sustainability

Objective

- To construct a solid state air-conditioner (solid state air-cooling system) consisting of thermoelectric modules (TEM) to cool the passenger lift cabin.
- To demonstrate the rapid cooling process by using Peltier modules, achieving thermal comfort in elevators.
- To demonstrate the precise control of temperature in car cabinet by using PID temperature controller to control current passing through the Peltier modules.
- To establish Peltier modules with a long life exceeding 100,000 hours.

Background

In this project, a solid-state air-conditioner (air-cooling system) consisting of thermoelectric modules (TEMs) to cool the passenger lift cabin was constructed. Commercial TEMs were not available until the 1960s, after the first important discovery relating to thermoelectricity dated back to 1821 by a German scientist, Thomas Seebeck, and later discovered by Jean Peltier in 1834. The physical properties of thermoelectric (TE) materials in converting electrical energy directly into thermal energy or vice versa, offer promising solutions for clean energy applications. Peltier cooler or Thermoelectric Coolers (TEC) is a semiconductor-based TEM that functions as a small heat pump when power is connected to it. During the cooling process, TEM device produced no noise. Its rapid cooling process with outstanding cooling temperature range makes it ideal for a wide range of applicable uses. The size of commercially available TEMs is small, typically from 1cm^2 to 36cm^2 in area, and 3mm to 5mm in thickness, making the overall TEC system compact. Most importantly, the TEC system does not use chemical refrigerant or liquid coolant. It is environmentally green and the system can be installed in any orientations on the lift-top's limited space.

Methodology

In this research project, TEM was used as the cooling source to demonstrate its feasibility as an air conditioner. Copper and aluminium heatsinks were used to act as cooling coil on the cold side, while copper and aluminium heatsinks were used for heat dissipation. A large block of graphite coated on the hot side for heat dissipation was used to monitor the improvement factor. The cooling capacity and COP of this Peltier-based air conditioner were continuously evaluated on the experimental uni-block systems as well as on the final full-scale prototype system. With the full-scale prototype test data, the performance key values were evaluated and compared with the commercially available compressor type air-conditioner. Based on the laboratory test results, further development in design and scale of the Peltier-based solid state cooling device was continuously built for conditions that are normally powered by the compressor-type air cooler. The system performance was studied under mock-up testing condition or actual field testing.

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Results and Findings

The current research results show that TEC may not be efficient. However, as compared with the traditional heat pumps and refrigerators, TEC is superior in its high reliability, low maintenance, no moving parts that cause vibration, no refrigerants, and direct energy conversion. The cooling temperature can be controlled easily by changing the input electrical current, so that the operation of TEC is highly adjustable. One main characteristic of TEC is that the performance is almost independent of its capacity, so it can be used as a cooler for confined space.

Because the TEC system contains no liquid form components, the system can be mounted in any orientation, which makes it a distinct and good choice for installation in a restricted space on the lift-top.

The prototype TECs were entirely built with commercial components. The high cost of the TEC unit was due to TEMs, which are specialized version. With mass production of TEMs, the overall cost of the TEC unit will be reduced. It is expected that the current prototype version would cost less than HK$1,500 in the foreseeable future. By then, the TEC system would become a good choice for cooling lift cabin in terms of cost-effectiveness.