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Design of a cheap and simple solar car air conditoner

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***Abstract*— This paper deals with a novel way to design a compact and portable air conditioner powered by the Solar PV module, without need of any fuel consumption and harmful refrigerant gases. The air conditioner is mainly designed keeping in mind, of using it in the cars replacing the conventional version of running the compressor by coupling it with the fuel driven car engine, thus preventing fuel consumption and producing green energy. The main feature of this model is its portability and energy efficient way of charging, thus saving the fuel that requires for a conventional car A.C. The following paper also deals an innovative method to design the controller circuit and the ice box where the dry ice is kept and used as refrigerant of the system. It is also found that the overall complexity of the car air conditioner till date is largely reduced in this model. This paper gives a comparative study of the energy efficiency in the present day car A.C. system driven by fuel and the model we designed.**

Keywords— Air conditioner, receiver-drier, crankshaft, heat-laden, sensible heat, latent heat, wall factor

Introduction

Air conditioning is the process by which air is cooled and dehumidified. The air conditioning in our car, our home and our office all work on the same principle. The following gives a brief overview of the present day scenario of the car a/c working principle. At first when the A/C system is turned on, the compressor, powered by a drive belt connected to the engine's crankshaft, pumps out refrigerant vapor under high pressure to the condenser. The condenser which is mounted in front of the engine's radiator with its parallel tubing and tiny cooling fins removes the heat from the refrigerant, changing it to the liquid state. The refrigerant then moves to the *receiver-drier* where moisture from the refrigerant is removed in the receiver drier. As the compressor continues to pressurize the system, liquid refrigerant under high pressure is circulated from the receiver-drier to the *thermostatic expansion valve*. The valve removes pressure from the liquid refrigerant so that it can expand and become refrigerant vapor in the evaporator. As the cold low-pressure refrigerant is released into the evaporator, it vaporizes and absorbs heat from the air in the passenger compartment. As the heat is absorbed, cool air will be available for the occupants of the vehicle. Now, a blower fan inside the passenger compartment helps to distribute the cooler air. The heat-laden, low-pressure refrigerant vapor is then drawn into the compressor to start another refrigeration cycle in the same manner. Thus this process can be found to depend entirely on the fuel system of our car; otherwise the compressor will not function. Our main goal here is to minimize this fuel consumption and to use the fuel entirely for the driving purpose. For our comfort we should put our attention to the abundant non conventional energy resources that are freely available everywhere. Moreover, in the humid and high temperature regions, such as Middle East world is entirely dependent on the fuel air conditioning system in their cars. But this fuel is fast reducing from the earth. So we have to look for alternatives. Apart from that, waste heat also rises the ambient temperature, causing environmental pollution. This solar model, which we have designed, does not use any fuels and hence no pollution is caused. It can work continuously for 4 hours. The portability and less maintenance cost compared to the current car air conditioning systems make this model most significant. Moreover the refrigerants i.e. the ice which we have used here is easily obtainable. The model is very simple to design, and hence easy to handle and repair. The installation of the system in any places can be done with ease.

The following paper gives the brief description of the design of the entire model and its controls. The plan of the paper is the following: in the next section we present the construction details along with the block diagram. Then the working principle is presented which is followed by the motor controls, circuitry diagram, and some model equations and calculations which the designer have to take care of to make a perfect one. And finally we draw the comparisons of energy efficiency of the present day scenario and the energy efficiency of the designed model and then the concluding remarks.

A. The Simple Model View

The following diagram gives a schematic view of our model. Here we have shown the ice box containing the ice at some temperature below 0˚C and chilled water near 0˚C. Just above the ice box there is a dc pump of 12V. The dc pump delivers the chilled water to the evaporator, which is kept enclosed in a synthetic wire mesh. The fan in the evaporator supplies the necessary cold air into the compartment. The curled pipe is the evaporator shown here.

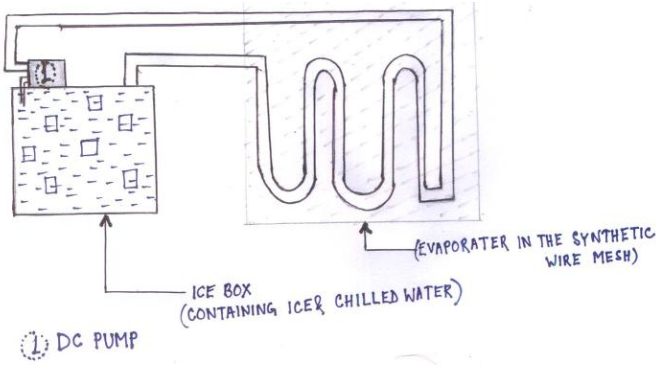


Fig 1

B. The Block Diagram

The following figure shows the controlled block diagram of the entire model. The solar module used here is of rating 12 volt, 35 watts. The solar module is connected to the charge controller (the entire circuit of the charge controller is shown in the control circuitry). The charge controller has two terminals. One goes to the battery (a computer UPS battery suffices) while the other terminal goes to the DC pump. The DC pump is joined with the evaporator fan. The feedback of the evaporator is given to the ice box. The ice box terminal is directly connected to the DC pump input. With the battery a two way switch is provided. The purpose of the switch is as follows: - If the switch is open i.e. in the OFF condition (which is generally kept in the morning) the solar module directly operates the air conditioner and charges the battery also. During the nights, the battery switch is ON which drives the DC pump and the battery provides the air conditioning. The easy to handle model can be installed anywhere with ease. The safety of the model is also ensured here. The overall size of this system is also considerable.

