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Design and Development of Solar Powered Air Cooler

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Abstract: ***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. 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 for residential and industrial applications.***

Keywords: Solar energy, Centrifugal fan, 3D modelling, Cooling pad, Solar battery C10

1. Introduction

This paper 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. 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.

2. Present Problem

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, which contribute to smog and acid rain, emit carbon dioxide, which may contribute to climate change.

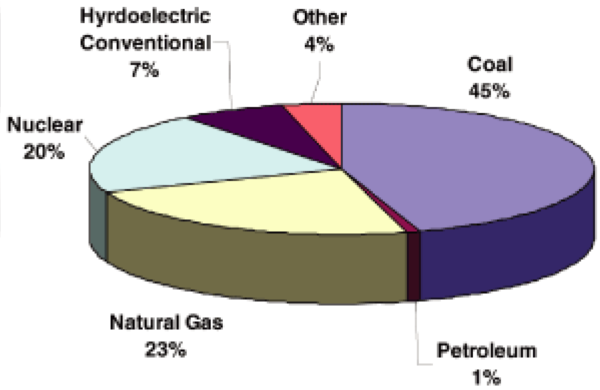

Figure 1: Production of electricity from different sources

- Longer power cut durations in villages and high cost of cooling products.

3. Proposed Solution

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.

3.1 Objective the Project

- To make aware of non conventional energy sources to reduce environmental pollutions.
- To provide solution for power cut problems in villages.
- To replace existing costlier and high energy consumption cooling methods.

4. Working Methodology

This project mainly consist of two sections:

4.1 Solar Energy Conversion

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 Figure 2: 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.

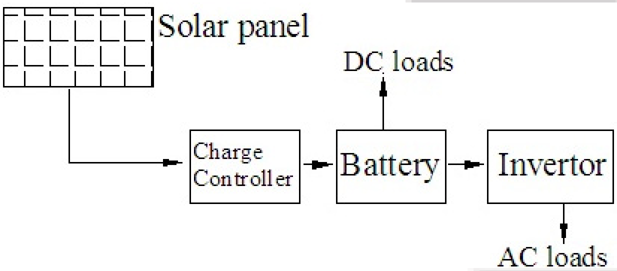

Figure 2: Solar energy conversion process

4.2 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.

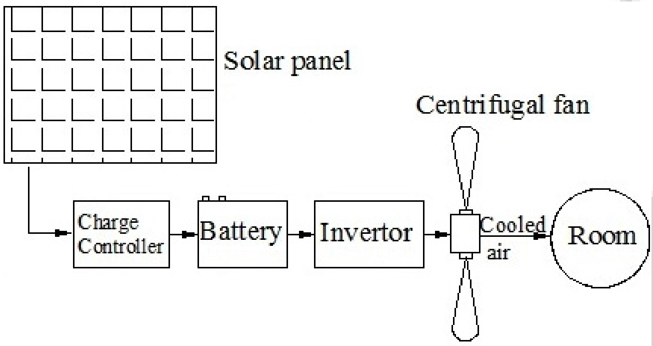

Figure 3: Process of cool air generation by centrifugal fan

5. Working Model of the Project

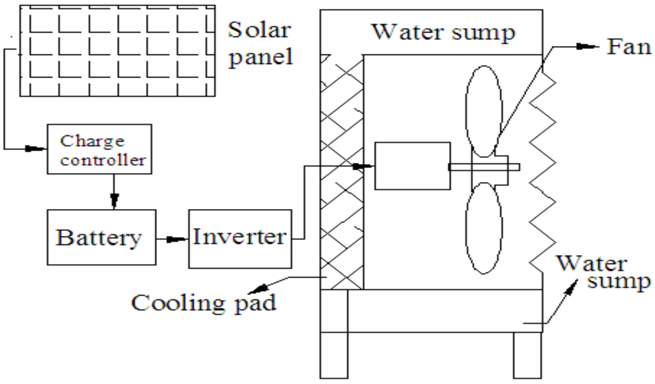

Figure 4: Solar powered air cooler

This concept is driven by solar energy. Components involved in this concept are solar panel, battery, charge controller, battery, inverter, blower, ceramic slabs and cooling pads. Solar panel is employed to convert sun light into electrical energy by means of photovoltaic effect. The generated electrical energy is supplied to the battery for storage purpose through charge controller which prevents from power fluctuations. As AC blower is used for cooler, so need to convert DC load from the battery to AC load by the help of inverter. Inverter converts DC load to AC. Load, now AC power can be supplied to the blower. This blower is surrounded by cooling pads through which continuous water supply is provided. When the blower is switched on, blower sucks atmospheric air into the cabin through the cooling pads, mean time heat transfer occur between water and air, so the cool air enters into the room thus providing required thermal comfort conditions.

