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A Review on Auto Tracking Solar Operated Air Cooler with Cooling Cabin

Harsha G. Nathjogi[1], Tushar A. Koli[2], Vijay H. Patil[3]
[1]*PG Student, Department of Mechanical Engineering, Godavari College of Engineering, Jalgaon, India*
[2]*Assistant Professor, Department of Mechanical Engineering, Godavari College of Engineering, Jalgaon, India*
[3]*Associate Professor and HoD, Dept. of Mechanical Engg., Godavari College of Engineering, Jalgaon, India*

***Abstract*: In hot and humid conditions the need to feel relaxed and comfortable has become one of few needs and for this purpose utilization of systems like air-conditioning and refrigeration has increased rapidly. These systems are most of the time not suitable for villages due to longer power cut durations and high cost of products. Solar power systems being considered as one of the path towards more sustainable energy systems, considering solar-cooling systems in villages would comprise of many attractive features. This technology can efficiently serve large latent loads and greatly improve indoor air quality by allowing more ventilation while tightly controlling humidity. Despite increasing performance and mandatory energy efficiency requirements, peak electricity demand is growing and there is currently no prevalent solar air cooling technology suited to residential application especially for villages, schools and offices. This project reviews solar powered air cooler with cooing cabin for household food items hence their viability for residential application.**

***Keywords*: Solar energy, Centrifugal fan, Cooling pad, Solar battery**

1. Introduction

This system reveals the comfort conditions achieved by the device for the human body. In summer (hot) and humid conditions feel uncomfortable because of hot weather and heavy humidity. So it is necessary to maintain thermal comfort conditions. Thermal comfort is determined by the room's temperature, humidity and air speed. Radiant heat (hot surfaces) or radiant heat loss (cold surfaces) are also important factors for thermal comfort. Relative Humidity (RH) is a measure of the moisture in the air, compared to the potential saturation level. Warmer air can hold more moisture. When you approach 100% humidity, the air moisture condenses—this is called the dew point. The temperature in a building is based on the outside temperature and sun loading plus whatever heating or cooling is added by the HVAC or other heating and cooling sources. Room occupants also add heat to the room since the normal body temperature is much higher than the room temperature. The present air cooling methods are evaporative coolers, air conditioning, fans and dehumidifiers. But running these products need a source called electricity. The producing of electricity is ultimately responsible for hot and humid conditions, i.e., global warming. Need of such a source which is abundantly available in nature, which does not impose any bad effects on earth. There is only one thing which can come up with these all problems is solar energy. Evaporative cooling is the process by which the temperature of a substance is reduced due to the cooling effect from the evaporation of water. The conversion of sensible heat to latent heat causes a decrease in the ambient temperature as water evaporated provide useful cooling. This cooling effect has been used on various scales from small space cooling to large industrial applications. As water evaporates, it draws energy from its surroundings which produce cooling effect. Evaporative cooling occurs when air, that is not too humid, passes over a wet surface so that the faster the rate of evaporation the greater the cooling and the efficiency of an evaporative cooler depends on the humidity of the surrounding air. Dry air can absorb moisture faster and no cooling occurs in the extreme case of air that is totally saturated with water. Generally, an evaporative cooler is made of a porous material that is fed with water. Hot, dry air is drawn over the material. The water evaporates into the air raising its humidity and at the same time reducing the temperature of the air. For better human comfort, cooling of living or work environment is vital in tropical climates. Researches carried out till date in evaporative air cooling process focus mainly on reducing the dry bulb temperature of the incoming air. Theoretical efficiency of 100% can be realized when dry bulb temperature of the room is equal to wet bulb temperature of the outside ambient air; Evaporative cooling efficiency is defined as the ratio between drop in dry bulb temperature across the cooler and the difference between inlet DBT and inlet WBT. Many researchers have worked on improving evaporative cooling efficiency to the maximum possible extent.

