Experimental Investigation of a Solar Powered Eco-Fridge

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Abstract

The objective of this paper was to experimentally investigate the performance of a solar powered eco-fridge under direct sunlight and various wind velocities. The experiment was done using solar powered eco-fridge, water as the refrigerant and cotton as the filler material. The solar powered eco-fridge works on the principle of evaporative cooling. Sunlight heats up the wet filler material and the solar energy causes the water to evaporate from the filler material. As the wet medium or filler material in between the cylinders is in contact with the inner cylinder the latent heat of vaporization is taken from the inner cylinder. Due to this, the inner cylinder becomes cooler and makes it perfect for the storage of perishables. The results indicate that the solar powered eco-fridge works normally and efficiently under all the environment conditions. The combined effect of sunlight and wind promotes the evaporation, thereby decreasing the temperature. The performance of solar powered eco-fridge had improved under direct sunlight and heavy wind velocities. The results show that the temperature inside the inner cylinder gets reduced between 5ºC to 9ºC on various experimental conditions.

Keywords: - *Solar powered eco-fridge, Evaporative cooling, Solar energy, Latent heat of vaporisation*

I. Introduction

The solar powered eco-fridge works on the principle of evaporative cooling. Sunlight heat up the wet medium and the solar energy causes the water to evaporate from the medium. As the wet medium in between is in contact with the inner cylinder the latent heat of vaporization is taken from the inner cylinder. Due to this, the inner cylinder becomes cooler and makes it perfect for the storage. The eco-fridge can be used as a refrigerator for storage of medicines, vaccines, beverages, cool drinks, fruits, vegetables, perishables etc. at a lower temperature than ambient conditions at remote areas where electricity is not available. Portable solar-powered eco-fridge has many advantages, it is a low cost one and there is no need of electricity and no leakage of harmful refrigerant.

Mohammed Bah Abba [1] designed and developed a pot-in-pot refrigerator. He developed this to help Sudanese families to preserve food. It is a refrigeration device which keeps food cool without electricity by using evaporative cooling. A porous outer earthenware pot, lined with wet sand, contains an inner pot (which can be glazed to prevent penetration by the liquid) within which the food is placed. The evaporation of the outer liquid draws heat from the inner pot. The device can used to cool any substances such as water, food or temperature sensitive drugs.

Emily Jayne Cummins [2] re-designed and fabricated the evaporative refrigerator, based on the evaporative cooler originally invented and engineered by Mohammed Bah Abba. It consists of two metallic cylinders, one inside the other. Unlike previous pot-in-pot coolers, the contents are kept dry and hygienic because the water does not come into contact with the substances.

II. Experimental Setup

A. Experimental System

The Solar powered eco-fridge was of 5.85L capacity. The inner cylinder is made of copper and outer cylinder is made of plastic. Cotton is used as the filler material which is placed in between the inner cylinder and outer cylinder. The inner cylinder is covered with a copper lid. To cover the top portion of the outer cylinder a wooden lid is provided. The temperature inside the inner cylinder of the eco-fridge is measured using a digital thermometer. The variation of temperature with respect to time is measured using the digital thermometer and digital stop watch.
Figure 1. shows the experimental test rig. The eco-fridge specification is given in Table 1.

