Design and Fabrication of Solar Modified Air Cooler for Centre Library

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Abstract-
The potential for solar air conditioning is enormous. Summertime, when cooling loads are at their peak, is when sunlight is most abundant. Unfortunately, the technologies that are now in use cannot effectively harness this enormous resource. For instance, photovoltaic (PV) cells are pricey and need a significant area of the roof to generate enough electricity to run an air conditioner. These panels can cost up to ten times as much as a typical air conditioner. The new solar air conditioner adopts a very different strategy. It is a thermally powered system that varies from earlier thermal systems in that it has inexpensive energy storage and is made to function with low-temperature solar collectors. A concentrated salt solution (desiccant, calcium chloride) that can be utilised to provide dehumidification is a kind of energy storage. In order to offer air conditioning, a cooler with a unique heat exchanger design combines cooling from water evaporation with dehumidification from the desiccant.

Key words: Soler energy , Air cooling system , Heat Exchanger, Fabrication etc.

1. Introduction

In general, it would be more economical for a solar-powered environmental management system to fulfil both the heating and cooling needs of the structure it controls. Numerous solar-powered heating and cooling systems have undergone thorough testing, however solar-powered air-Coolers have mostly been the subject of demonstrations. The thermal energy from the sun is captured by solar cooling technologies, which then utilise this heat to produce cold air for homes, businesses, schools, and factories. These innovations eliminate the necessity for using natural gas or electricity. Our reliance on foreign fuels is currently being greatly reduced by the manufacture and installation of solar heating and cooling systems across the globe. In order to grow this quickly expanding, job-generating sector, we need wise policies.

It creates chilly or hot air using solar energy. This technology can be utilised to lessen the mechanical cooling system's negative environmental effects in terms of energy usage. The fact that this system has no moving parts makes it noiseless, noncorrosive, inexpensive to maintain, long lasting, and environmentally beneficial with no possibility for ozone depletion or global warming. Solar cooling systems can be used to either offer comfort cooling or refrigeration for food preservation. Compared to solar heating, solar cooling has less expertise. Only a few brief trials on solar cooling have been reported, despite the fact that several solar heated buildings have been planned, constructed, and used for extended periods of time. However, it is anticipated that in a few years, research will bridge the gap between the two.

2. Problem Identification

Due to what is known as "metabolism," humans emit heat an average of 100 kcal per hour per person. A body temperature of about 36.90 C (98.40 F) is maintained by the human body's internal temperature control system. However, the temperature of the skin varies depending on the ambient temperature and relative humidity. Heat must move from the skin to the surrounding air in order to disperse the heat produced by metabolism and keep the body temperature at a reasonable level. There will be a constant flow of heat from the skin if the temperature outside is somewhat lower than the body's. On the other hand, on a hot summer day, the surrounding temperature is higher than that of the body, preventing the flow of heat from the skin to the surroundings, which causes the person to feel hot. However, if the surrounding temperature is very low, as on a cold winter day, the rate of heat flow from the body will be quite rapid, the person will feel cold. In this case, water from the body evaporates at the skin's surface, dispersing heat produced by metabolism. This aids in preserving a healthy body temperature. However, very little water can evaporate if the ambient air is both hot and extremely humid place from the skin surface, and so the person feels hot and uncomfortable.

3. Objective

The specific objectives of our project are as follows,

- To develop a simple, cheap and portable cooling and heating system which does not require much maintenance and can be easily carried wherever necessary.
- To find out the system applicability, depending on climate which helps heating in winter and cooling in summer.
- To minimize investments in the system costs so it can be cost effective.
- To reduce the energy requirement and also use renewable resources to run the system as maximum energy gets into dehumidifying the air.
- To reduce the use of refrigerants that are harmful and non-eco-friendly. These refrigerants can contribute to global warming and also result in the depletion of ozone layer.

The overall objective of the project is to demonstrate a thermally driven solar air conditioner thathas the potential of being economically viable compared to conventional electrically driven systems. The immediate objectives were to obtain component test data and modeling results that can be used to support the overall project.

4. Literature Review

Adarsh Mohan Dixit, Arjit Raj Sahu (2013)," Water Cooler Double purpose: To produce hot and cold water simultaneously". Evaporator & condenser are used in this simultaneously. Evaporator in the water cooler is not used when condenser is removed and it is replaced by another exchanger. Heat is released on the level of condenser is 3 to 4 times the electric power used by the compressor. Hence in this project they coupled the water cooler to the water heater in order to rise its temperature to an acceptable threshold. During cool weather condition the water cannot be heated sufficiently. Hence we recourse to electric supplement but it also cannot satisfy 90% of our annual needs. In this device the outgoing gas from the compressor will transfer its heat to the water of cumulus to a place that doesn't have ambient air. Then the hot gas goes towards the pressure reducer which is followed by an evaporator and at the end it returns to the compressor to start a new cycle. From this project the refrigeration COP is 3 and the thermal COP is 4 so they deduce that the total COP of the system is 7.They concluded that adding the regenerator of heat on the level of condenser and evaporator will result in increased performance.