A. Solar Energy in India

Solar power in India is a fast developing industry. The country's solar installed capacity reached 26 GW as of 30 September 2018. India expanded its solar-generation capacity 8 times from 2,650 MW on 26 May 2014 to over 20 GW as on 31 January 2018. The 20 GW capacity was initially targeted for 2022 but the government achieved the target four years ahead of schedule. The country added 3 GW of solar capacity in 2015-2016, 5 GW in 2016-2017 and over 10 GW in 2017-2018, with

the average current price of solar electricity dropping to 18% below the average price of its coal-fired counterpart. In January 2015 the Indian government expanded its solar plans, targeting US$100 billion in investment and 100 GW of solar capacity (including 40 GW from rooftop solar) by 2022. India's initiative of 100 GW of solar energy by 2022 is an ambitious target, since the world's installed solar-power capacity in 2017 is expected to be 303 GW. The improvements in solar thermal storage power technology in recent years has made this task achievable as the cheaper solar power need not depend on costly and polluting coal/gas/nuclear based power generation for ensuring stable grid operation. In addition to its large-scale grid-connected solar PV initiative, India is developing off-grid solar power for local energy needs. Solar products have increasingly helped to meet rural needs; by the end of 2015 just under one million solar lanterns were sold in the country, reducing the need for kerosene. That year, 118,700 solar home lighting systems were installed and 46,655 solar street lighting installations were provided under a national program; just over 1.4 million solar cookers were distributed in India.

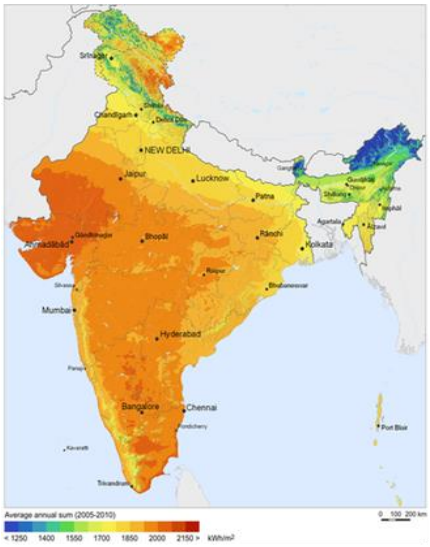

Fig. 1. Solar energy in India

In January 2016, Prime Minister Narendra Modi and French President François Hollande laid the foundation stone for the headquarters of the International Solar Alliance (ISA) in Gwal Pahari, Gurgaon. The ISA will focus on promoting and developing solar energy and solar products for countries lying wholly or partially between the Tropic of Cancer and the Tropic of Capricorn. The alliance of over 120 countries was announced at the Paris COP21 climate summit. One hope of the ISA is that wider deployment will reduce production and development costs, facilitating the increased deployment of solar technologies to poor and remote regions. A report published by the Institute for Energy Economics and Financial Analysis (IEEFA) found that India installed 10 GW of solar in 2017, almost double its record in 2016. Crucially, India's "Scheme for Development of Solar Parks" has proven successful at attracting foreign capital toward construction of the world's largest ultra-mega solar parks.

2. Literature review

The purpose of this paper to review the critical points of the project from the referred works.

O. Amer, R. Boukhanouf, and H. G. Ibrahim , 'A Review of Evaporative Cooling Technologies'[1],Air-conditioning plays an essential role in ensuring occupants thermal comfort. However, building's electricity bills have become unaffordable. Yet the commercially dominant cooling systems are intensively power-consuming ones, i.e. vapor compression systems. This paper aims to review the recent developments concerning evaporative cooling technologies that could potentially provide sufficient cooling comfort, reduce environmental impact and lower energy consumption in buildings. An extensive literature review has been conducted and mapped out the state-of-the-art evaporative cooling systems. The review covers direct evaporative cooling, indirect evaporative cooling and combined direct-indirect cooling systems. The indirect evaporative coolers include both wet-bulb temperature evaporative coolers and dew point evaporative coolers have been of particular interest because of high thermal performance. The dew point evaporative coolers have shown great potential of development and research opportunity for their improved efficiency and low energy use.

