"Development of Auxiliary Automobile Air Conditioning System by Solar Energy"

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Abstract - *Air conditioner is the primary accessory of a passenger car which is used to maintain the vehicle cabin temperature and humidity at comfortable levels for a passenger. But this system consumes a lot of power and negatively affects the fuel efficiency of a car. Depleting natural oil resources, increasing oil prices and environment pollution increases the awareness about the Need to use renewable sources. In past years, lot of efforts have been made towards the application of solar energy to electric and hybrid cars, but a limited work is done on particularly air conditioning case. In the present work, feasibility study of air conditioner has been discussed using solar energy. With the implementation of solar conditioner in automobile the fuel efficiency will be increased and the tail pipe emissions are reduced. Also by disattaching compressor from engine and making it run through the solar energy, the load on engine decreases.*

Key Words: **Automobile, Solar, Air-Conditioner, Car, Motor, Compressor,**

1. INTRODUCTION

As the use of fossil fuels is maximum, at peak in today's world, there is a chance of diminishing fossil fuels in next generation. So to save the fossil fuels to some extent for future generation and to save our environment from pollution created by fossil fuels like petrol and diesel. we came up with an idea of "Automobile Solar Air conditioner". Use of petrol and diesel cars are getting maximum day by day. We will design an Automobile air conditioner system which will work on solar energy. We will use solar panels which will charge automatically from sunlight and will power the battery. The components like compressor, DC motor, fan motor are connected in circuit through which our automobile air conditioner will work on solar energy. The main concept of this project is to reduce the use of fossil fuels and to decrease the engine load and increase the average by disconnecting compressor from engine. Yogesh Sunil Wanborikar, Abhay Sinha [4] studied that the renewable energy is vital for today's world as in near future the non renewable sources that we are using are going to get exhausted. The solar vehicle is a Step in saving these non renewable sources of energy. I. Daut, M. Adzrie, M. Irwanto, P. Ibrahim, M. Fitra[3] investigated the design and construction of a direct current (DC) air conditioning system integrated with photovoltaic (PV) system which consists of PV panels, solar charger, inverter and batteries. how to design and construct the system with enough electrical energy supplied to it. With considering of these several factors, it will help to improve the stability and efficiency of the system for greener solutions to the world's energy needs. **E. Janotkova, M. Pavelek** [2] presented new trends in the area of automobile air conditioning, which is fast becoming standard equipment. Their Attention is focused on the refrigerant and ventilation circuit of the air conditioning equipment, and on the control system.

1.1 Modified Circuit of Auxiliary Solar Operated Automobile Air Conditioner

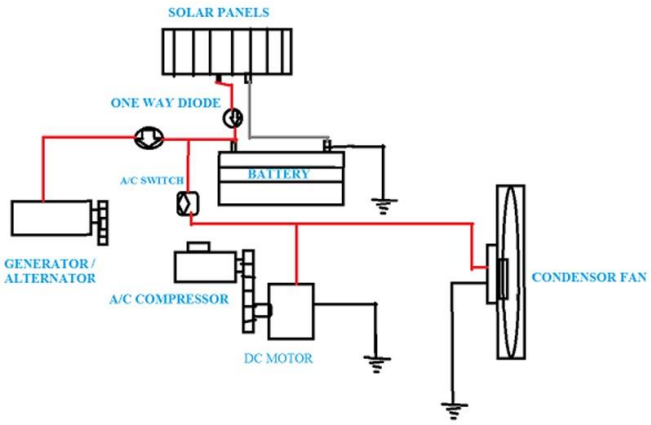


Fig -1: Circuit of Solar Operated Automobile AC System

A solar panel may be installed of the roof of the car. The generated electricity from solar panel is stored in the battery. This stored battery power is used to run the compressor of auto air conditioner with the help of electric motor. The compressor is not connected to the engine. Solar controller is attached between solar panels and battery for safety of battery.

