RESEARCH ARTICLE OPEN ACCESS

Integrated Design and Fabrication of a Solar-Assisted Air Cooling Unit

S. Prateep Kumar[1], S. Damodaraiah[2], K. Siva Chandra[3]

[1](Department of Mechanical Engineering, JNTUA College of Engineering, Pulivendula, Andhra Pradesh, India
Email: prateepkumar.s@gmail.com)

[2](Department of Physics, JNTUA College of Engineering, Pulivendula, Andhra Pradesh, India)

[3](Department of Electronics and Communication Engineering, JNTUA College of Engineering, Pulivendula, Andhra Pradesh, India)

--************************----------------------------------

Abstract:

In present work, solar power is stored in a battery. This power is used to run the air cooler whenever we required. Solar energy means all the energy that reaches the earth from the sun. It provides daylight makes the earth hot and is the source of energy for plants to grow. Solar energy is also put to two types of use to help our lives directly solar heating and solar electricity. Solar electricity is the technology of converting sunlight directly in to electricity. It is based on photo-voltaic or solar modules, which are very reliable and do not require any fuel or servicing. Solar electric systems are suitable for plenty of sun and are ideal when there is no main electricity. Our objective is to fabrication and develops a solar system normally "SOLAR AIR COOLER".

Keywords **—** Photo-voltaic, Solar air cooler, Solar electric systems, Non-conventional energy.

--************************----------------------------------

I. INTRODUCTION

Human beings give off heat, around an average of 100 kcal per hour per person, due to what is known as 'metabolism'. The temperature mechanism within the human body maintains a body temperature of around 36.9 degree C (98.4degree F). But the skin temperature varies according to the surrounding temperature and relative humidity. To dissipate the heat generated by metabolism in order to maintain the body temperature at the normal level, there must be a flow of heat from the skin to the surrounding air [1]. If the surrounding temperature is slightly less than that of the body, there will be steady flow of heat from the skin. But is the surrounding temperature being very low, as on a cold winter day the rate of heat flow from the body will be quite rapid, thus the person feels cold, on the other hand on a hot summer day, the surrounding temperature is higher than that of the body, and so there cannot be flow of heat from the skin to the surroundings, thus the person feels hot. In such a situation water from the body evaporates at the skin surface dissipating water from the body evaporates at the skin surface dissipating the heat due to metabolism [2, 3]. This helps in maintaining normal body temperature. But if the surrounding air is not only hot but highly humid as well, very little evaporation of water can take place from the skin surface, and so the person feels hot and uncomfortable [4, 5].

Fuel deposit in the will soon deplete by the end of 2020, fuel scarcity will be maximum. Country like India may not have the chance to use petroleum products. Keeping this dangerous situation in mind we tried to make use of non-pollutant natural resource of petrol energy [6, 7].

The creation of new source of perennial environmentally acceptable, low-cost electrical energy as a replacement for energy from rapidly depleting resources of fossil fuels is the fundamental need for the survival of mankind. We have only about 25 years of oil reserves and 75 – 100 years of coal reserves. Resort to measure beginning of coal in thermal electric stations to serve the population would result in global elemental change in leading to worldwide drought and decertification. The buzzards of nuclear electric-stations are only to will. Now electric power beamed directly by micro-wave for orbiting satellite. Solar power stations (s.p.s) provide a cost-effective solution even though work on solar photo voltaic and solar thermo electric energy sources has been extensively pursued by many countries. Earth based solar stations suffer certain basic limitations. It is not possible to consider such systems and meeting continuous uninterrupted concentrated base load electric power requirements [8, 9].

II. FABRICATION OF SOLAR AIR COOLER

The lists of components that are used in this work are as follows: Solar Panel, Panel Stand, Battery (12V D.C), Switch, Temperature Sensor, Digital Screen, D.C Motor, Impeller Blades, Bolts & Nuts, D.C Water Pump, Connecting Wire, Sheet Metal, Blower.

Solar Panel construction

The solar panel array consists of multiple solar panels interconnected to harness sunlight and convert it into usable electrical energy. The 12x6 configuration refers to a specific arrangement where twelve solar panels are arranged horizontally, with six panels stacked vertically.

Battery construction

A 12V lead-acid DC battery is a common type of rechargeable battery widely used for various applications, including powering small electronic devices, backup power systems, and automotive starting, lighting, and ignition (SLI) systems. Lead-acid batteries are generally rated in terms of how much discharge currents they can supply for a specified period of time; the output voltage must be maintained above a minimum level, which is 1.5 to 1.8V per cell. A common rating is ampere-hours (A.h.) based on a specific discharge time, which is often 8h. Typical values for automobile batteries are 100 to 300 A.h.

III. RESULTS AND DISCUSSION

Air Cooler Working

The solar panel is converting sun rays to the Electricity by "Photo-Voltaic Effect". This electrical power is stored in a 12-Volt battery. Battery D.C power is used to run the D.C motor and D.C water pump. Block diagram, Photo-voltaic Effect and major components of our project are already discussed above chapters. The D.C motor is coupled with impeller blades. The D.C motor runs during the air cooler button ON, the impeller blades start rotating. The water pump is used to circulate the water to the blower unit. The forced air is flow through the water which is sprayed by water pump, so that the cold air produced. The solar panel stand and complete diagram are shown in figure 1 and 2.

