HIGH EFFICIENCY, HIGH CAPACITY COOLING AND REFRIGERATION

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Milestones and Key Activities Completed Since Last Report

Summary of Progress
Tasks 1 through 3 are complete. The project is on budget and on schedule. Significant positive results have been obtained. The progress is described by task below.

Task 1 – Identify Candidate Refrigerants
Evaluation of fluids to be used was completed successfully. Initially, four materials were chosen for testing. Because of the positive results obtained with two of the materials, two additional materials were selected for testing.

Task 2 - Construct Bench Top Test Device
A bench scale test apparatus was constructed. A calorimeter device was fabricated to measure the temperature of a fixed volume of water using RTDs (Resistance Temperature Devices) that were sensitive to 0.01°C. The cooling effect was then calculated by measuring the temperature change imparted to the water by the refrigerant that was allowed to expand out of the evaporation chamber. The apparatus was constructed to allow easy warm up and straightforward charging. Multiple runs with well-known refrigerants were conducted to check the repeatability of the results and for comparison with thermodynamic tables.

Water Bath / Calorimeter Construction
Consideration was given to the materials of construction of the water bath. Due to its lower thermal conductivity, lower heat capacity, and low density, plastic was selected as the material of choice. A readily available, clear polypropylene container with plastic screw lid was obtained. The plastic container had adequate radius to house the steel cylinder (i.e. the evaporation chamber) and was cut to the appropriate height. Sufficient clearance in the water bath was needed for a magnetic stir bar located underneath the suspended steel cylinder. To accommodate the magnetic stirrer, a flat bottom, plastic cover was cemented and waterproofed to the cut end of the polypropylene container.

The water bath was well insulated using black foam insulation tape normally used to wrap pipes and pipe joints. The lid was insulated using a 1” thick polystyrene sheet that was cut to fit inside the lid. Similarly, the bottom was insulated with a 1” thick polystyrene sheet, but still allowed operation of the magnetic stir bar. Thermocouples would not have provided sufficient accuracy for the anticipated temperature drop in the water bath. Therefore, RTD temperature sensors were favored over thermocouples due to their superior resolution and accuracy. Two RTD temperature sensors were mounted at separate locations in the water bath. The final computed temperature was the arithmetic average of the two temperature readings.
Due to the magnetic flux of the stirrer, the readings of the RTDs exhibited unacceptable noise when the stirrer was operating. This was remedied by operating the magnetic stirrer only 10 seconds of every minute elapsed time. Data were then filtered of the corrupted temperature readings.

Water level was maintained via a drain hose and siphon break. The outlet of the hose/siphon break was placed at a fixed height and remained fixed for all runs. Prior to the start of any run, hot or cold water was added to the water bath to adjust the starting temperature. The excess water was allowed to drain until the level had stabilized. The water level was constant for all runs.

**Evaporation Chamber**

The evaporation chamber was a carbon steel cylinder with one threaded opening. The threaded opening allowed straightforward disassembly and charging. The test chamber was connected to the threaded fitting of a reinforced refrigerant hose. Rubberized hose was selected over metal pipe due to its lower thermal conductivity. A hand valve connected via the reinforced refrigerant hose controlled the release of refrigerant during a run.

**Task 3 - Test Candidate Refrigerants in the Bench-Top Device**

All testing has been completed. The test apparatus was baselined with known refrigerants, then tested with the chosen materials.

Two of the materials showed average cooling capacity increase of 24.2% with 1.3% relative standard deviation. These positive results encouraged further testing with an additional two materials.

The additional two materials were chosen based on the apparent mechanism for capacity increase seen with the first two positive results. The second two materials had an average cooling capacity increase of 28.6% with 1.1% relative standard deviation. We are extremely pleased with the results. We have greatly exceeded our success target of a minimum of 15% cooling capacity increase, and have essentially achieved our original theoretical estimate of 30-50% cooling capacity increase. From the apparent mechanism seen, additional cooling capacity improvement should be possible.

Despite the test apparatus’ simple design and ease of use, the results obtained were exceptionally consistent. Most test results were within 1.5% standard deviation over multiple runs. No further testing is planned for this project at this time.

**Future Activities**

Cost and benefit analysis will be performed based on the results obtained from testing.

Work is progressing on the final report for this project. Data analysis is generally complete. The report may be submitted ahead of schedule.

**Schedule and Budget**

Overall this project is ahead of schedule and within budget.