1.2 Implementation In Maruti Suzuki WagonR

The present project is an air-conditioning system designed to be installed in vehicle. The air-conditioning system derives power from solar cell and the electric power is used to drive the electric motor with compressor to produce the cooling. The solar cell is also installed with maximum power point tracking (MPPT) for the battery charger. The system provides a new method of solar driven system together with the

existing power system in a vehicle. Invention provides a method to work with the existing system based on retrofitting and without deteriorating the overall performance and affecting other components.

Fig -2: Implementation in Car

1.3 Solar Panel:

Fig -3: Solar Panel Implementation in Car

Solar cells, also called photovoltaic (PV) cells by scientists, convert sunlight directly into electricity. PV gets its name from the process of converting light (photons) to electricity (voltage), which is called the *PV effect*. The PV effect was discovered in 1954, when scientists at Bell Telephone discovered that silicon (an element found in sand) created an electric charge when exposed to sunlight [1]. Soon solar cells were being used to power space satellites and smaller items like calculators and watches.

1.4 Electric Battery

Fig -3: Lead Acid Battery

The lead-acid battery has been a successful article of commerce for over a century. Its production and use continue to grow because of new applications for battery power in energy storage, emergency power, and electric and hybrid vehicles (including off-road vehicles) and because of the increased number of vehicles for which it provides the energy for engine starting, vehicle lighting, and engine ignition (SLI).

1.5 Electric DC Motor

Fig -4: 24V DC Motor

A motor is an electrical machine which converts electrical energy into mechanical energy. The principle of working of a DC motor is that 'whenever a current carrying conductor place in a magnetic field, it experiences a mechanical force.

1.5 Compressor

In the air-conditioner system compressors are use for the compression of refrigerant to operate the AC system. In automobile use mostly swash plate type compressor.

Fig -5: Swash Plate Type Compressor

2. Specifications of Circuit Components

2.1 Solar-Panel Specification:

Type = polycrystalline silicon panel
Power = 100 Watt
Voltage = 24 V
A 20 ampere current rating solar charge controller is placed between panel and battery for the safety issues of battery.

2.2 Battery Specification:

Battery Type= Lead Acid Battery
Ampere= 35 amp × 2
Voltage= 24 volt

2.3 Compressor Specification:

Type of Compressor= Swash Plate Type
Piston=5 Pistons
Displacement=117 cc
Compressor oil= Denso 8
Type of pulley= Polygroove
Pressure Range= 1.3MPa (inlet) to 2.7MPa (outlet)

2.4 Car's Roof And Hood Available Area Is Measured For The Installation Of Solar Panel:

Available roof area= 148*85=12580cm^2
Available Hood area = 68×120 = 8160 cm^2
Total area = 20740cm^2

3. Experimental Setup

- Place solar panel on the roof of car.
- Connect positive terminal of solar panel to positive terminal of battery1.
- Connect negative terminal of solar panel to negative terminal of battery1.
- There is a solar controller between panel and battery.
- Connect battery1 and battery2 in series.
- The positive terminal of DC motor is joined to the positive of battery2.
- The negative terminal of DC motor is joined to the negative of battery1.
- On the AC switch on dashboard.
- Motor will supply power to compressor to run.
- Give a direct connection of compressor magnetic clutch to positive terminal of battery2.
- The clutch will be engaged and the AC starts working.

3. Result

Polycrystalline silicon panels are selected for this application, because this type of solar panel shows good cost to power ratio as compare to mono-crystalline and amorphous silicon panels.

Fig -6: Ampere of Solar Panel

Generally polycrystalline panel give an efficiency of 15%, but in this kind of automobile application, angle between solar radiation and solar panel cannot be maintained ideally. And if a mechanism is made for variable sun tracking, then one should have to compromise with the aerodynamic shape of the vehicle.

That may cause little improvement and major harm to the vehicle performance. So panel should be placed as the vehicle aerodynamic shape.

Due to lack of possibility of ideal angle formation between sun rays and solar panels, panels may work with less effectiveness, so a lower photovoltaic efficiency of 13% is taken for this system design calculations.