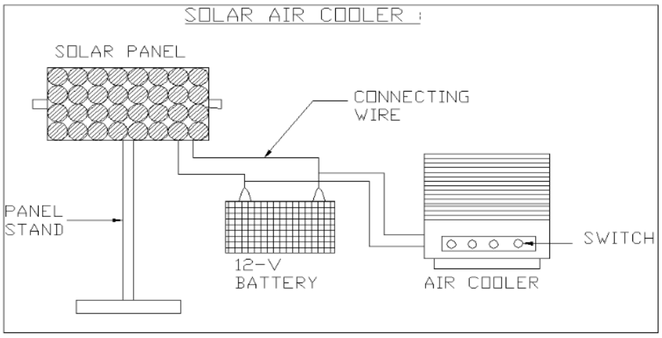

Fig. 1 Solar Air Cooler Circuit.

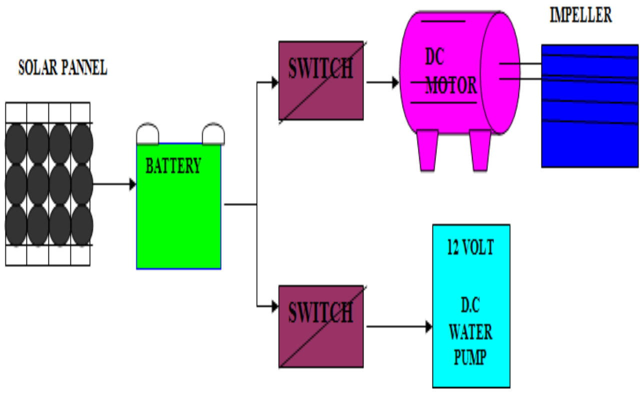

Fig. 2 Block Diagram of Solar Air Cooler.

Working Principle:

1. Solar Panel Operation: During daylight hours, the solar panel absorbs sunlight and converts it into electricity. This electricity is either directly

used to power the air cooler components or stored in the battery for later use.

2. Battery Charging: The surplus electricity generated by the solar panel charges the 12-volt battery. The battery ensures uninterrupted operation of the air cooler during periods of low sunlight or at night.

3. Motor and Pump Activation: The electrical energy from the battery powers the 12-volt motor and pump. The motor drives the fan or blower, while the pump circulates water from the reservoir through the cooling pads.

4. Cooling Process: As the pump circulates water through the cooling pads, the air passing through the pads gets cooled through the process of evaporation. The fan or blower then distributes this cooled air into the surrounding environment, providing a cooling effect. The assembling of solar air cooler is shown in fig. 3.

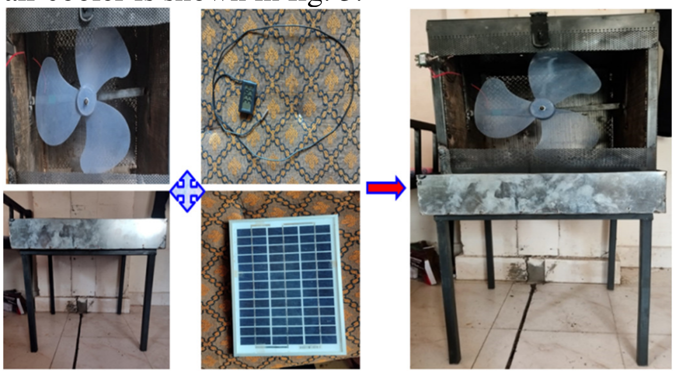

Fig.3 Assembling of Solar Air cooler.

System Operation:

Daytime Operation: During daylight hours, the solar panel generates electricity, which powers the air cooler directly or charges the battery. The cooler operates efficiently as long as there is sunlight available.

Nighttime Operation: In the absence of sunlight, the battery powers the air cooler, ensuring continuous operation. The stored energy in the battery allows the cooler to function throughout the night.

Battery Management: A charge controller may be employed to regulate the charging and discharging of the battery, preventing overcharging or deep discharge, thus prolonging the battery's lifespan.

The advantages as follows: Simple in construction, This system is noiseless in operation, It is portable, so it can be transferred easily from one place to other place, Power is stored in a battery, Cost-effective: Utilizes free solar energy, reducing electricity bills, and Maintenance cost is low. Hence, the solar air cooler is used in: Home, Industries, Meeting hall, and Seminar halls.

