Solar Thermal Adsorption Refrigeration In Patna, India

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Abstract

The purpose of this project is to improve the design, function, and efficiency of the Solar Thermal Adsorptive Refrigeration (STAR) system. Existing prototypes in Patna, India are unable to hold a sufficient vacuum or create any sufficient cooling effect. Through a redesign of previous prototypes and the utilization of copper components and soldering methods, an improved prototype was created. This prototype is capable of holding a significant vacuum and creating a cooling effect.

Introduction

Due to an unreliable electrical grid, the state of Bihar, India is unable to maintain a reliable power supply. The frequent power-outages that occur affect the ability of clinics and hospitals to refrigerate vaccines. Without proper refrigeration, 30-60% of the vaccines spoil, creating a limited supply of vaccines within the community. The goal of this project is to continue to work on the STAR system to refrigerate the vaccines during these power-outages. The system relies on adsorption and de-adsorption cycles of ethanol and activated carbon to produce a refrigeration temperature between 3-8°C while utilizing appropriate and sustainable materials.

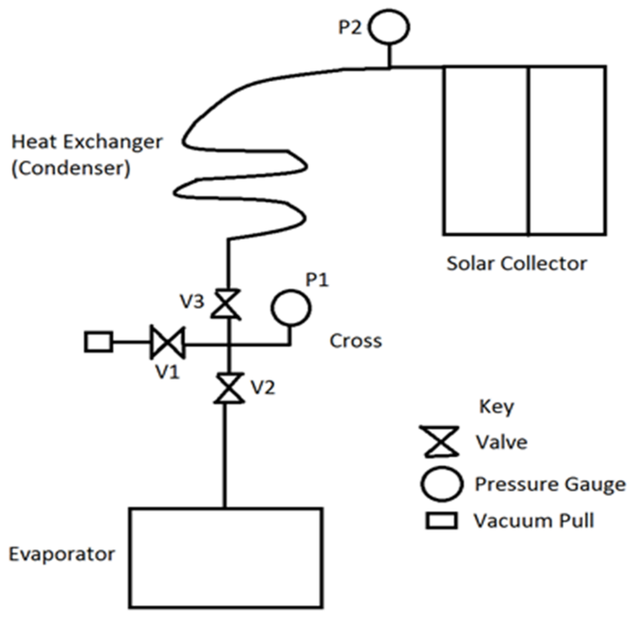

Figure 1: System Graphic

Project Description

The main issue faced by previous teams to create a working STAR system stems from the inability to achieve and maintain a high vacuum (-29.5 in Hg) over a long period of time. Pulling vacuum is crucial to the operation of the system because it is the driving force behind ethanol vaporization and adsorption onto the activated carbon, which in turn creates the cooling effect. Previous attempts have included building the system out of a variety of metals with welded connections as well as with CPVC using heated press-fit connections. Both attempts were unsuccessful, so the team discovered copper as a potential material, utilizing solder as the sealing method between the connections. Copper has a high thermal conductivity, is capable of significant heating and cooling, and is capable of having vacuum-proof connections using a simple soldering method.

With a new material and sealing method selected, a prototype was created consisting of a solar collector, condenser, and evaporator. It was then tested to determine its ability to hold vacuum and to cool the refrigerator space.

Figure 2: Evaporator

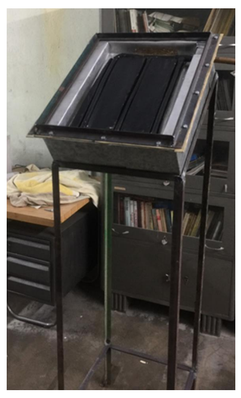

Figure 3: Solar Collector

Results & Discussion

The team successfully created a fully functional STAR system that is capable of holding vacuum for a long period of time.

The team confirmed that connecting copper pipes with copper connectors using soldering as the sealing method creates connections that are effectively leak-proof.

The team was able to achieve cooling using the created system (Lowest temperature= 16.3 °C). Unfortunately, the degree of cooling was not as low as needed for vaccine storage (3-8 °C). However, the team is confident that a system could reach the desired cooling temperature if the system is sized appropriately.

The team made developments in identifying an appropriate phase change material. Peanut oil appears to be the best, but it's availability is limited in the northern parts of India, where Patna is located.

The team made developments in creating internal magnetic valves but concluded that further research needed to be done once a system that could reach the desired cooling temperature is created.

Figure 4: Final System

Recommendations

Determining the specific adsorption ratio of the ethanol-carbon pair using carbon from India will assist in the correct sizing of the system. The test system used in India to determine this ratio was unable to hold a vacuum. Additionally, the scale used in weighing the samples was a common fruit scale, unable to reach significant figures.

A reduction in the overall number of connections within the system will decrease costs and build time. The system built contains 50+ connections and can easily be reduced by checking the pipe and fitting sizes available in India compared to the U.S..

Implementation of a plastic tube or insulator between the evaporator and the condenser. This would prevent the ethanol from cooling all sections of the system and potentially concentrate the cooling to the evaporator.

Implementation of a valve between the solar collector and the condenser. This will trap the cooling ethanol in the condenser without the risk of the ethanol re-adsorbing too early or letting the ethanol into the evaporator at too high of a temperature.

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www.solar-alternatives.com
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