Solar Powered Air Cooler with Cooling Cabin

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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.*

Cooling process is very important to maintain the foods, fish and many items at constant temperature to avoid the effect of viruses. Cooling process employs the different methods to cool the air. But considering the lower application and cost effective the water cooling system is considered for our project. The main aim of our project is to supply the cooled air with the help of water circulation. It consists of Solar panel, Battery, Fan, Water tank and Pump. The present air cooling methods are evaporative coolers, air conditioning, fans and dehumidifiers.

Keywords- Solar energy, Cooling cabin, Impeller, 3D modeling.

I. INTRODUCTION

Solar energy is the light and radiant heat from the Sun that influences Earth's climate and weather and sustains life. Solar power is sometimes used as a synonym for solar energy or more specifically to refer to electricity generated from solar radiation. Since ancient times, solar energy has been harnessed for human use through a range of technologies. Solar radiation along with secondary solar resources such as wind and wave power, hydroelectricity and biomass account for most of the available flow of renewable energy on Earth.

Solar energy technologies can provide electrical generation by heat engine or photovoltaic means, space heating and cooling in active and passive solar buildings; potable water via distillation and disinfection, day lighting, hot water, thermal energy for cooking, and high temperature process heat for industrial purposes. Sunlight can be converted into electricity using photovoltaics (PV), concentrating solar power (CSP), and various experimental technologies. PV has mainly been used to power small and medium-sized applications, from the calculator powered by a single solar cell to off-grid homes powered by a photovoltaic array.The term "photovoltaic" comes from the Greek φώς (phos) meaning "light", and "voltaic", meaning electrical, from the name of the Italian physicist Volta, after whom a unit of electrical potential, the volt, is named.

A solar cell, or photovoltaic cell (PV), is a device that converts light into direct current using the photoelectric effect. The first solar cell was constructed by Charles Fritts in the 1880s. Although the prototype selenium cells converted less than 1% of incident light into electricity, both Ernst Werner von Siemens and James Clerk Maxwell recognized the importance of this discovery.

II. 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.
- 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

III. 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.

Solar energy, radiant light and heat from the sun, is harnessed using a range of technologies such as solar heating, solar photovoltaic's. The Earth receives 174 petawatts (PW) of incoming solar radiation. Approximately 30% is reflected back to space while the rest is absorbed by clouds, oceans and land masses. Photovoltaic's is a method of generating electrical power by converting solar radiation into direct current electricity by photovoltaic effect.

IV. OBJECTIVE

1. To make aware of non conventional energy sources to reduce environmental pollutions.
2. 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.
3. 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.

V. WORKING METHODOLOGY

This project mainly consist of three sections,

Solar Energy Conversion

Solar energy conversion is done by using battery, inverter and charge controller. As sunlight 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 and may protect against overvoltage, which can reduce battery performance or lifespan, and may pose a safety risk. The stored energy directly can used for DC loads or else need to be converted AC (alternate current) by the help of inverter. Below shown figure explains solar
energy conversion.

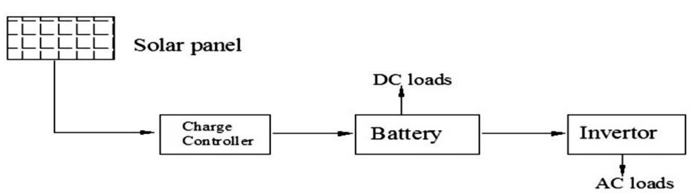

Figure 1. Solar Energy Conversion Process

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.

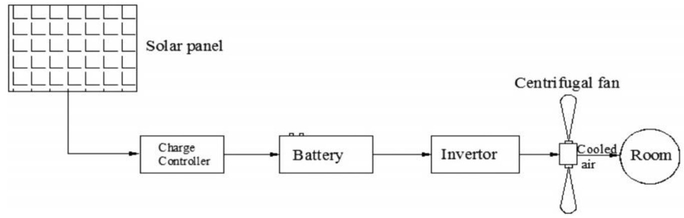

Figure 2. Process of Cool Air Generation by Centrifugal Fan

Cooling Cabin for Household Food Items

First thing, here it is natural cooling process. Cooling cabin is provided just below the air cooler section. This cabin built is up with cooling pads and ceramic slabs. Ceramic slabs are surrounded by cooling pads through continuous water supply is provided. This process leads to producing cooler region in the cabin. So this cabin can be used for preservation of food.

