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Design And Fabrication Of Solar Air Humidifier

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Abstract: **The present air humidifier methods are evaporative coolers, air conditioning, fans and dehumidifiers which are powered by electricity. In current scenario the production of electricity is tedious process and which are from non renewable resources. In hot and humid conditions the need of 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. So the use of renewable energy resource is the solution to this problem that is solar energy which is clean and eco-friendly .The aim of the project is to use the solar energy to power the air humidifier. The idea is to use solar energy to power the air humidifier which works on the combined effect of direct and indirect evaporative cooling .This technology can efficiently serve large in villages, hot and humid places where there is longer power cuts. Despite increasing performance and mandatory energy efficiency requirements, peak electricity demand is growing and there is currently no prevalent solar air humidifier technology suited to residential application especially for villages, schools and offices. This project reviews solar air humidifier for residential.**

Keywords: Evaporative cooling (Direct and indirect), *Solar energy, Ventilator motor (fan).*

1. INTRODUCTION

In summer season, humans feel uncomfortable because of hot weather. So it is necessary to maintain thermal comfort conditions. Thermal comfort is determined by the room's temperature, humidity and air speed. Relative humidity (RH) is also important factor determining the thermal comfort for humans. It is the measure of the moisture in the air. Inorder to maintain the thermal comfort for humans, the air humidifiers, air coolers is the solution. But the air humidifiers are powered by electricity. The production of Electricity is tedious process and which is from non renewable resources. In villages, towns where there is longer power cuts, so the use of conventional of air humidifiers does not serve the purpose. So the solution is use of renewable energy resource that is solar energy to power the air humidifier which works on the combined effect of evaporative cooling(direct and indirect). The solar air humidifier is the best solution in villages, hot and humid places. The solar air humidifier is best suited for residential purpose.

II. Evaporative cooling

As water is evaporated, energy is lost from the air, reducing the temperature. This is the principle of evaporative cooling. Evaporative cooling works by using the water's large enthalpy of vapourization. The dry air's temperature can be reduced sufficiently through the phase change of liquid water to water vapour (evaporation). This principle is used cool air using much less energy than refrigeration. In dry climates and arid conditions, evaporative cooling has the added benefit of conditioning the air with more moisture for the comfort of building occupants.

The cooling potential for evaporative cooling of the air is depends on the wet bulb depression, the difference between dry-bulb temperature and wet-bulb temperature. In arid climates, evaporative cooling can used to reduce energy usage and total equipment. It can be as an alternative to compressor-based cooling. Evaporative air coolers lower the temperature of air using the principle of evaporative cooling. Evaporative cooling is the process of humidifying the air, which causes a lowering of the temperature of the air. The energy needed to evaporate the water is taken from the air in the form of latent heat of vapourization of water, which affects the temperature of the air. The energy present in the water vapour component of the air, whilst the air remains at a constant enthalpy value.

2.1. Direct Evaporative cooling: Direct evaporative cooling (open circuit) is used to lower the temperature and increase the humidity of air by using large enthalpy of evapourization, through the phase change from liquid water to water vapour. In this process, the energy in the air is not changed. In this process, Warm dry air is changed to cool moist air. The heat of the outside air is use to change the phase from liquid water to water vapour. The RH increases to 70 to 90% which reduces the cooling effect of human perspiration. The moist air has to be continually released to outside or else the air becomes saturated and evaporation stops.

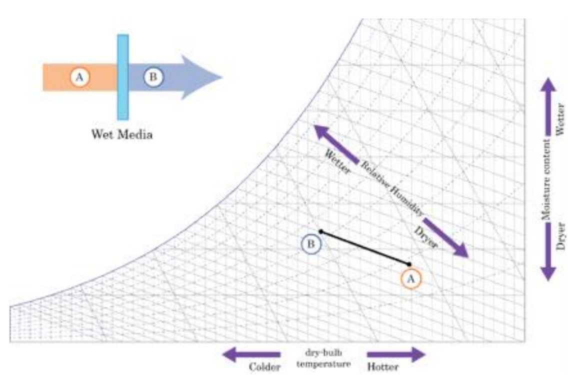

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Fig1: direct evaporative cooling

2.2. Indirect Evaporative cooling: Indirect evaporative cooling (closed circuit) is a cooling process which uses direct evaporative cooling and also heat exchanger to transfer the cool energy to the dry air. The cooled moist air from the direct evaporative cooling process does not comes in direct contact with the conditioned supply air. The moist air stream is released outside or used to cool other external devices such as solar cells which are more efficient if kept cool. One indirect cooler manufacturer uses the so-called Maisotsenko cycle which uses multi-step heat exchanger that can reduce the temperature to the temperature below the wet-bulb temperature. While no moisture is added to the incoming air but the relative humidity (RH)of air does rise a little according to the Temperature-RH formula. Indirect Cooling is an effective technique used for hot-humid climates where we cannot afford to increase the moisture content of the supply air due to indoor air quality and human thermal comfort concerns. The following graphs describe the process of direct and indirect evaporative cooling with the changes in temperature, moisture content and relative humidity of the air.

