The Cooler Guys

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Problem

The problem we set out to address is refrigeration in the absence of a reliable power grid. A situation like this can occur after a natural disaster or in developing countries. As when a power grid is offline, refrigerated items such as food, drinks, medicine or vaccines often spoil and need to be discarded. Our team set out to propose a solution to this issue.

Objectives

3 Main Objectives

- 12 volt battery will be able to power the refrigeration system. This will be achieved through the use of an inverter to increase the power into the system.
- System will be able to cool the contents of the cooler to below 40°F.
- Battery can be fully charged by the solar panel before refrigeration system runs again.

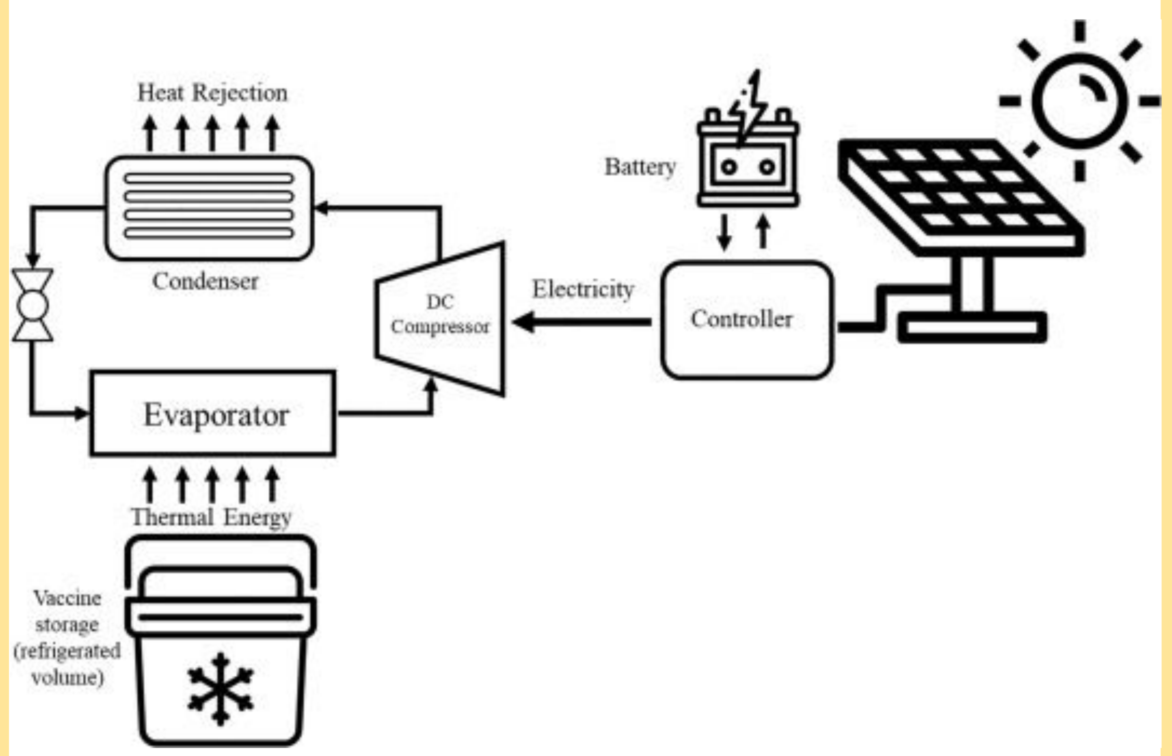


Figure 1. Solar Powered Refrigeration Cycle Diagram

Our Solution

Design Overview

Our solution is to develop a portable, solar powered cooler which can help in these times of need. This cooler will have a full refrigeration system inside the cooler and will be powered by a battery. A solar panel will be on top of the lid for power generation, as well as the capability of being powered by AC power from a wall outlet. The battery will be connected to an inverter to allow for the battery to meet the power need of the system.

