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Eco-Refrigerator - A Sustainable approach towards the problem of Food Insecurity

Mrinal Abhinav[1],

Assistant Professor, Mechanical Engineering, JIMS Engineering and management technical campus, Greater Noida, U.P, India

Somadri Tiwari[2],

Payel Sarkar[3],

Akanksha[4]

[2,3,4]Students, Mechanical Engineering, JIMS Engineering Management Technical Campus, Greater Noida, U.P, India.

ABSTRACT

As we claim to live in a modernized and developed world today, there are various places around the globe which are relatively been left untouched by civilization, modernization and development. These places don't have access to several facilities we tend to take for granted. One of them happens to be electricity without which the people of these regions face many basic issues, like lighting, heating, cooling and food preservation, etc. In most cases, lack of access to these resources leads to food wastage on a large scale in these areas. The ECO-REFRIGERATOR is something to look out for in the future. Using the prominent proposal for implementation and development, this refrigeration unit can change the way food is preserved in areas that have limited access to electricity. It can also change the future of the food transportation industry by using nature inspired habits. It is an essential tool that can change the very lives of those in need of it. The principle on which ECO-REFRIGERATOR is based is evaporation technique and is a cooling device that works without any electricity and, it's also cheap and portable, making it ideal for those in remote and rural areas who struggle to keep their produce fresh.

Keywords:- Eco- Refrigerator, Evaporation, Evaporative Cooling, Sensible Cooling, Air-Intake System, Conduction and Convection.

INTRODUCTION

In this era of modernization and industrialization, food wastage is growing to alarming proportions while not many administrations are necessarily paying proper attention to the issue at hand. As per the United Nations' Food and Agriculture Organization (FAO), close to 1.3 billion tonnes of food goes to waste every year. This wastage is costing the world economy a mind boggling $750 billion. One of the major reasons behind the growing problem of food wastage is that our farmers or vegetables/fruits vendors do not have proper storage facilities. A recent study conducted by Indian Institute of Management, Kolkata, revealed that only 10 per cent of foods get cold storage facility in India, this factor, accompanied by inappropriate supply chain management, has resulted in India becoming a significant contributor towards food wastage both at pre and post-harvest waste in cereals, pulses, fruits and vegetables. India ranks 63 among 88 countries in Global Hunger Index with 20 crore Indians sleeping hungry on any given night, but in spite of this, nearly 21 million tons of wheat are wasted in India each year instead of reaching the needy. Major Reasons for this inefficiency is due to uneven distribution of cold storages in India which is due to the Heavy investment in installations and Shortage of power in these rural areas. In order to found out a sustainable solution towards this critical problem, we design Eco-Refrigerator, a refrigerating device based on evaporation and using benefits of natural technique like heat transmission through conduction and convention in the moist soil just like the way mammals and insects keep themselves Cool in hot summer days. On our further research we found that 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 Evaporation or transpiration remain cooler than their environment. 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]

LITERATURE REVIEW

The different type of refrigerating devices based on evaporation 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 cooler [5].On our investigation, we found the following works done related to Evaporative cooling-:

[Abbah[6] (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 them is filled with moist sand, which will produce the cooling effect by the principle of Evaporation. The aim of the experiment was to discover how effective and economical the Zeer storage is in preserving foods where Zeer is the Arabic name for the large pots used. 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).

[Roy (1985)][2]:-The India Agricultural Research Institute develops a cooling system through the process of Evaporation. 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. 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.

[Raha (1994)][8]:-In this a Cabinet is constructed in such a way to enclose Evaporative materials. 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.

[Sharma and Rathi (1991)][9]:-The charcoal cooler is made from an open timber frame. The door is made by simply hanging one side of the frame. The wooden frame is covered in mesh, inside and out, leaving a cavity which is filled with pieces of charcoal. The charcoal is sprayed with water and when wet provides an evaporative cooling.

DESIGN AND CONSTRUCTION

The Eco-Refrigerator should be designed in such a way so that first it draws an ambient air from the surrounding which may be naturally or by using blower of about 12V and 1.2A current (to enhance the speed of intake air), the drawn air then passes through plastic pipe 1.5m above the ground, this whole setup is called as an Air receiver unit, then that warm air is directed underground through copper tubing of 15 mm diameter where air enters in the pipe and since there will be some temperature difference underground, heat is lost to the surroundings due to which a drop in dry bulb temperature will occur because of conduction. Then air travels into a coiled copper pipe of 12mm diameter in an evaporation chamber where sensible cooling will occur and sensible temperature drop will be seen. Air can be cooled to 5-10 degree Celsius. An axial fan of 60 Hz is used which evaporates the water and enhances the temperature drop. That cooled air enters the cooling chamber where it cools the food called as refrigerating chamber.
Hence basically, there are four major units required for this Eco-Refrigerator i.e. Air Receiver Unit, Copper Tubing, Evaporation Chamber and Refrigerating Chamber.