- Average sunshine received in India = 5.4 kWh/m^2
- Power generated when panel receive whole day sunshine: = 5.4 kWh/m^2 ×1.2580m^2 ×0.13
  = 0.883kWh

Measured output of solar panel:

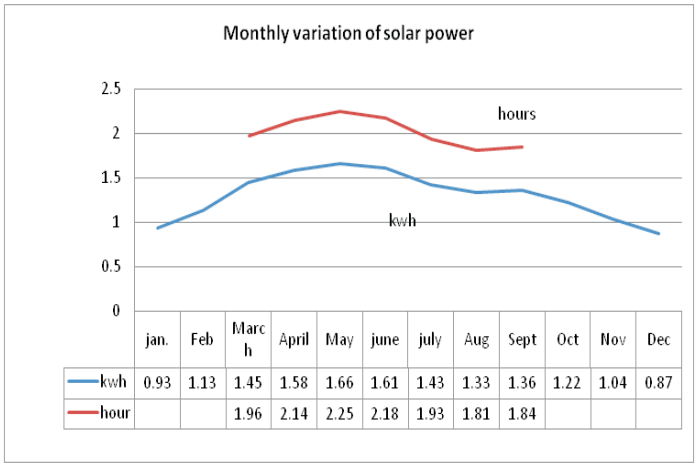
- Voltage=24V
- Current=10Amps
- Power=100Watts
-

Generated power is stored battery, having following specifications:

- Battery type = lead acid
- Capacity = 3.0 kWh (50 % depth of discharge)
- Voltage = 24V
- A 20 ampere current rating solar charge controller is placed between panel and battery for the safety issues of battery.

Power Generated And Load Run Time:

Polycrystalline panel is able to generate 0.883kWh energy in alto car, if it takes whole day sunshine and car air conditioner needs 0.738 kW power at peak load. Hence, it can be. Calculated that, using polycrystalline panel, it can generate power which is sufficient to run car air conditioner for nearly 1 hour.



	jan.	Feb	March	April	May	june	july	Aug	Sept	Oct	Nov	Dec
kwh	0.93	1.13	1.45	1.58	1.66	1.61	1.43	1.33	1.36	1.22	1.04	0.87
hour			1.96	2.14	2.25	2.18	1.93	1.81	1.84			

Chart -1: 1 Monthly Powers Generated and Load Run Time

Solar energy varies from day to day. So the graph shows the monthly variations of solar power generation by using polycrystalline solar panel on the roof of the car. Air conditioner running hours are also shown up to which it can be run at full load. In India, like country air conditioner is used six to seven months of a year. The biggest advantage of this system is that availability of solar energy has a direct Relation with the cooling load of air conditioner. In other months of the year this solar power may be used for heating application or other accessories.

3.1 Cost Comparative Analysis

Solar operated auto air conditioner system is eco friendly as compare to the present engine driven AC system. Generally combustion of one litre of petrol emits 240 gm of carbon mono oxide, 2.5 kg of carbon Di oxide, 1 gm of hydro carbons, and 0.1 gm of nitrogen oxide. But for successful implementation of this system, it should be cost effective also. So a cost comparison is made between the present system and solar operated system. Break even analysis (BEP) is made for this cost analysis.

i) The vehicle is run maximum 2 hours daily.
ii) Car takes complete day sunshine that may be during running or parking time.
iii) Car gives 20km/litre mileage without air conditioner work and 16km/litre with air conditioner work.
iv) Fuel price is 70 Rs/litre
v) A car runs nearly one lakh km in 10 years of life.

Fixed cost:

- **Cost of panel:** There is installation capacity of 100 Watt solar panel space on Maruti Suzuki WagonR car, and the cost of large polycrystalline panels is generally taken as 40 Rs/watt,
- Hence Panel cost = 100×40= 4000 Rs
- Cost of Lead acid battery = 5000 Rs

There are requirement of some other equipments like solar charge controller, AC motor, inverter etc.
So balance of system (BOS) cost is taken as 5000 Rs.
Total initial cost i.e. fixed cost = 14000 Rs

Variable cost:

In this system the only variable cost is battery replacement cost. As already mentioned, lead acid batteries are having a life of 1200 cycles. Generally a car uses 250 days of a year.

