Design and Analysis of Solar Wind Chill Refrigeration System

Jitendra S. Pachbhai[1] Mrunal S. Armarkar[2] Akshay Meshram[3] Neel Deshpande[4]
[1]Assistant Professor [2,3,4]Student
[1,2,3,4]J.D.C.O.E.M, Nagpur, India

Abstract— First of all, evaporation is the best way to effective control of the lowering of temperature. The utilization of the evaporation refrigeration system has been utilized for proper requirement of the desired temperature. An evaporative cooler is made up of a porous material that is fed with water Refrigeration is a process of moving heat from one location to another in controlled conditions. A proper description of latest technologies is being shown in this paper with their dimensions and analysis. Various survey has been carried out to serve these system in effective manner.

Key words: Pot-in-Pot Refrigerator, Solar Wind Chill Refrigeration System

I. Introduction

Cooling through evaporation is an ancient and effective method of lowering temperature. Both plants and animals use this method to lower their temperature. Trees, through the method of Eva transpiration remain cooler than their environment. [5]

The principle underlying evaporative cooling is conversion of sensible heat to latent heat. The warm and dry outdoor air is forced through porous wall or wetted pads that are replenished with water from cooler's reservoir. Due to low humidity of the incoming air some of the water gets evaporated. Some of the sensible heat of the air is transferred to water and become latent by evaporating some of water. The latent heat follows the water vapor and diffuses into the air. Evaporation causes a drop in the dry-bulb temperature and a rise in the relative humidity of the air. [1]- [7]

Evaporation cooling is dependent on the condition of the air and it is necessary to determine the weather condition that may be encountered to properly evaluate the possible effectiveness of evaporative cooler. On the other hand, the amount of water vapor that can be taken up and held by the air is not constant: it depends on two factors: the first is the temperature of the air, which determines the potential of the air to take up and hold vapor. The second involves the availability of water: if little or no water is present, the air will be unable to take up very much amount of water. [5]

In rural areas of India, vegetarian food is often preserved in a clay pot refrigerator. The cooling space is smaller clay pot inserted within a larger clay pot. The annular space between the two pots is filled with sand are occupied by water. Convective and radiative heat transfer from hot and dry surrounding evaporates this water and brings about cooling of space in the inner pot where food is kept. This slows both the respiratory process and activities of micro-organism which are destructive activity during storage of food. The mathematical model of pot in pot refrigerator using Reynolds flow model is presented by A.W. Date. [1]

An evaporative cooler is made up of a porous material that is fed with water. Hot dry air is drawn over the material. The water evaporates into the air raising the humidity and at the same time reducing the temperature of the air. [5]

The different type of evaporative cooler designs under review includes pot-in-pot, cabinet, statics, and charcoal cooling chamber. The gap between them is either filled with jute, damp cloth, or sand .Water is linked to the cooler at the top, thus keeping chamber cooled. [5]

The pot-in-pot refrigerator, also known as Zeer in Arabic, is a way of keeping cool without electricity by using evaporative cooling. It is constructed by placing a clay pot within a larger clay pot with wet sand in between and a wet cloth on top. As the water evaporates, there is a drop in temperature. The food stored in the inner container cools so it can be kept fresh for much longer in a hot, dry climate. The Arabic word "zeer" means large pots. The concept of cooling water and other items in clay pots can be dated back to Egypt around 2500 BC., where frescos show slaves fanning large clay pots. This type of evaporative cooling has also been used by the Indus Valley Civilization that existed around 3000 B.C. in the areas known today as northeast Afghanistan and Pakistan and northwest India.

Refrigeration is a process of moving heat from one location to another in controlled conditions. The work of heat transport is traditionally driven by mechanical work, but can also drive by heat, magnetism, electricity, laser, or other means.

Following are the types of refrigeration systems.

- Solar Mechanical Refrigeration.
- Photovoltaic Operated Refrigeration.
- Absorption Refrigeration.
- Pot in Pot Refrigeration.

A. *Experimentation and Analysis*

Following are the readings taken out in Malaysia using thermometer inside pot.

Time after setting pot in pot refrigerator	Temperature inside the pot (ºC).	Air Temperature Outside the pot (ºC).
15 minutes	23.7	23.8
20 minutes	23.6	24.0
30 minutes	23.2	23.8
40 minutes	21.7	24.7
1 hour	21.0	24.8
1 hour 15 minutes	20.4	25.0
1 hour 30 minutes	20.1	24.7
1 hour 40 minutes	19.9	24.7
2 hour 30 minutes	19.5	24.0
2 hour 40 minutes	19.4	24.4
13 hour	19.4	25.0

Table 1: Following are the readings taken out in Malaysia using thermometer inside pot.

B. Description and Working of our System

Our solar wind chill system consists of an air receiver unit, a pot in pot system, evaporator tank, copper tubing, and a cooling chamber. Wind blows warm air through a funnel and is directed underground, where it cools down. Then it travels into a coiled copper pipe in an evaporation chamber. A solar powered fan evaporates the water. Water is cooled below 40 degree Fahrenheit. The cooled air enters the storage chamber where it cools the food.