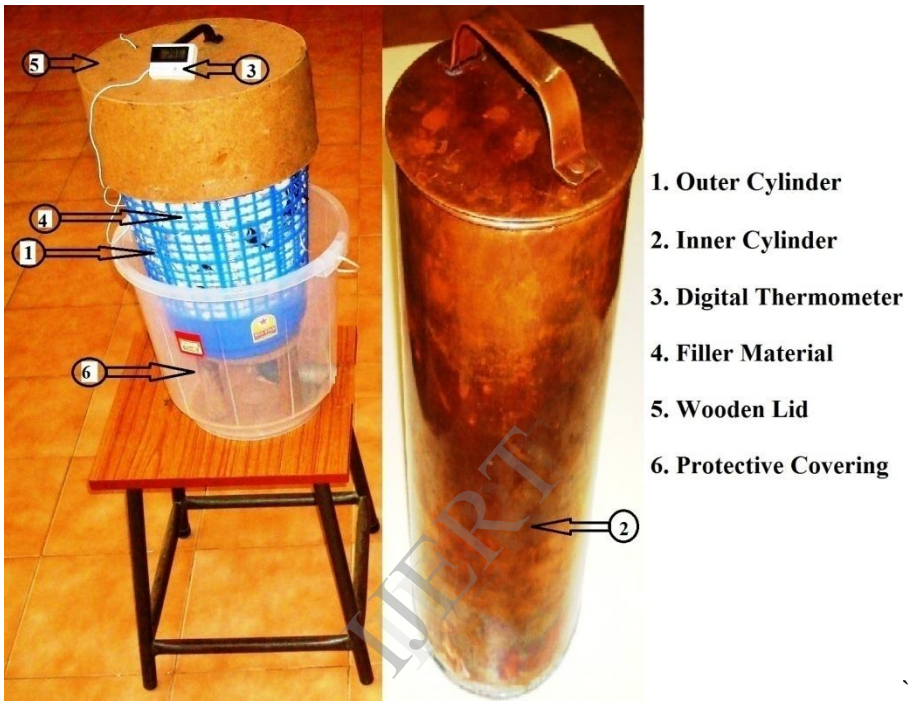

Fig. 1 Experimental Test Rig

Table 1: Eco-Fridge Specifications

Inner cylinder capacity	5.85 L
Inner cylinder material	Copper
Outer cylinder material	Plastic
Filler material	Cotton
Refrigerant	Water

B. Experimental Procedure

Schematic diagram of the experimental apparatus is shown in Figure 2. The space between the inner cylinder and porous outer cylinder is first filled with the filler material like cotton in a thick and tight manner. Turn on the water supply and apply required amount of water to all portion of the filler material. A digital thermometer is used to measure the temperature inside the inner cylinder of the eco-fridge. The inner cylinder and outer cylinder are then covered with respective lids. The eco-fridge is the placed over a suitable stand and kept inside a protective cover.

The experimental apparatus is then placed under direct sunlight. Using an electric fan of varying speed, air flow rate over the eco-fridge can be varied there by varying the evaporative cooling rate. The system was operated at four wind velocities, normal ambient wind velocity, low wind velocity, medium wind velocity, and heavy wind velocity. At each condition, variations of temperature inside the inner cylinder were noted down at every thirty minutes interval using digital thermometer and digital stop watch.

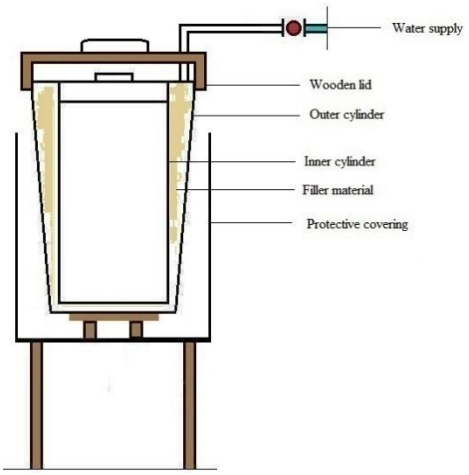

Fig. 2 Schematic diagram of the Experimental apparatus

The experiment was done until steady state condition was attained inside the inner cylinder. The performance of the eco-fridge under direct sunlight was first measured at normal ambient wind velocity, low wind velocity then at medium wind velocity and finally at heavy wind velocity. The test results of the system under various operating conditions was compared and conclusions are arrived based on the readings obtained from the tests carried out.

III. Results and Discussions

Figure 3. gives the temperature variation inside the inner cylinder of the eco-fridge for a certain amount of time under various environmental conditions. There was an enhancement in the cooling rate and reduction in temperature inside the inner cylinder from normal ambient wind velocity to the maximum wind velocity. It was found that the maximum reduction in temperature occurs at maximum wind velocity this was because the evaporative cooling rate is maximum at this condition.