Akhilesh Yadav, Rajatkumar Bachan, Dattaprasad Tendolkar, Sankesh Torashkar (2018),"Design & Fabrication of 360 Cooler Cum Heater " As we are in need of heating and cooling simultaneously in many of the rural area in India. This paper helps us to understand the process of evaporative cooling. In this they have created a 360o simple evaporative air cooler in which cooling is achieved by direct contact between the water particles and air stream. In which the minimum outdoor temperature required for successful 360o evaporative cooling is about 35o C and even lower than that. The 360o evaporative cooler depends on the outdoor temperature as well as relative humidity, dry bulb temperature and low wet bulb temperature. This can't be used where relative humidity is high. This system doesn't dehumidify the air but on contrary further humidify air.

Vijay Kumar Kalwa, R Prakash , 2012, "Design & development of solar power air cooler". This research paper gives the information about the problems faced by the excess usage of the non-renewable resources. Room occupants also add the heat to the room since the normal body temperature is much higher than the room temperature. Hence the solution to the problem can be solved by the requirement of the sources which are abundantly available in nature that's Solar Energy.

Maneesh Bhardwaj (2012), "Solar Air Cooling", They stated the major disadvantages of the solar cooler that is ; High cost of manufacturing , low conversion efficiencies & need for continual streams of photons to produce power. The peak output from solar panel can be obtained during Noon hours.

S.A.Abdalla, Kamal N. (2016), "A radiant air-conditioning system using solar driven liquid desiccant evaporative water cooler". They described that the solar driven liquid "desiccant" evaporative cooling system & method used for investigating it's performance is providing cold water for radiant air-conditioning system in Khartoum. For more than decades, Air-conditioning is considered as the reliable & efficient source due the popularity gained by the Vapour Compression Machines. But the air-conditioners produces harmful effects on the ozone layer due to presence of Halogenated Hydrocarbons. In liquid Desiccant Evaporative Cooling process, air is used, dehumidified by desiccant solution to cool water by direct evaporative cooling. It's considered to be modified version of the direct evaporative cooling that can cater for different climatic conditions. They concluded that the system is environmental friendly as it requires low high grade input & improves indoor air quality substantially in energy efficient manner radiant air-conditioning.

R.Sai.Lavanya, Dr. B.S.R.Murthy (2008), "Design of solar using aqua-ammonia absorption refrigeration system", The system invented here works on Ammonia Absorption System which provides refrigeration effect by using two fluids & some quantity of heat input, rather than electrical input as in more familiar vapour compression cycle. In Absorption system, Secondary fluid is used to circulate refrigerant because temperature requirement for cycle falls into low to moderate temperature range. Usage of Absorbent depends on the temperature.

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5. Experimental Diagram

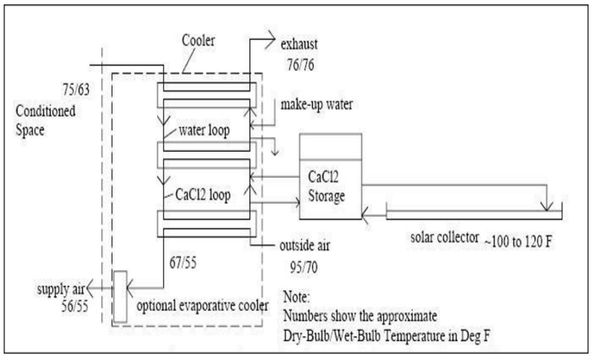


Fig 1. Experimental Diagram of Solar Air Cooling

6. Experimental working

A suggested thermally powered solar air conditioner that fixes the issues of the previous solutions. The main concept is to chill and dehumidify using a desiccant liquid, typically calcium chloride (CaCl). The air is dried off by the chiller using calcium chloride. With exhaust air, water is cooled by evaporation. The figure includes approximate air dry-bulb/wet-bulb temperatures in degrees F for demonstration reasons. This schematic displays the cooler configuration that was considered for this project.

The differential in temperature between a desiccant surface in contact with an air stream and a water surface is what powers this cooler. While the temperature of a desiccant surface corresponds to a higher temperature, that of a water surface is similar to the air's wet-bulb temperature. The difference in temperature between the desiccant equilibrium temperature and the wet-bulb equilibrium temperature for a concentrated calcium chloride solution is roughly 15 to 20 °F. The cooler offers a method for effectively cooling with a desiccant that is only somewhat effective.