C. CREO Design of our System

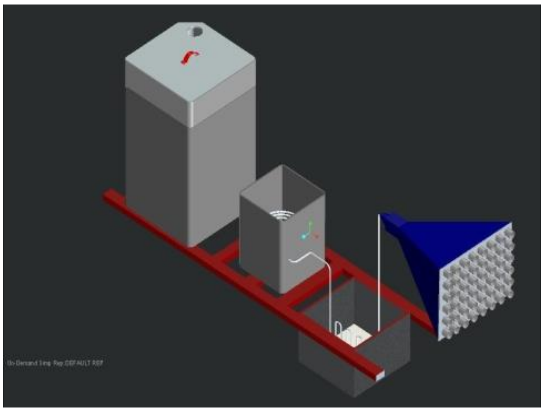

Fig. 1: CREO design of our system

D. CAD Model of our System

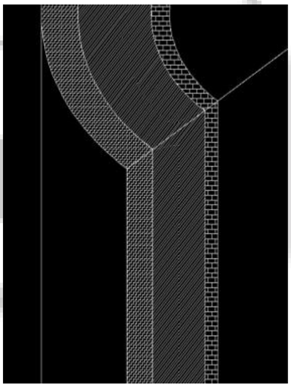

Fig. 2: CAD Model of our System

E. Design Calculations

- c/s of cardboard: 0.8 m *0.8 m.
- outer dia of bottle: 0.08 m
- c/s area of bottle: 0.005 sq-m
- no of bottles :approx 60
- velocity of still wind: 3.6 m/s
- velocity inside air receiver :25 m/s
- mass flow rate of air: 2.33 kg/s
- Temperature inside pot: 20-25 degree celcius.
- Length of tubings: 3.6 m
- Thermal conductivity of copper: 400 W/mk
- Temperature of soil: 20 degree celcius
- Temperature of air at the inlet of tubing:30 degree celcius
- Final air temperature before evaporation:25 degree celcius

II. LITERATURE SURVEY

A. Mohammed Abbah (Longmone, 2003)

A teacher in Nigeria, developed a small scale storage pot-in-pot system that uses two pots of slightly different size. The smaller pot is placed inside the large pot and the space between then is filled with sand. In Sudan, the Practical Action and the Women's Association for Earthenware Manufacturing have been experimenting with the storage design of Mohammed Abbah. The aim of the experiment was to discover how effective and economical the Zeer storage is in conserving foods. Zeer is the Arabic name for the large pots used. The results are shown in the following table (Longmone, 2003). As a result of the tests, the Women's Association for Earthenware Manufacturing started to produce and market the pots specifically for food preservation (Longmone, 2003).

B. Roy (1985)

The India Agricultural Research Institute develops a cooling system that can be built in any part of the country using locally available materials (Roy, 1985). The basic structure of the chamber can be built from bricks and river sand, with a cover made from cane or other plant materials and sacks or cloth. There must be a nearby source of water. Construction is fairly simple, first the floor is built from a single layer of bricks, and then a cavity wall is constructed of bricks around the outer edge of the floor with a gap of 75mm (3") between the inner wall and the outer wall. This cavity is then filled with sand. About 400 bricks are needed to build a chamber of the size shown below. A covering for the chamber is made with canes covered in sacking all mounted in a bamboo frame. The whole structure should be protected from sunlight by making a roof to provide shade. After construction of the walls and floor, the sand in the cavity is thoroughly saturated with water. Once the chamber is completely wet, a twice daily sprinkling of water is enough to maintain the moisture and temperature of the chamber.

C. Raha (1994)

A convenient cabinet is usually encapsulated by evaporating cool surfaces. In some cases, the cabinet is constructed from metallic materials with charcoal placed adjacent to the sides with the result that heat conduction takes place between the outer and inner metal container walls and combine radiative and convective heat transfer within the storage area. This results in little or no temperature difference between the evaporative cooler storage chamber and the ambient air temperature. In particular, seepage of water is inhibited by the non-porous container (Raha, 1994).

D. Sharma and Rathi (1991)

The charcoal cooler is made from an open timber frame of approximately 50mm x 25mm (2" x 1") in section. The door is made by simply hanging one side of the frame. The wooden frame is covered in mesh, inside and out, leaving a 25 mm (1") cavity which is filled with pieces of charcoal. The charcoal is sprayed with water and when wet provides an evaporative cooling. The frame work is mounted outside the house on a pole with a metal cone to deter rats and a good coating of grease to prevent ants from getting to the food (Sharma and Rathu, 1991). The top is usually solid and thatched, with an overhang to deter flying insects. All cooling chambers should be placed in a shady position, and exposure to the wind will help the cooling effect. Airflow can be artificially created through the use of a chimney (i.e., using a mini electric fan or an oil lamp to create airflows through the chimney) the resulting draft draws cooler air into the cabinet situated below the chimney. The butch cooling cabinet uses this principle to keep its contents cool. Wire mesh shelves and holes in the bottom of the raised cabinet ensure the free movement of air passing over the stored food.

III. FUTURE SCOPE

Scope for future work as suggested in above is to utilize these system for the betterment of farmers in rural areas where there is a problem for the storage of their food at given conditions. Due to its environmental friendly aspects it can be used without the danger of the pollution. By increasing the dimensions of these systems we can able to achieve these system for the preservation of foods in large scale. There is no skill required to run these system just a need of simple maintenances it can be run for longer time.

IV. CONCLUSIONS

Evaporative cooler to some extent has influenced the rate of water loss by reducing the temperature in the storage chamber and increasing the relative humidity. Moreover, fruits and vegetables continue the life process that existed before harvest. They respire and in doing so use up oxygen and give up carbon dioxide and generate heat. Temperature and relative humidity have been established to be a major factor that causes the deterioration of foodstuff. Since significant evaporative colling temperature depression from the ambient air temperature always occurs during the times of the day when cooling is most desired, the cooling condition achieved are suitable only for the short term preservation of vegetables and fruits soon after harvest.

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