Figure 2. Prototype

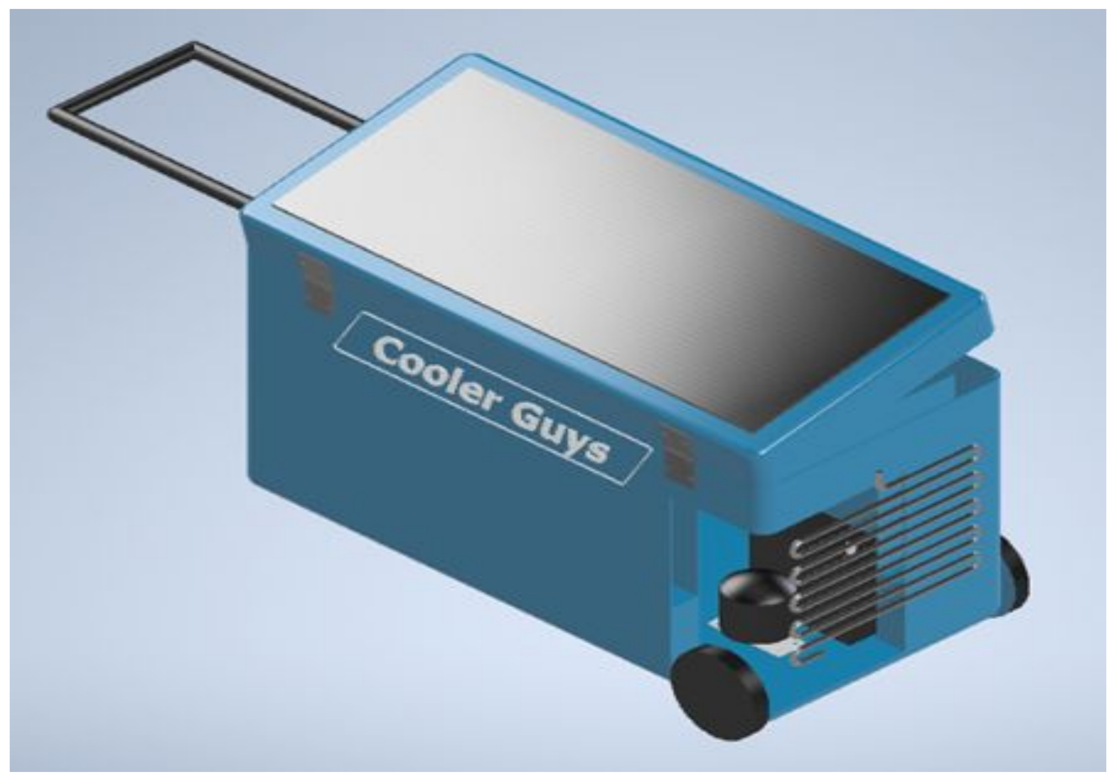


Figure 3. Final Concept Design

Calculations

Heat Transfer Out of Cooler

The rate at which the inside of the cooler is heated from the outside air is important as it will help to calculate how long the cooler will be, or not be operating to allow the battery to be recharged. The rate of heat transfer into the cooler from the outside air is determined by the experimental R-value of the cooler walls, the outer surface area of the cooler walls, and a known temperature inside and chosen temperature outside of the cooler.

System Operation and Off Time

The operation and rest time of the cooler is dependent on the mass of cooler contents, the specific heat value of the contents, the temperature change of the contents, and the heat into or out of the cooler depending on if it is in operation or not.

Electrical Calculations

Once the compressor is operating, the total battery discharge time assuming a continuous operation is:

$$t_D = \frac{(I_B)(V_B)(\eta_B)}{(I_C)(V_C)} = \frac{(18Ah)(12V)(0.85)}{(0.8A)(120V)} = 1.92\ hours$$

However, the time to fully charge the battery with a 100W solar panel during "peak sunlight" is:

$$t_C = \frac{(I_B)(V_B)}{(P_{S.P.})} = \frac{(18Ah)(12V)}{(100W)} = 2.16\ hours$$