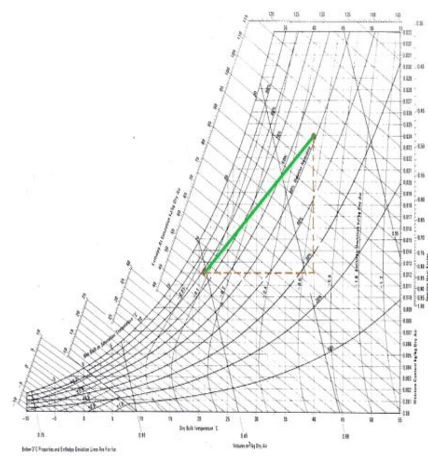
To transfer thermal energy from the entering outside air to the exhaust air, the cooler uses three counterflow heat exchangers. The top heat exchanger in the illustration is a direct contact unit that evaporatively sends water into the exhaust air stream. The water temperature coming out of this heat exchanger is close to the exhaust stream's wet-bulb temperature as it leaves the conditioned room.

The development of extremely affordable, high-performance heat exchangers is a crucial component for making the system function. The heat exchangers must be able to transfer substantial amounts of thermal energy at a small temperature differential in order for calcium chloride to function properly.

The design strategy adopted for this project was to make the most of inexpensive materials, like plastic, in the creation of the heat exchangers, as will be covered in greater detail later. The advantage of plastics is their resistance to water and salt solution corrosion. The drawback of plastic is that it is weaker and has far lower thermal conductivity than metals. Large primary surfaces with minimal pressure variations were used in the design.

7. Results and Discussion

Step 1: Using a sling thermometer, we first determine the wet bulb temperature and dry bulb temperature of the surrounding air in order to determine the relative humidity and temperature of the air that is being stored in a thermion box.
Step 2: Next, we measured the air temperatures that were collected in the thermion box at both times.
Step 3:-At this point, we plot the ambient air conditions and the collected air on a psychometric chart.
Step 4:-After plotting both the condition on psychometric chart, we find out the change inspecific humidity of air.
Step 5:-This change in specific humidity shows the dehumidification process.
Now, during the testing of project we observe following reading-
Dry bulb temperature of surrounding air (t_{dbs}) = 41^{o}c
Wet bulb temperature of surrounding air (t_{wbs}) = 28^{o}c
Dry bulb temperature of collected air (t_{dbc}) =22^{o}c
Wet bulb temperature of collected air (t_{wbc}) =17^{o}c



Psychometric chart

8. Advantages

• As temperatures rise around the world, there will certainly be a greater demand for air conditioning. Considering the rising need for energy, anticipate costs to rise steadily.
• Utilising solar energy to cool our own atmosphere through a solar air conditioning solar panel array is any far more practical, long-term option. When you consider it, the days when you require air-cooling the most are typically the days when the sun is at its highest point.
• The solar air conditioner can operate with accuracy.

Utilising a solar panel to absorb and store heat from the sun as thermal energy by simply warming water, solar air conditioning uses the sun's energy.

9. Limitations

- In cloudy conditions solar collector cannot work properly as sun rays are not uniform.
- $CaCl_2$ is mainly for dehumidifying the humid air but in dry conditions it cannot dehumidify the air as no moisture is present.
- Prolong use of $CaCl_2$ may result in scale formation.
- Slow working process as less moving parts.
- Less efficient due to intermittent supply of suns radiation.
- $CaCl_2$ results in corrosion of heat exchanger parts.
- Process totally dependent on supply of suns radiation.
- $CaCl_2$ have salty odour.
- Precaution is to be taken while handling of $CaCl_2$ as it harms to skin and while making solution it generates loads of heat.

10. Application

A significant alternative among the space-conditioning solutions accessible to the industry is desiccant technology. Desiccant cooling units offer advantages over the more popular vapour-compression and absorption units in many cooling applications. Desiccant systems, for instance, are particularly successful at handling the high humidity loads brought on by ventilation air and do not use ozone-depleting refrigerants. Additionally, they utilise waste heat, natural gas, or solar thermal energy, which reduces peak electric demand.

As a result, during the past few years in the West, the usage of desiccant cooling and dehumidification systems for building comfort conditioning has progressively expanded. Recent developments in adsorptive materials, coupled with novel dehumidifier designs, are enhancing the technology's appeal.

11. Conclusion

We have successfully built the solar air conditioner in accordance with the project's stated plan. This device utilises the desiccant (CaCl2)'s ability to chill air by using sun radiation to dehumidify humid air.

The following observations are made:

• It successfully dehumidifies the humid air in our surroundings. By absorbing atmospheric heat, it also has a cooling effect.

• It is more affordable than other typical electric air conditioners because the whole cost of the project is only about Rs. 3247.00, and it is also less bulky.

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