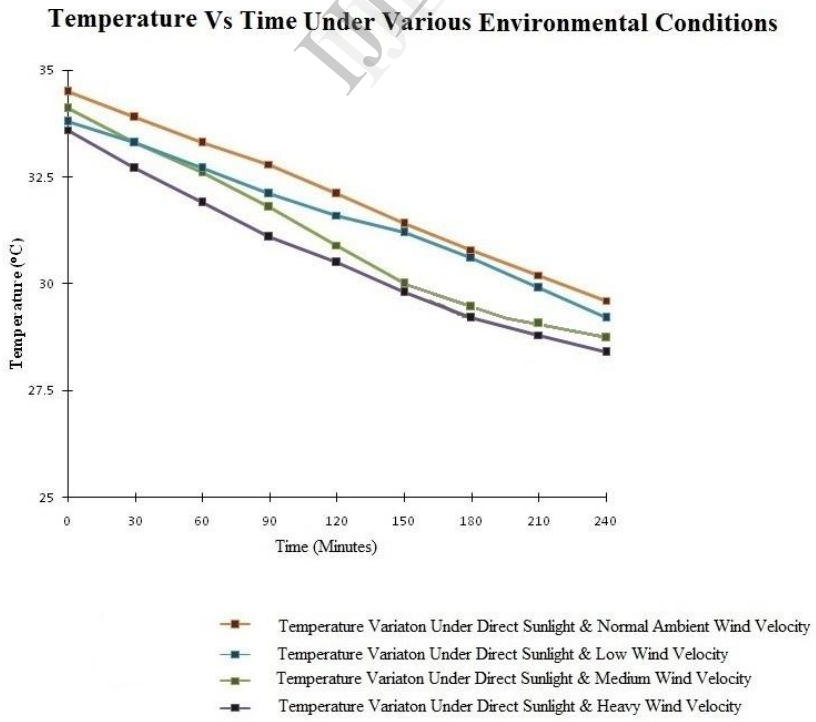

Fig.3 Temperature Vs Time under various environmental conditions

Table 2 provides the Temperature Vs Time variation of eco-fridge for a certain period of time under four different environmental conditions namely; direct sunlight/normal ambient wind velocity, direct sunlight/low wind velocity, direct sunlight/medium wind velocity, direct sunlight/heavy wind velocity

Table 2: Temperature Vs Time variation of eco-fridge for a certain period of time under direct sunlight/normal ambient wind velocity, direct sunlight/low wind velocity, direct sunlight/medium wind velocity, direct sunlight/heavy wind velocity

Time (Minutes)	Temperature Variation Under Direct Sunlight & Normal Ambient Wind Velocity	Temperature Variation Under Direct Sunlight & Low Wind Velocity	Temperature Variation Under Direct Sunlight & Medium Wind Velocity	Temperature Variation Under Direct Sunlight & Heavy Wind Velocity
0	34.1	33.6	33.8	34
30	33.3	32.7	33.3	33.9
60	32.6	31.9	32.7	32.3
90	31.8	31.1	32.1	31.8
120	30.9	30.5	31.6	30.1
150	30	29.8	31.2	28.4
180	29.9	29.2	29.6	27.1
210	29.5	28.4	27.9	26.2
240	29	27.8	26.2	25.2

IV. Conclusions

The performance of the solar powered eco-fridge under various environmental conditions was investigated experimentally. The main conclusions are listed as follows:

(1) The solar powered eco-fridge works normally and efficiently under all the environment conditions.
(2) The combined effect of sunlight and wind promotes the evaporation of the refrigerant thereby promoting evaporative cooling thereby decreasing the temperature of inner cylinder to a greater extent.
(3) The results confirmed that the temperature inside the inner cylinder of the eco-fridge get reduced on all operating conditions.
(4) The temperature of the inner cylinder get reduced to 5.1ºC, 5.8ºC, 7.6 ºC, 8.8 ºC under direct sunlight/normal ambient wind velocity, direct sunlight/low wind velocity, direct sunlight/medium wind velocity, direct sunlight/heavy wind velocity respectively, for certain period of time.
(5) The eco-fridge can be used as a refrigerator for storage of medicines, vaccines, beverages, cool drinks fruits, vegetables etc. at a lower temperature than ambient conditions at remote areas where electricity is not available.

Acknowledgement

This study was supported by the UG section of Department of Mechanical Engineering, Jyothi Engineering College, Cheruthuruthy, Thrissur-679531, Kerala, India

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