Abstract

Either for pleasure, health, or to stay alert, many people drink hot coffee and tea every day. The scope of this project was to develop a thermos lid that improves upon existing products. To address this issue, we designed ThermoTEC. The design incorporates metal fins and a thermoelectric cooler (TEC), used as a heat pump to supply heat to the fluid. Prototype testing and analysis data proved that ThermoTEC maintains hot fluids at a constant temperature longer than the benchmark.

Design Overview
1. RCG-6 Thermoelectric Cooler: Designed to fit under the lid, this TEC heats up the aluminum fins when it is plugged into a power source with reverse polarity in order to be used as a heat pump.
2. Aluminum Fins: Transfers heat to the fluid to keep it at an ideal drinking temperature for long periods of time.
4. Cover: Provides contact pressure for a better thermal connection between the TEC and the heat sink.
5. Lid: Stops heat from dissipating, keeps the TEC in place, and prevents spills.

Testing & Results
The system was analyzed during several two hour tests using first the flat plate and then the pin fin heat sinks. Steady state values were achieved by varying the power supply between a low and high wattage of 6.61 W and 15.5 W, respectively. Key notes of testing results from Figure 4 are as follows:
- Plate: Steady-state temperature of 61°C at 2.3 amps.
- Pin fin: Steady-state temperature of 67°C at 2.3 amps.

Table 1: Heat Analysis

<table>
<thead>
<tr>
<th></th>
<th>Heat loss (W)</th>
<th>Heat loss (W)</th>
<th>Output of TEC (W)</th>
<th>Efficiency (%)</th>
<th>Input Power (W) Needed to Hold Temp at 55°C</th>
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</thead>
<tbody>
<tr>
<td>Benchmark</td>
<td>-6.222</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td>Pin Fin (7.5W)</td>
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<td>57.24</td>
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<td>-2.036</td>
<td>+4.347</td>
<td>37.55</td>
<td>16.270</td>
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</table>

Figure 1: Single-stage thermoelectric cooler.

Figure 2: Section view of ThermoTEC.

Figure 3: Iconic model of ThermoTEC.

Figure 4: Transient temperature between two different heat sinks.

Figure 4: Testing of the prototype.

Analysis
- Analysis showed that ThermoTEC and our benchmark have the same heat loss of about 6.5 W when no voltage is applied.
- ThermoTEC’s most efficient heat sink is the pin fin, coinciding with our analysis of an ideal fin.
- With the pin fin, ThermoTEC requires 11 W to keep its fluid at a constant temperature of 55°C.

Conclusion
Results confirmed that ThermoTEC outperforms the benchmark, validating the proof of concept. The temperature of the fluid remained constant as determined by the applied voltage.

Acknowledgments
Hans Mayer, Prof. Stephen Laguette, Prof. Bennett, Prof. Paden, Kamala Qalandar, Mitchell D’Ewart

References