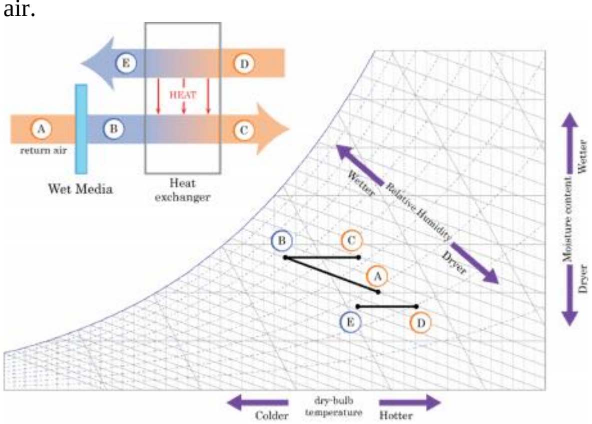

Fig2: Indirect Evaporative cooling

III. Objective of the Project

The objective of the project is to use solar energy to power the air humidifier which works on the combined effect of direct and indirect evaporative cooling. This is useful in arid places and villages where power cuts longer.

VI. Working Methodology

This project mainly consist of two sections:

4.1. Conversion of Solar energy: Conversion of Solar energy is done by using solar panel, battery, inverter and charge controller. Solar panel converts solar energy from sunlight into electrical energy by photoelectric effect. This electrical energy stored in battery in the form of chemical energy. Charge controller is used to prevent overcharging of the battery and protect against overvoltage. The stored energy directly can use for DC loads or else need to be converted AC (alternate current) by the help of inverter.

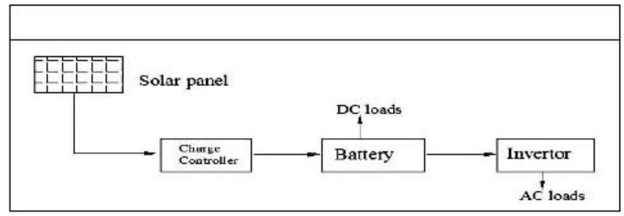

Fig3: Conversion of Solar Energy

4.2. Cool air generation by ventilator motor: The electrical energy from inverter is used to run the ventilator motor (fan). This ventilator motor (fan) covered with cooling pads, through which cool 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. The partly cool air is allowed to pass over the copper coil which at front of the ventilator motor. The water is pumped through the copper coil where heat transfer occurs between air and water. This is combined effect of direct and indirect evaporative cooling. Now cool air enters into the room.

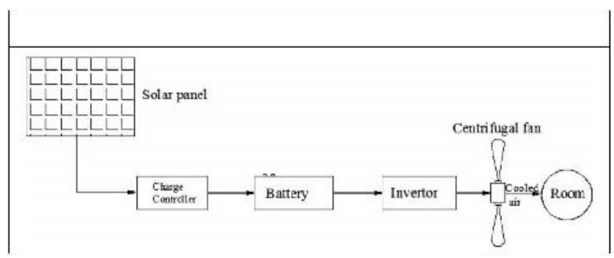

Fig4. Cool air generation by ventilator motor

V. Working Model

The model is powered by solar energy. Components used in this model are solar panel, battery, charge controller, inverter, ventilator motor (fan), cold water tank, cooling pads, water pump and copper coil. Solar panel is used to convert solar energy (sunlight) into electrical energy by means of photovoltaic effect. The electrical energy generated is stored in the battery for through charge controller which prevents from overcharging and power fluctuations. As AC ventilator motor (fan) is used for cooler, so we need to convert DC load from the battery to AC load by the help of inverter. The ventilator motor (fan) is surrounded by cooling pads and copper coil in the front of the fan through which continuous water supply is provided from cold water tank with the help of pump. When the fan is switched on, fan sucks atmospheric air through the cooling pads and copper coil, mean time heat transfer occur between water and air, this is combined effect

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of direct and indirect evaporative cooling. Thus the cool air enters into the room thereby providing required thermal comfort conditions.

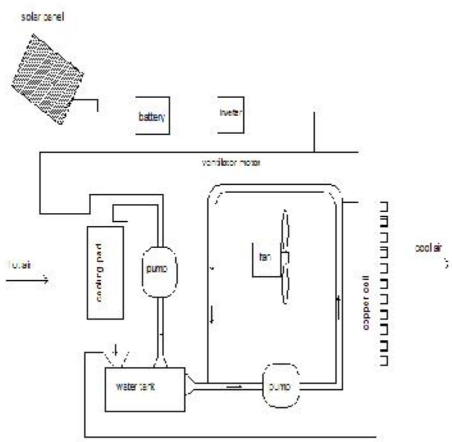


Fig5. Model Diagram

I.