VI. DESIGN CONSIDERATIONS OF THE PROJECT

Capacity of the fan required for a particular area can be calculated as:

Criteria: With supply of water through the cooling pads.

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

$$Mw * (T1-T2) = V/Vs1 \quad *[(ha1-ha2) - (w1-w2)]\ T2$$

where as
mw – Mass of water entering into the cooling pads per minute
V – Volume of air (m3) entering into the room per minute (min)
Vs1 – Specific volume of air entering into the cooling room
ha1 – Enthalpy per kg of dry air at T1
ha2 – Enthalpy per kg of dry air at T2
w1 – Mass of vapour per kg of dry air at T1
w2 – Mass of vapour per kg of dry air at T2
Considered conditions,
T1 = 30 °C and T2 = 25 °C
Relative humidity = 60%
mw = 2 kg of water per minute (assume)

From: Psychometric chart

ha1 = 72.5 KJ/Kg of dry air
= 17.31 kcal/kg
ha2 = 56 KJ/Kg of dry air

= 13.37 kcal/kg

w1 = 0.016 grams/kg of dry air

w2 = 0.012 grams/kg of dry air

Vs1 = 0.880 m3/kg

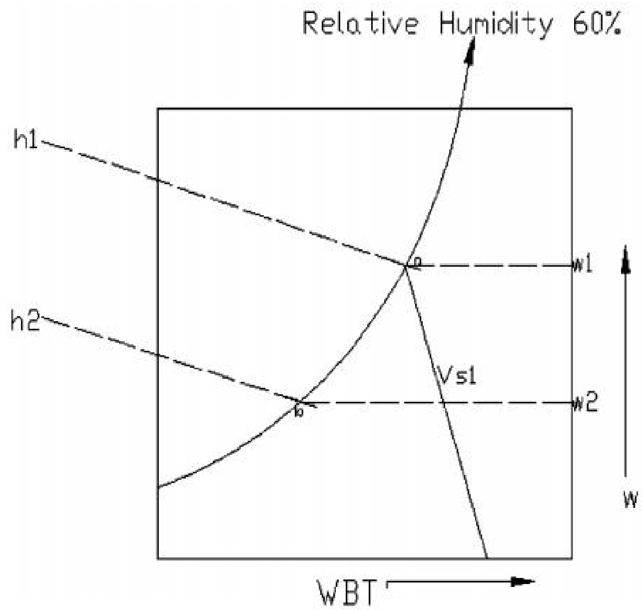

Figure 3. Psychometric Chart

Substituting above mentioned values in Equation

2* (30-25)=V/0.880[(17.31-13.37)-(0.016 - 0.012)* 25]

V = 2.291m3 /min

So the fan capacity of 2.5 m3/min is selected.

Capacity Solar Panel and Battery Required

Hence selected Blower (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

V = 12 v and I = 10 Ah

P = 10*12 = 120 Wh

So, the 35 W centrifugal fan runs for

120/35 = 3.42 / 3.5 h

This means the battery could supply 35 W blower for 31/2 hours.

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

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 40 W panel in 4 hours

sunshine, 40*4*0.85 = 136 Wh

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

So the solar panel of 40 W and battery of

10 Ah are selected (Office purpose).

Cooling cabin calculation

Size Of Cooler :-

Air delivery or Air displacement(in Cubic feet per minute CFM) = [Area of room in square feet] x [height of room] /2

= (10*10*10)/2 = 500 CFM

i.e. V1 = 14 cub m/min [1 CFM = 0.028 cub m/min]

The factor 2 in denominator denotes that the air in the room is changed once in every 2 minutes.