Miss.Namrata Govekar, Mr.Akshay Bhosale, Mr.Amol Yadav, 'MODERN EVAPORATIVE COOLER' [2], Human always tries for better comfort and sophistication at each level of his life. Considering air conditioning, evaporative cooler is used in dry climates. But such evaporative coolers are not suitable in humid environment and also their performance is poor in the places where ventilation is not proper. Reason behind this is nothing but, uncontrollable humidity increment in the working environment (cabin) due to process of evaporation. Report is sequential details about research carried out on the evaporative cooler in order to remove this disadvantage. The important parameter in whole report is nothing but relative humidity which should be maintained in specific range for getting better thermal comfort. Report briefly explains the basic concept required to understand evaporative cooling and performance of evaporative cooling. It also explains why evaporative cooler is not as effective as air conditioners.

Akhilesh Yadav, Rajatkumar Bachchan, Sankesh Toraskar, Dattaprasad Tendolkar, Prof. Ramankumar, 'Design and Fabrication of 360 cooler cum Heater'[3], This paper is based on innovation to conventional coolers. In conventional or normal cooler we get one directional air flow only. This cooler is designed in such a way that the people sitting in any area in the room will get equivalent cooled air. The cubical cooling chamber consist of four cooling pads. The exhaust fan in mounted above the chamber, below which the heating coil is mounted. Thus this cooler can be used as a heater in winter

season and as a cooler in a summer season.

Sunil J. Kavle, Vivek M. Shahane, Nivrutti Satpute, Vitthal N. Garje, Prof. Shrikant D Jadhav, '*Manufacturing Of 360 Degree Rotation Air Cooler'*[4], India's energy demands are expected to be more than double by 2030, and there is a pressing need to develop ways to conserve energy for future generations. Thus energy consumption can be reduced drastically by using energy efficient appliances. In India, the Union ministry of power's research pointed out that about 20-25% of the total electricity utilized in government buildings in India is wasted due to unproductive design, resulting in an annual energy related financial loss of about Rs. 1.5 billion. Conventional heating ventilation and air conditioning systems (HVAC) consume approximately 50% of the building energy. This type of air conditioning is therefore neither eco- friendly nor sustainable. Selection of proper air conditioning system for buildings can not only help the country save electrical energy but also reduce greenhouse emissions. An evaporative cooler (also swamp cooler, desert cooler and wet air cooler) is a device that cools air through the evaporation of water. Evaporative cooling differs from typical air conditioning systems which use vapor-compression or absorption refrigeration cycles. Evaporative cooling works by exploiting water's large enthalpy of vaporization. The temperature of dry air can be dropped significantly through the phase transition of liquid water to water vapor (evaporation), which can cool air using much less energy than refrigeration. In extremely dry climates, evaporative cooling of air has the added benefit of conditioning the air with more moisture for the comfort of building occupants. Evaporative cooling, being used by mankind for centuries is based on a very simple principle. When a hot and dry air is allowed to pass through a wet pad, the temperature of incoming air is reduced with an increase in specific humidity as some water from the pads is evaporated taking the latent heat of vaporization from the incoming air. 360 air cooler is cheaper than air conditioning also consumes less power than air conditioning. Externally mounted evaporative cooling devices were used in some automobiles to cool interior air—often as aftermarket accessories until modern vapor-compression air conditioning became widely available After some time air may be sufficiently cooled by 360 Evaporative process, results in considerable increase of humidity. For better effect add ice cube or chilled water in bottom tank.

Rajesh Maurya, Dr. Nitin Shrivastava, Vipin Shrivastava, 'Performance Evaluation of Alternative Evaporative Cooling Media' [5], In this paper different cooling pads have been studied. Three types of cooling pad made of a cellulose, aspen fiber, and coconut coir were comparatively studied. This study is performed in summer and based on weather conditions of Bhopal, India; maximum dry bulb temperature of air 41.2 ˚C and 26.1 ˚C wet bulb temperature. The relative humidity of 31.1 % is carried out from online psychometric calculator. The primary air velocity considered varies between 0.5 m/s to 3.0 m/s and the performance of the cooling pads are analyzed based on the saturation efficiency, leaving air temperature, specific humidity, relative humidity, cooling capacity and water consumption. Graphs are plotted for variation in Saturation efficiency and cooling capacity for different materials of pad with air mass flow rate. Saturation efficiency of the cooling pads made of cellulose was in the ranges of 64.55 to 55.29 %, for aspen it was 80.99 to 68.86%, and for coconut coir 68.15 % to 50.79 % was observed. It is seen that the saturation efficiency decreases with increase in velocity of air and the cooling capacity increases with air velocity. It is also observed that the Aspen fiber has higher efficiency while coconut coir has lower and the water consumption rate increases with air mass flow rate.