Then battery replacement is required after 2 years or after 30,000 km of run. Generally battery has a 40% resale value. Hence battery maintenance cost is Rs 2000 on 30,000 km use.

Variable cost per unit km run:
Rs 2000/30000=0.0677 Rs /km
Total cost: Fixed cost + Variable cost × km run.

Fuel saved value by solar air conditioner:

As we have already assumed that, car gives the mileage of 20km/litre when car run without air conditioner operation and 16 km/litre with air conditioner operation.

Fuel saved using solar energy $= \frac{x}{16} - \frac{x}{20}$ Litre [5]

Here x, is the distance travelled by the car with Air conditioner,

Now, saving in Rupees $= 70 \times \left(\frac{x}{16} - \frac{x}{20}\right)$ [5]

We can plot a graph using all the data that is calculated above,

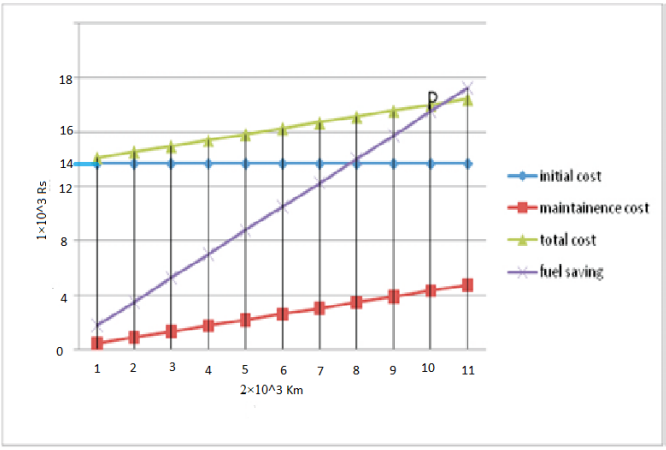


Chart -2: Cost Analyses through Breakeven Point

In the above graph point 'p' is the breakeven point, which shows the point at which there is no profit and no loss.

Calculation of BEP:

X co-ordinate shows the car total km run and y co-ordinate shows the cost
Fixed cost (F): y = 14000
Variable cost or maintenance cost (V): y= 0.0677 x
Total cost (T): y= 14000 + 0.0677 x

Value of fuel saved by this solar operated system after x km:

$y = 70 \times \left(\frac{x}{16} - \frac{x}{20}\right)$ [5]

or y = 0.875 x

At breakeven point:
[14000 + 0.0677 x] = 0.875 x

x= 17342 km

At this point, if car runs 17342 km, owner of car can get his spent cost of solar system back in the form of fuel saving and any over running of car from this point gives him profit.

4. CONCLUSIONS

Feasibility of the solar driven auto air conditioner is checked under different working conditions and following conclusions are determined through the appropriate calculations and practical consideration with reasonable assumptions:

- There is direct relation between solar energy and AC requirement i.e. more the sunshine more will be the requirement of cooling(say in summer) and less the sunshine less will be the requirement of cooling (say in winter or monsoon). This relation gives the major strength to this project feasibility.
- Air conditioner compressor can be run with the help of 230 V, AC motor of power 738 watt.
- Sufficient solar power to run the motor can be generated by installing a solar panel on the roof of the car. This solar energy can run the motor nearly 1 hour a day at peak load.
- Polycrystalline solar panel and lead acid battery are advised for such a system work. Because this combination makes a good compromise between cost and work performance.
- This solar operated Air conditioner system is both eco friendly and cost effective. It reduces the dependency of Air conditioner on car engine i.e. air conditioner can be run without engine working like on red light etc.
- Extra solar energy can also be used for power the other car accessories like music system, light, 12 V car batteries etc.

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