Calculations:

Cooling Load Calculations of a Room [10, 11]:

$$Q = UA\,(T_o - T_i) + Q_{int} + Q_{sol} + Q_{vent}$$

1. **Walls:**
   Surface Area = 67 m^2.
   Material = Brick with Plaster.
   U = 1.5 w/m^2-k.
   Q_{wall} = UA (T_o - T_i)
   = 1.5 * 67 * (35 - 26)
   = 904.5 W
2. **Roof:**
   Surface Area = 20 m^2
   Material = Concrete slab with insulation.
   U = 0.7 w/m^2 k.
   Q_{roof} = UA (T_o - T_i)
   = 0.7*20*(35-26)
   = 126 W
3. **Window:**
   Surface Area = 2 m^2
   Material = Double – glazed glass
   U = 2.8 w/m^2k
   Solar Transmission Coefficient = 0.65
   Solar Radiation = 500 w/m^2
   $Q_{window\ cond}$ = UA (T_o - T_i)
   = 2.8*2*(35 – 26)
   = 50.4 W
   $Q_{window\ solar}$ = STC*Solar Radiation*A
   = 0.65*500*2
   = 650 W
   $Q_{window\ Total}$= 650 + 50.4 = 700.4 W
4. **Door:**
   Surface Area = 2 m^2
   Material = Wood
   U = 2.5 w/m^2k

Q_{door} = UA (T_o - T_i)
= 2.5*2*(35 - 26)
= 45 W

5. Ventilation:
Air Change Ratio: 0.5 Changes per Hour (Volume = 61.164 m^3, so 30.582 m^3/h
Q_{vent} = ρ C_p V (T_o – T_i)
= 1.225*1.005*30.582*(35-26)
= 338.852 W

6. Internal Heat Sources:
For 1 Occupant Heat Rejected = 356 BTU's /hr
1 W = 3.41 BTU/ hr
= 356/3.41 = 104.398 W
Heat gain by 4 Occupants = 417.595 W
Heat gain by Lighting = 62 W
$Q_{IHS\ Total}$ = 479.595 W
Q_{Total} = Q_{wall} + Q_{roof} + $Q_{window\ Total}$ + Q_{door} + Q_{vent} + $Q_{IHS\ Total}$
= 904.5 + 126 +700.4 + 45 + 338.852 + 479.595
= 2594.347 W

To maintain 26°c inside the room, the cooler need to counteract. Total Heat gain of 2594.347 W or 2.594 KW to gain a inside temp of 26°c.

Cooling Load of Cooler

$Q = mc_p\Delta T$
m = ρ A V
V = πdN/60
= 1.2*20*12.57
= π*0.3*800/60
= 288 kg/s
= 12.57 m/s
Q = 288*1.005*(35 - 26)
Q = 2604.96 W or 2.605 KW.

∴ Cooling Capacity of Solar air cooler is greater than cooling load of the space you intend to cool. So, Cooling effect of decreasing 9°C will be done by our cooler.

IV. CONCLUSION

The integration of solar energy into air cooling systems has led to the development of solar air coolers, which offer both environmental and economic benefits. These systems utilize photovoltaic panels to power fans or pumps, circulating air or water through cooling mediums such as evaporative pads or heat exchangers. As a result, solar air coolers provide efficient cooling while reducing reliance on grid electricity and minimizing carbon emissions.

In terms of results, solar air coolers have demonstrated significant potential in regions with abundant sunlight and high temperatures, where conventional air conditioning systems consume considerable energy. By harnessing solar power, these systems can effectively lower indoor temperatures, improve comfort levels, and reduce electricity bills for residential, commercial, and industrial applications. Additionally, solar air coolers contribute to mitigating climate change by reducing the demand for fossil fuels and decreasing greenhouse gas emissions associated with conventional cooling methods.

REFERENCES

[1] Chris Dixon et al., Progress of Thermoelectrical Power Generation Systems.
[2] Fabio Maria Montagnino, Solar cooling technologies
[3] Chun Sing Lai, Levelized price of electricity for solar electric phenomenon and electricity storage, Applied Energy 190 (2017), pp-191-203
[4] Farhan a. khmamas , 2012, ―Improving the environmental cooling for air-coolers by Using the indirect-cooling method‖ ARPN journal of engineering and applied sciences, vol. 5, No. 2, page No. 66-73.
[5] A. S Alosaimy, 2013 ―Application of Evaporative Air Coolers Coupled With Solar Water Heater for Dehumidification of Indoor Air‖ International Journal of Mechanical & Mechatronics Engineering, Vol: 13, No: 01 page no. 60- 68.
[6] Basic Photovoltaic Principles and Methods‖ SERI/SP- 290- 1448 Solar Information Module 6213 Published February 1982 page. No. 9-15.
[7] Ajao K., Lawal A., Onaolabo N., and Eniayenkan E. (2012) Development and preliminary testing of a compressed laterite soil brick machine, Annals of faculty of engineering, Hunedoara, Romania International Journal of Engineering ISSN 1584-2665.
[8] Akelere F., and Akhire N. (2013) Design and Construction of a Three-Mould Hydraulic Interlocking Brick Moulding Machine, Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS) 4(3): 527-532, www. jeteas.scholarlinkresearch.org
[9] Umar M.B. (2014), Design, Fabrication and Testing of a Multipurpose Brick/Block Making Machine, a thesis submitted to the Department of Mechanical Engineering, Nigerian Defence Academy, Kaduna, Nigeria
[10] REFRIGERATION AND AIR CONDITIONING - **A.S. Sarao, P.S. Gaabi**
[11] SOLAR ENERGY UTILIZATION - **G.D.RAI.**