Alosaimy A S (2013), "Application of Evaporative Air Coolers Coupled with Solar Water Heater for Dehumidification of Indoor Air" [6], In the present work, novel configuration of solar powered desiccant dehumidification system is investigated. The proposed system comprises two evaporative air coolers. One of the two coolers functions as an absorber and the second, which is coupled with solar water heater, functions as a desiccant regenerator. In the experimental part of this investigation, Calcium Chloride is regenerated using solar energy. Hot water from a solar collector is circulated through an air heater to regenerate the liquid desiccant. Mathematical model, which can be applied for analysis of the proposed system, is developed. Absorption-regeneration cycle for the dehumidifier is described and analyzed. An expression for the efficiency of the simple cycle is introduced. Theoretical analysis shows that strong and weak solution concentration limits play a decisive role in the value of cycle efficiency. System efficiency with consideration of heat and work added to the system is well defined. The limits of regeneration temperature and mass of strong solution per kg of produced vapor are found highly dependent on the operating concentration of desiccant. Experimental results show that solution with 30% concentration can be regenerated up to 50% using solar energy. Good agreement is found between the trained data of the ANN model and the experimental measurements for the whole range of the air inlet temperature.

*Farhan Khmamas (2012), "Improving the Environmental Cooling for Air-Coolers by Using the Indirect-Cooling Method" [*7] , Air-coolers are widely used as a cheap and convenient method for cooling; however, noise, humidity, smoking, and difficulty in controlling the interior temperature are its major disadvantages. In this research, we suggest using the indirect evaporative cooling method instead of the direct method. In this method the air-cooler is modified to operate as a cooling tower to produce cooling water by the evaporation process; this represents the outdoor unit. The cooled water is pumped to the indoor unit which consists of a fan coil unit. Many experiments were carried out to calculate the Evaporation Cooling Effectiveness (ECE) in case of the direct and indirect cooling (forced or natural). The results for the two cases were compared. It is concluded that the (ECE) reduces by 15% for

forced evaporation case, and by 22% for the natural case, as compared with the direct case and (with in 30/5/2008 and 16/6/2008).

*Aayush Sharma, VarunVaidya and K.Jamuna (2017 IEEE),"Design of an Automatic Solar tracking controller"[*8] ,Each day sun illuminates the whole earth by rising in east and setting in the west. The parallel rays of the sun irradiating directly gives the best output and hence the panel must directly face the sun throughout the day for maximum efficiency. The designed solar tracker is controlled using controllers and servo motor to obtain the good performance. The system can be programmed to rotate at various step angles as per need and also the sensitivity of the system can also be altered giving much greater flexibility over traditional systems. The system has been designed for single axis tracking but the algorithm can be extended to be used for dual axis tracking as well.

*Jing Xu, Kaihua Wu, Li Ma3 (2009 IEEE) "All-Weather Automatic Solar Tracking Method Applied in Forest Fire" [*9] , The monitoring equipment of forest fire prevention usually needs all-weather supply of electric power. But most of solar power systems applied in forest fire prevention use fixed-mounted solar panels. This problem results in low efficiency of electricity generation. Thus the area of solar panels has to increase to meet electricity demand of the equipment. An all-weather automatic solar tracking method was proposed, which combined the photoelectric detection and the solar trajectory tracking modes. The method used a sunlight intensity sensor to estimate weather conditions firstly. Then it utilized a solar position sensor and a solar trajectory algorithm to determine the changes of solar position. Finally, different tracking models were taken to track the sun in sunny, cloudy and rainy days. Through simulation experiments, this method could effectively reduce the impact of weather change and ensure to track the sun stably and accurately all weather.