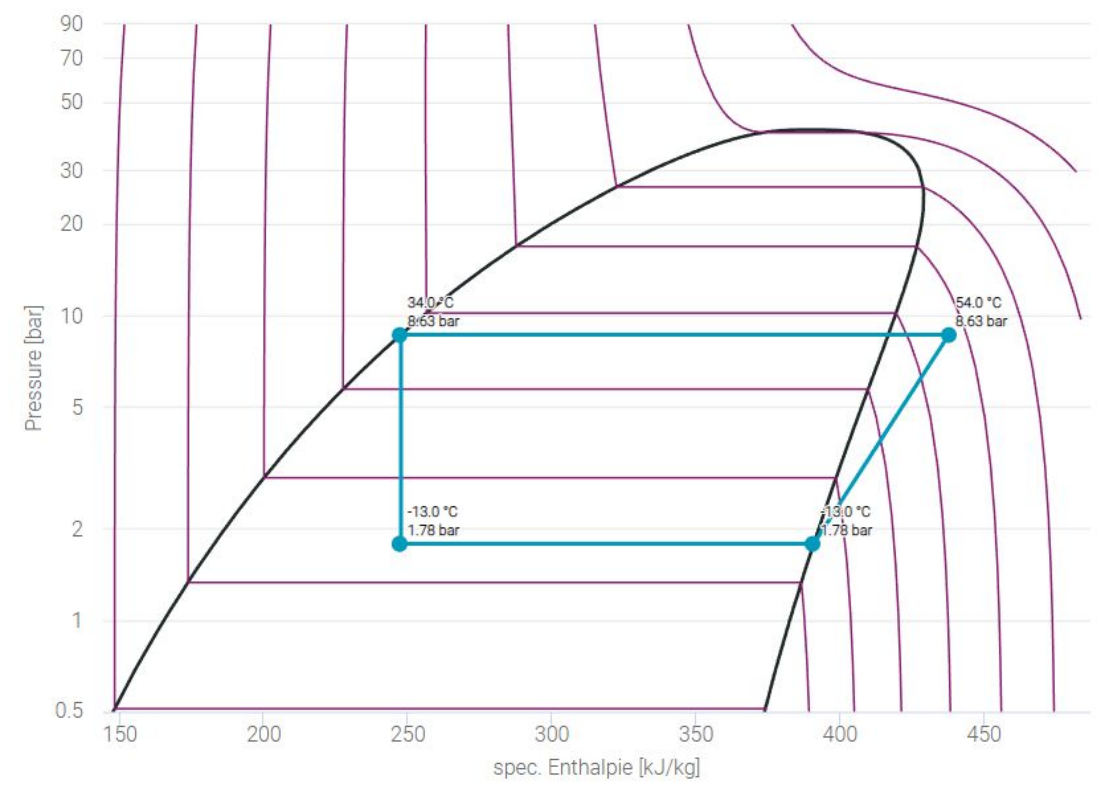
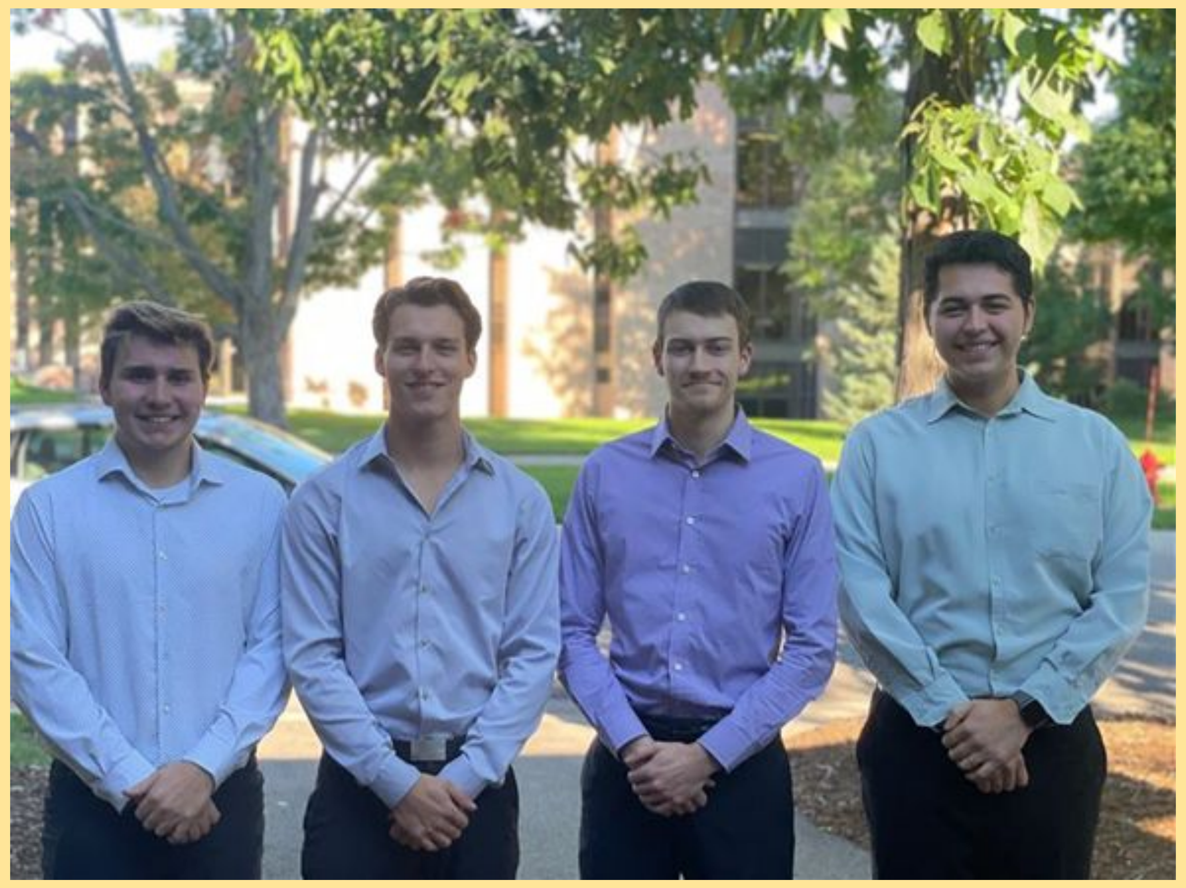


Figure 4. Prototype Refrigeration Cycle P-h Diagram



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Conclusions

Operation and Off Time

With the cooler contents being 25% water in volume, which was used as the typical cooler content, the operational time per cycle for the system is 57.95 minutes and will be off for 3.44 hours per cycle. This is a desired result as the system will be off far longer than when it is on, allowing for the battery to recharge. System time on and off increases as more contents occupy the volume of the cooler.

Electrical Power

Using the time cycle data for a 25% water volume, it can be concluded that the system is able to last for almost a day before needed to be plugged to a conventional power or recharged. Peukert's Law:

$$t_{@25\%} = H\left(\frac{C}{I*H}\right)^k = 20h\left(\frac{18Ah}{0.8A*20h}\right)^{1.15} = 22.9\ hours$$

Acknowledgments

- Andrew Wilson (Project Advisor)
- Christopher Hartemink (Industrial Consultant)
- Chris Sorenson (Machine Shop Advisor)
- Chuck Holwerda (Engineering Lab Advisor)

2023: Team 18