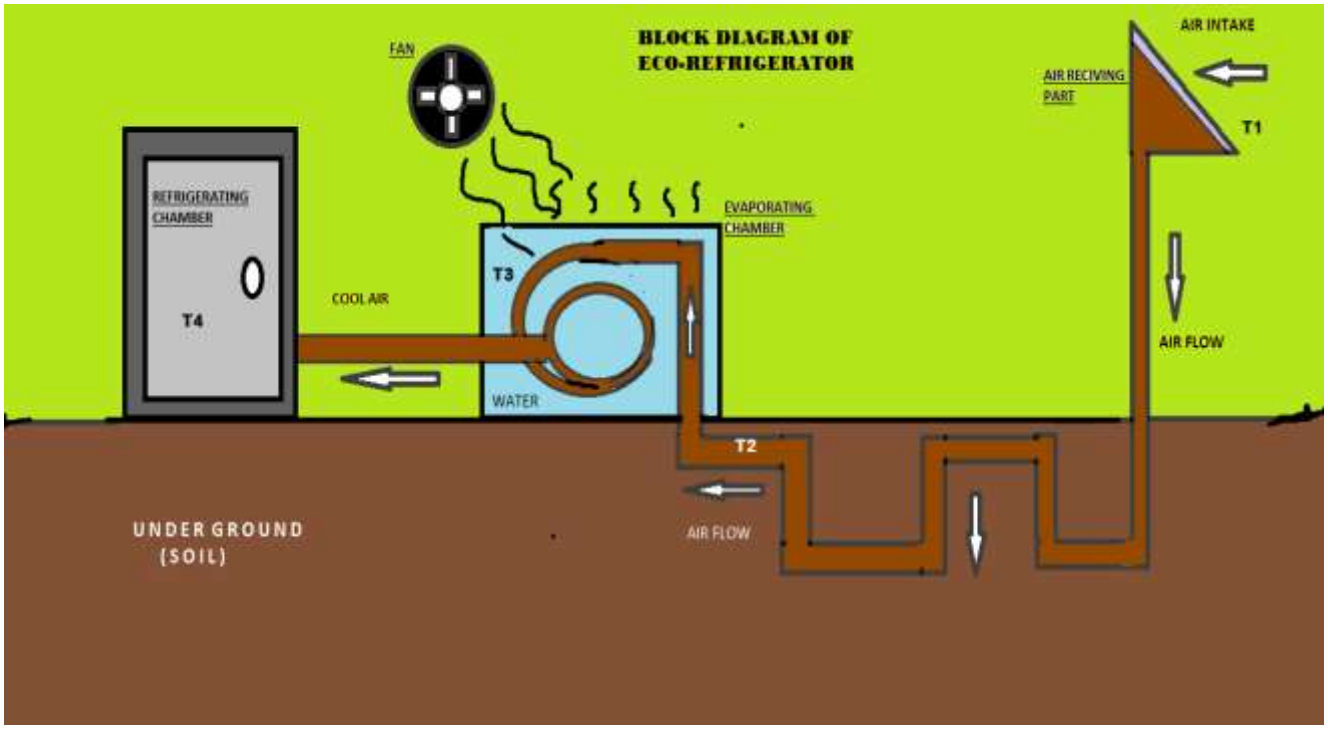

Fig1:- Block diagram of Eco-Refrigerator

1. Air Receiver Unit-: In this air is drawn passively using a funnel or through blower which is moved underground by connecting plastic pipe to the funnel. Blower can be run by a lithium-ion battery of 12V.

2. Copper Tubing:- In underground, plastic pipe is connected to a copper tube that's should be buried underground and arranged in the form a coil, so that when air comes underground through the mechanism of conduction and convection, a drop in the temperature of the intake air takes place. Water should be sprayed atleast 2 times a day for effective heat loss. The diameter of copper pipe should be about 15mm.

3. Evaporation Chamber:- After travelling underground, that air is fed into a chamber where copper tube of diameter 12mm arranged in a helical form is immersed in a water ,so that evaporation could takes place there, due to which sensible cooling would takes place and air inside the coil is chilled to desired temperature. A fan is also placed there to increase the effectiveness of evaporation process which can either run by a 12V lithium ion rechargeable battery or by a solar cell.

4. Refrigerating Chamber: - That chilled air inside the copper tubing is fed to a refrigerating chamber which should be perfectly insulated to prevent any temperature loss. We can use thermocol as the insulating material. In this, food to be preserved can be kept.

5. T_1, T_2, T_3 and T_4 are the temperatures shown by thermal sensors placed at air intake system, in the buried pipe, one in evaporative chamber and one in refrigerating chamber giving us clear idea of the cooling in the whole setup.

CONCLUSION

Our research says that this prototype model of Eco-Refrigerator based on evaporative cooling can be used as an alternative to the conventional refrigerators and the cold storages in the rural area which will provide effective cooling in low investment and can be used conveniently in rural areas for preserving food, farm produce and poultry farm produce etc. It will further definitely help in decrease in food wastage and provides an approach in eradicating Food insecurity. It works more efficiently in high windy areas and where an appreciable amount of relative humidity is found in atmosphere.

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