*Abdul Al-Azzawi, Wahab Almuhtadi (2010 IEEE) "New Air Cooler with Low Power Consumption"[*10] , Energy saving mechanism is the reason behind this research project that led us to design, develop and build a new evaporative air cooler unit with high efficiency and low power consumption. This was done by designing a new water distribution system that eliminated the water pump of the standard unit and modifying its mechanical parts. Also, design of an intelligent controller was added to optimize performance of the new unit. This prompted to attain lower energy consumption, longer mean time between failures, lower maintenance, and independence from the power grid. Several tests and analyses have been conducted on both the newly designed unit and the standard unit. The new design delivered air with noticeably higher humidity and lower temperature than the existing unit. The low energy consumed by newly designed unit, also led to a reduction in size of the proposed photovoltaic solar panels as a Power source.

3. Problem definition, objectives

A. *Problem definition*

- The producing of electricity is ultimately responsible for hot and humid conditions, i.e. global warming. As in below shown chart it is clear that major quantity of electricity is produced by coal (fossil fuel).
- Fossil fuels also contain radioactive materials, mainly uranium and thorium, which are released into the atmosphere.
- Electricity generation produces nitrogen oxides and Sulphur dioxide emissions, which contribute to smog and acid rain, emit carbon dioxide, which may contribute to climate change.
- Longer power cut durations in villages and high cost of cooling products.

B. *Objectives*

- To make aware of non-conventional energy sources to reduce environmental pollutions.
- This product preferably suitable for villages, because they face lot of power cut problems in summer (around 12 to 14 hrs. in day). And for offices and schools which runs in day to which save energy.
- As air-conditioning and refrigeration consumes more power and mainly cost of refrigerating and air conditioning products are very high. So would like develop product which runs by solar energy and provide cooling effect for house hold food items at lower cost.

4. Methodology

A. *Solar energy conversion*

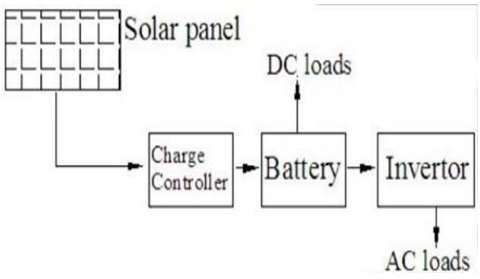

Fig. 2. Solar energy conversion process

Solar energy conversion is done by using battery, inverter and charge controller. As sun light falls on solar panel, which converts into electrical energy by photoelectric effect. This electrical energy stored in battery in the form of chemical energy. Charge controller is employed in between solar panel and battery which prevents overcharging Figure1: Solar energy conversion process and may protect against overvoltage, which can reduce battery performance or lifespan, and may pose a safety risk. The stored energy directly can use for DC loads or else need to be converted AC (alternate current) by the help of inverter.

B. Cool air generation by centrifugal fan

The converted energy is used to run the centrifugal fan. This fan covered with cooling pads, through which water is passed at a specific rate. As the fan sucks the hot air through cooling pads, heat transfer occur between air and water thus generated cool air enters into the room.

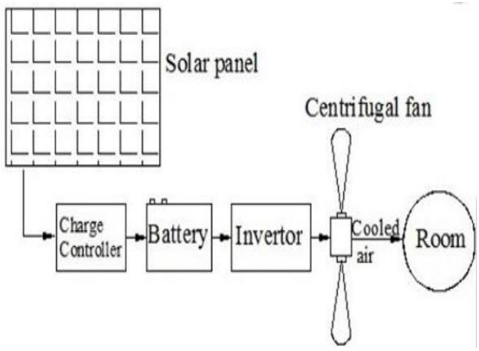

Fig. 3. Process of cool air generation by centrifugal fan

5. Conclusion

- So as comparing the cost of this product with the existing products in the market is, solar product appeals better and affordable by common people.
- This solar product will perfectly suits for villages, schools and offices and thus prevention from the power cut problems.
- It will comprises of many attractive features such as usage of solar energy, cooler and cooling cabin at lower cost.
- This method is eco-friendly and natural, electricity savers.
- Durability of our product is more thus minimizing the cost.
- No electricity will spent so this product saves the energy and saves environment from getting polluted.

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