VI. DESIGN CONSIDERATIONS OF THE PROJECT

6.1. Capacity of the fan: Criteria: With supply of water through the cooling pads and copper coil.So, heat transfer between water and the air is given by following equation

$$m_w*(T_1-T_2) = \quad ha_1-ha_2)-(w_1-w_2)\ T_2] \qquad (1)$$

Where as

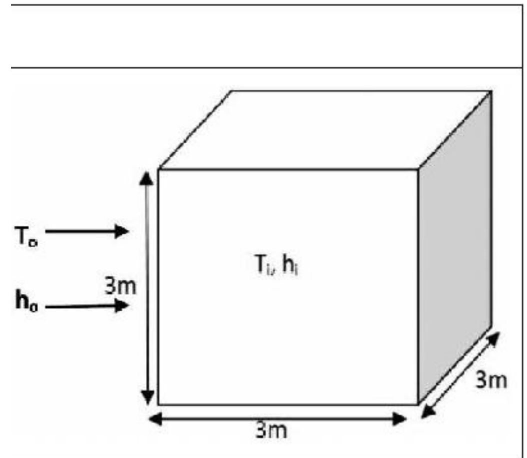
m_w – Mass of water entering into the cooling pads per minute
V- Volume of air (m^3) entering into the room per minute (min)
V_{s1} – Specific volume of air entering into the cooling room
ha_1 – Enthalpy per kg of dry air at T_1 ha_2 – Enthalpy per kg of dry air at T_2
w_1 – Mass of vapour per kg of dry air at T_1
w_2 – Mass of vapour per kg of dry air at T_2 Considered conditions,
T_1 = 30 °C and T_2 = 25 °C

m_w = 2 kg of water per minute (assume)
From: Psychometric chart

ha_1 = 72.5 KJ/Kg of dry air = 17.31 kcal/kg

ha_2 = 56 KJ/Kg of dry air = 13.37 kcal/kg
w_1 = 0.016 grams/kg of dry air
w_2 = 0.012 grams/kg of dry air
V_{s1} = 0.880 m^3/kg
Substituting above mentioned values in Equation (1) v= 2.5 m^3 / min

Relative humidity = 60%
So the fan capacity of 2.5 m^3/min is selected.



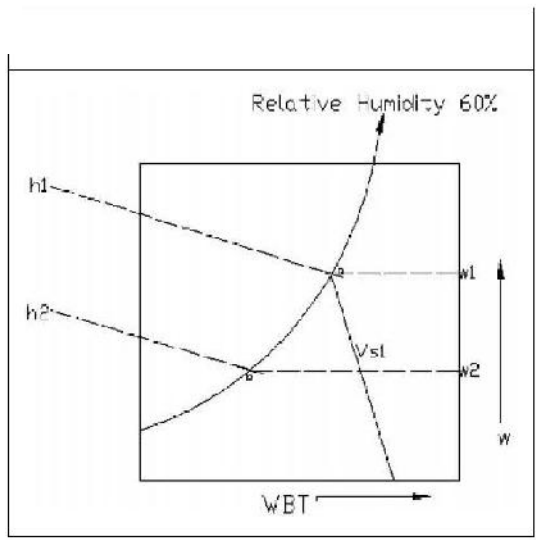


Fig6. Psychometric chart.

6.2. Capacity of solar panel: Hence selected Ventilator motor (Fan) Specification: 230 v, 50 Hz, 35 W

So to run 35 W blower on for 1 hour will take

35*1 = 35 Wh from the battery (Battery capacity is measured in Amp hours)

Convert this to watt hours by multiplying the Ah by the battery voltage

For 10 Ah, 12 v battery the watt hours is given by

$$P = V*I \qquad ...(2)$$

V = 12 v and I = 10 Ah
P = 10*12 = 120 Wh

So, the 35 W centrifugal fan runs for 120/35 = 3.5 h

This means the battery could supply 35 W blower for 3 $_2{}^1$ hours.

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Energy generating capacity of solar panel over a period of time:

To calculate the energy it can supply to the battery,

Materials and Components	Cost
Ventilator Motor (fan) 35 W	1000
Water Pump	700
Cooling Pad	500
Solar Panel 12 V 50W	2750
Battery 12V,10Ah	1500
Frame and other parts	1000
Total	7450

multiply watts by the hours exposed to sunlight, and by 0.85 (This factor allows for natural system losses).

For the solar 50 W panel in 4 hours sunshine, 50*4*0.85 = 170 Wh
For 1 hour, 50*1*0.85 = 43 Wh

So the solar panel of 50 W and battery of 10 Ah are selected (domestic purpose).

VII. Results and Discussion

The output of this model is to provide Comfort thermal conditions achieved in the room. The room temperature up to 25°C and relative humidity of 60% can be achieved.

IX. Conclusion

The cost of this model better and affordable by common people. This solar product perfectly suits for villages and arid places where there is power cuts problems. The above model is eco friendly and natural, electricity savers. No electricity is spent so this product saves the energy.

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