HEAT LOAD CALCULATION:-

1BTU/hr=0.293 Watt

Area of room (BTU) = L*W*31.25

= 10*10*31.25

= 3125 BTU/hr

= 915.625 Watt

2. North window without shading(BTU)

= L*W*1.4

= 2*2*1.4

=5.6 BTU/hr

= 1.6408 W

3. South window without shading (BTU)

= L*W*1.4

=2*2*1.4

=5.6 BTU/hr = 1.6408 W

4. Occupant (BTU) = No. of People*600

= 3*600

=1800 BTU/hr

= 527.4 W

Note:- assuming 600 BTU per person

Heat gain:- Color TV =100w/24hr

=4.1667w/hr

Computer = 6.25w

Lighting Equip. = 2(22)+40

= 84W/24hr

=3.5 W/hr

5. Equipment (BTU) = Total equipment Watts*3.4

=(4.1667+6.25)*3.4

= 35.4167 BTU

= 10.3771 W

6. Lighting (BTU) = Total Lighting Watts*4.25

= 3.5*4.25

= 14.875 BTU

= 4.3583 W

7. Total (BTU) = eqn (1+2+3+4+5+6)

= 1461.042 W

Air delivery = 500CFM

Through air cooler = 500*163.17 BTU/hr

= 500*16317*0.293

=23904.405W >HeatLoad

(i.e. 1461.04 W)

VII. 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.

It is used among other tasks for:

- Design (parametric and direct solid/surface modeling).
- Manufacturing finished design by using included machining modules.

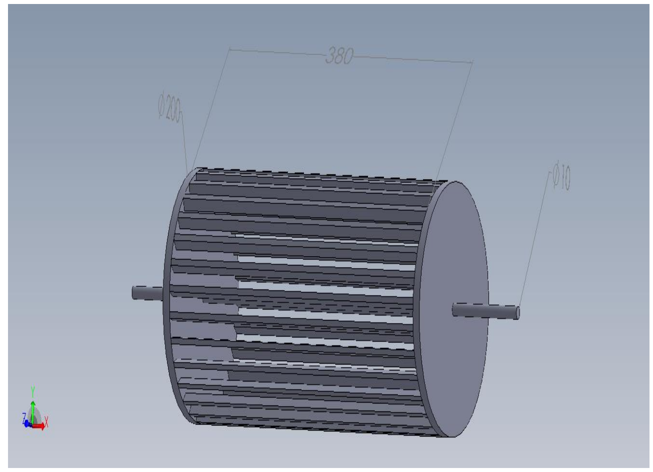

Figure 4. 3D Model of the Impeller

3D DESIGN

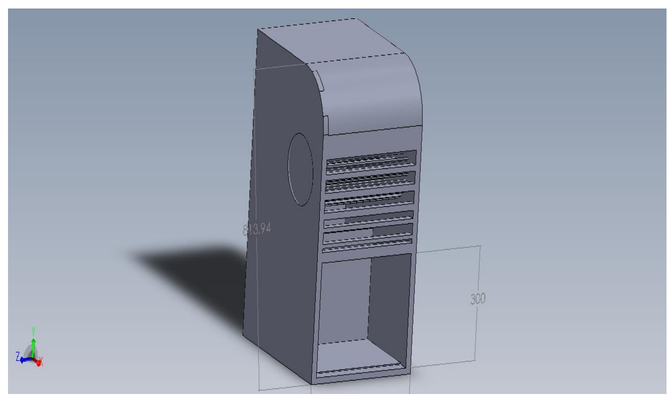

Figure 5. Air cooler with cooling Cabin

VIII. RESULTS AND DISCUSSION

The output of the project is

- Comfort thermal conditions achieved in the living room. That is room temperature up to 24 °C and relative humidity of 60%.
- At lower cost natural cooling cabin for preservation of food has been developed.

IX. 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 perfectly suits for villages, schools and offices and thus prevention from the power cut problems. It comprises of many attractive features such as usage of solar energy, cooler and cooling cabin at lower cost. The above method is eco friendly and natural, electricity savers.

Durability of our product is more thus minimizing the cost. No electricity is spent so this product saves the energy and saves environment from getting polluted.

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