6. Design Considerations of the Project

6.1 Capacity of the fan required

Criteria: With supply of water through the cooling pads.

So, heat transfer between water and the air is given by following equation

$$m_w*(T_1-T_2) = \frac{V}{v_{s1}}[(ha_1-ha_2)-(w_1-w_2)\, T_2] \qquad (1)$$

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)

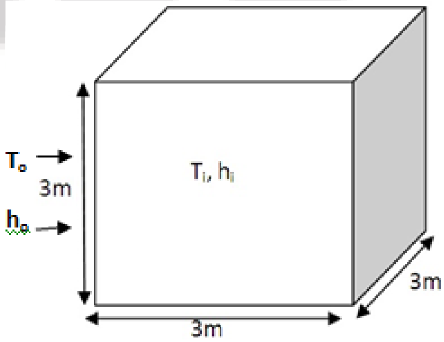

Figure 5: Room Considered

V_{s1}- Specific volume of air entering into the cooling room
h_{a1}- Enthalpy per kg of dry air at T_1
h_{a2}- 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,
$T_1=30^oC$ & $T_2=25^oC$
Relative humidity= 60%
m_w=2kg of water per minute (assumme)

From: Psychometric chart
h_{a1} =72.5 KJ/Kg of dry air
= 17.31kcal/kg
h_{a2} =56 KJ/Kg of dry air
= 13.37 kcal/kg

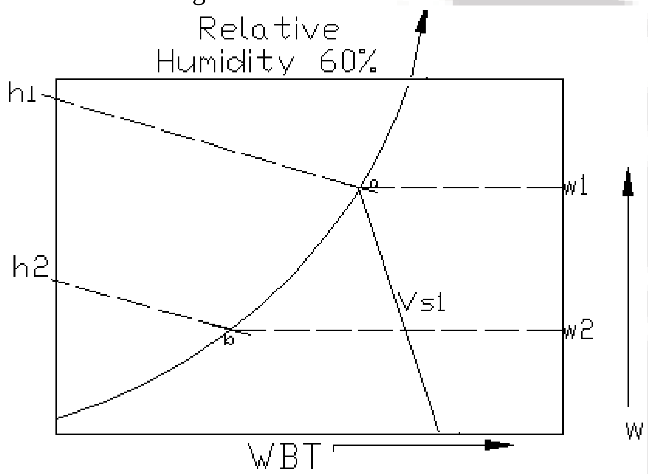

Figure 6: Psychometric chart

w_1=0.016grams/kg of dry air
w_2=0.012 grams/kg of dry air
$V_{s1}=0.880m^3/kg$
Substituting above mentioned values in equation (1)

$$2*(30-25) = \frac{V}{0.880}[(17.31-13.37)-(0.016-0.012)*25]$$

$V=2.291m^3/min \approx 2.5m^3/min$
So the fan capacity of $2.5m^3/min$ is selected.

6.2 Capacity Solar Panel and Battery required

Hence selected Blower (Fan) Specification: 230v, 50Hz, 35W
So to run 35W blower on for 1 hour will take

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

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

$$P=V*I \quad (2)$$

V=12v and I=40Ah

P= 40*12=480Wh

So, the 35W centrifugal fan runs for

120/35=13.71≈14h

This means the battery could supply 35W blower for 14 hours.

To calculate the energy it can supply to the battery, multiply watts by the hours exposed to sunlight, then multiply the result by 0.85(This factor allows for natural system losses)

For the solar 40W panel in 4 hours sunshine, 40*4*0.85 = 136Wh

For 1 hour, 40*1*0.85 = 34Wh

So the solar panel of 40W and battery of 40Ah are selected (Office purpose).

7. 3D Modelling of the Cooler Fan

Modelling of the cooler fan has been done with the help of modeling software NX 8.0, formerly known as NX Unigraphics, is an advanced CAD/CAM/CAE software package developed by Siemens PLM Software. Below shown images are captured from NX8.