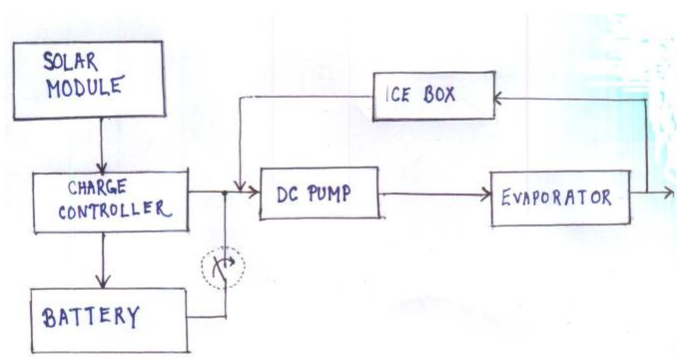
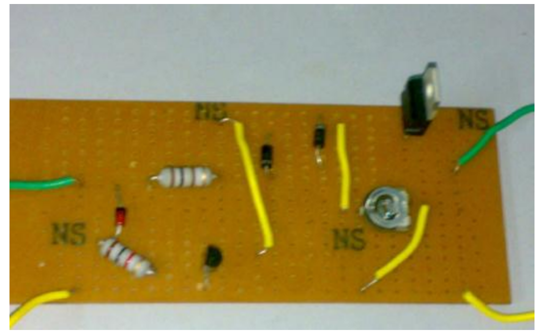


Fig 2

II. CONTROL CIRCUITRY



A. **Fig 3**

The above diagram gives the experimental set up of the charge control circuit of the PV module. The solar panel produces the output voltage across it as per its specifications. A p-n junction diode is connected to the positive terminal of the solar module as per the configuration shown. As per the load connected, the series voltage regulator IC 7812 has been used. This IC produces a voltage of 12Volts at its output pin. A p-n junction diode along with a resistor of suitable specification has been connected to the output pin of IC 7812. A n-p-n transistor along with a Zener Diode works as an amplifying mechanism whenever the combination of the solar panel and IC 7812 fails to provide the desired voltage to the load. This charge control circuitry efficiently regulates and thus maintains a constant voltage across the external load

B. Model Equations and Specifications for the designers

The following are some equations and calculations examples shown for the designers to consider while making one model. The calculation of heat radiation in a human body (sensible heat + latent heat) is found approximately to be 400BTU/hr.

a) Thus the total heat radiated from passengers=Number of passengers×400BTU/hr

b) Leakage air from outside

Cfm(cubic feet per minute)

Hin=height of inside space
Win=width of inside space
Lin=length of inside space
k=wall factor

c) Therefore, q=sensible heat/hour=cfm×0.68×(W1-W2)BTU/hr
W1=weight of humidity outside
W2=weight of humidity inside

Heat Radiation from equipment=3.415 BTU/hour approximately

d) Ventilation Air accepted heat=Q= (cfm×1.08) × (T1-T2)
T1=outside temperature
T2=inside temperature

Energy Efficiency Ratio (E.E.R)

e) EER= (BTU/hr)/ (watt/hr)

Example: - Air conditioner uses 8000 BTU/hr and the input is 860 watt

Then EER=9.3BTU/watt hr

Generally a good EER rating varies in the range 5.4 to 9.9.

In our country the most humid discomfort temperature ranges from 34˚C to 38˚C. And if this temperature can be brought down to 22˚C-25˚C it provides sufficient relief. So the temperature is to be lowered around by 15˚C. In other countries this temperature lowering might vary. The time it takes to lower the temperature is near about 5 minutes.

From the above equations it can be easily calculated how much ice is required and the temperature by which the water must rise to provide the relieving effect. In our model 0.03 ton of ice suffice. And it is found that it can be used on a continuous basis of 4hours.

C. Energy Saving Comparison

TABLE II

Substance	Consumption Of Heat (MJ)	Effic-Iency (%)	Energy Waste / Day	Energy Waste /year	Total Cost (1year) (Rupees)
Petroleum	34.5	70	42	12600	9587.97
Solar PV module	34.5	220	13.44	4032	4261.32

D. Reasons for using water as a refrigerant

Water, we all know is a highly non flammable substance. Moreover water is also noted for its in toxic nature and its easy availability with almost no cost.

The ice box design

The ice has been used here as primary refrigerant for the system. The ice box design is an inexpensive one, with simple metallic tank with double layer construction on all the six surfaces. All the walls of the tank are insulated by polyurethane foam, and the metallic enclosed dry ice plates are placed behind the insulations. (Similar to the simple box used by the ice cream vendors). This simple design prevents melting of the dry ice shortlyUnits

I. CONCLUSION

There are 2 modes of working of the model described above. They are the" pumping of water from the ice box to the evaporator" and "recycling this water" back into the pump.

Secondly, the fuel consumption is saved to a large extent. This model has no pollution effect either. A total of 8568MJ energy per year is saved.

And thirdly, the total cost comparison shows that Solar PV module, although the initial investment for installing the module is a bit high, but compared to an overall yearly basis the cost goes nearly down by nearly half the amount. In Indian money, the lowering of the cost is shown in the table.

Now, if any one wishes to use the model on a large scale basis, may be in the industries they can increase the mass of the ice box. Our experimental model works for 4 hours constantly. Increasing the mass of the box can rise the working duration for 10 hours also.

Acknowledgment

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