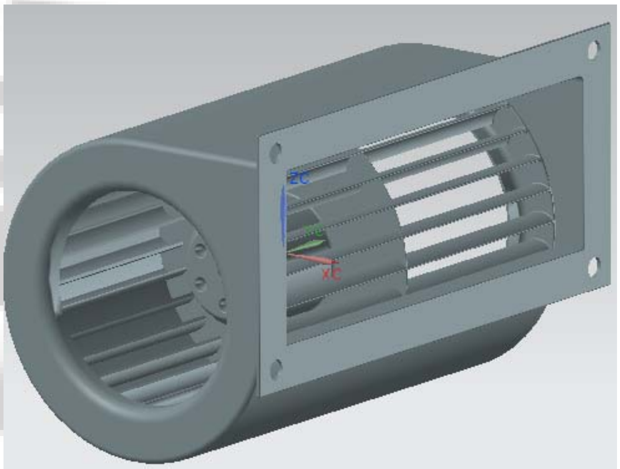

Figure 7: 3D model of the impeller

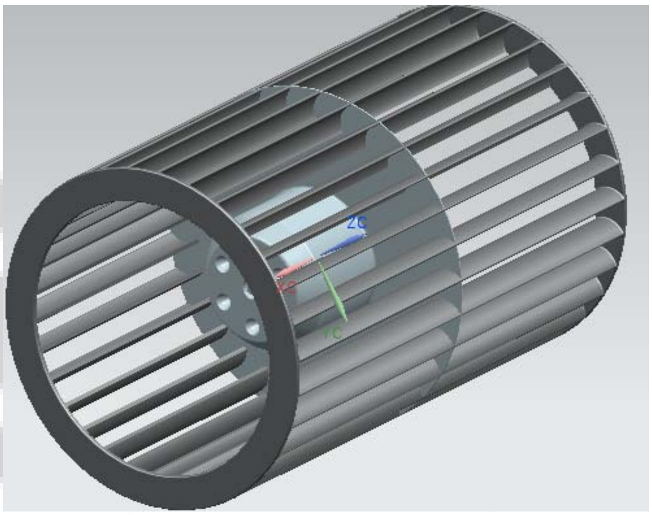

Figure 8: Impeller inserted in casing

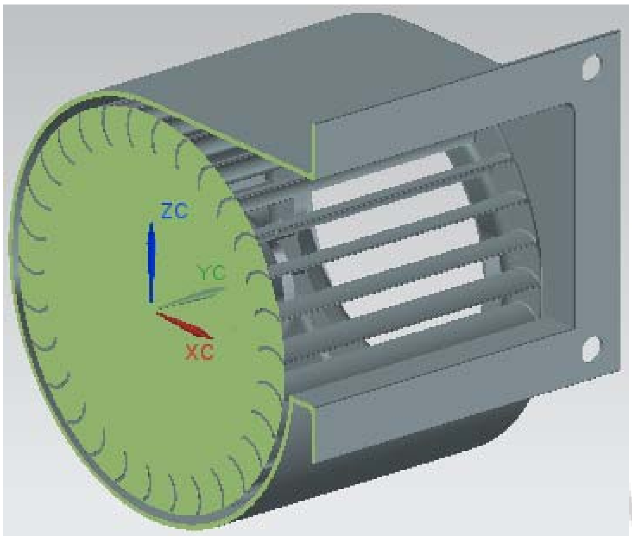

Figure 9: Section view of the fan

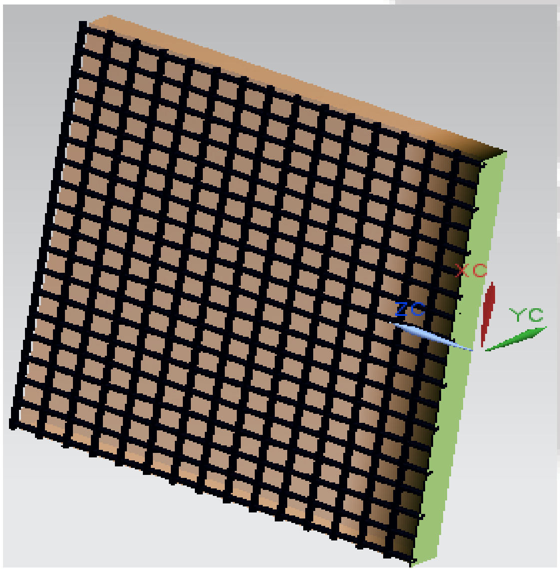

Figure 10: Cooling pad placed between metal meshes

8. Results and Discussion

The output of the project is Comfort thermal conditions achieved in the living room. That is room temperature up to 25^{o}C and relative humidity of 60%.

Table 1: Cost estimation

Sl. No.	*Components name*	*Qty.*	*Cost (Rs.)*
1.	Solar panel	1	3000
2.	Fan	1	1000
3.	Cooling Pad	2	200
4.	UPS	1	2000
5.	Frame material	-	600
6.	Miscellaneous	-	150
	Total		6950

9. Conclusion

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 perfectly suits for villages, schools and offices and thus an alternate to the power cut problems. It comprises of many attractive features such as usage of solar energy, cooler and cooling cabin at lower cost. It is eco friendly and natural, electricity savers. Durability of the product is more thus minimizing the cost. No electricity is used so this product saves the energy and saves environment from getting polluted.

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