Design and Fabrication of automatic climate control system for automobile

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Abstract – *Automobiles have always been in a phase of development since their birth. Vehicles parked under the sun are a very common scene in towns and cities due to lack of space for parking in these areas. When these cars are parked under the sun, the vehicle cabin starts developing an uncomfortable climate. Due to the higher cabin temperatures the softer plastics can undergo partial bung causing the release of many toxic gases which is toxic for us. These high temperatures can cause the electrical components like the various electronic sensors to be damaged and start showing poor performances.*

Our project "The Automatic Climate Control System in an Automobile" is a collective solution to the above mentioned problems. The idea is of great relevance when taken into account for short time purposes. In this day and age where the number of automobiles increase every day and the area for parking decreases this system can be highly useful.

Key Words: Air conditioning, automobile, comfortable climate

1. INTRODUCTION

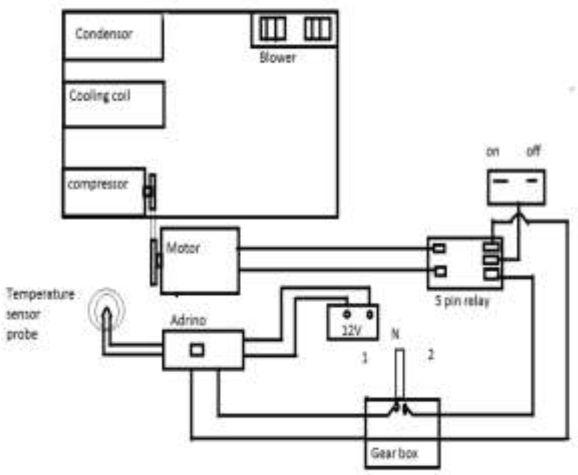
In the current scenario the numbers of vehicles being used are increasing day to day. As the number of vehicles increases the space required for their parking has to be necessarily increased. This is a serious problem now a day. The vehicle parked outdoors is a common scene now a day. We see a number of vehicles parked under sun in busy cities and towns and we are also aware about the uncomfortable condition that this produces. The vehicles parked under the sun produces a very high temperature inside the car. This is responsible for many technical and biological problems.

Automobile parked under sun in a very sunny day produces a very high temperature making it very difficult for the passenger to get inside the automobile. We all know that the new generation automobiles are packed with a number of plastic components. Due to this very high temperature the components are often subjected to partial burning. This is a source of many harmful gases like carbon monoxide, sulphur oxides and poisonous gases like benzene. This can affect our respiratory system and various skin diseases. Long term exposure to such condition can cause serious chronic diseases. Moreover our modern automobile makes use of a number of electronic components. These components are seriously affected by high temperature. The performance gets lowered and fails to work. Moreover the performance of the vehicle like its mileage is also affected by this temperature condition.

The automatic climate control system is a solution to these problems. The system helps in maintaining a comfortable climate inside the automobile even in off condition by coupling the ac unit of the automobile, the engine with an electronic control unit. As the temperature inside the automobile crosses the set limit the system starts working and a comfortable climate is maintained inside the automobile. The system makes use of a temperature measuring probe that is connected to an electronic control unit. The temperature of probe is the input to the arduino control unit. This input determines the working of the entire system, if the temperature inside the automobile is above the set limit. The ac unit starts working provide that the gear is in the neutral position. This ac unit works when the car is parked, when the temperature is above the set temperature limit and the gear is in the neutral position. Thus the project is a solution to this serious problem faced now a day.

2. COMPONENTS AND WORKING PRINCIPLE

The air conditioning system includes motor, compressor, condenser, evaporator, blower, expansion valve. Consider the case of a car that is parked outdoors under the sun. In the fabricated model instead of using an engine we are making use of a 2 hp single phase dc motor. The system is provided with a temperature probe that is connected to the dashboard of the automobile where the temperature is maximum. The temperature measured from the probe is the input to the arduino. This input is compared and control the working of the system. In the working of the system the input from the temperature probe is sent to the arduino. This input is compared with the set upper and lower limit. If the temperature is above the upper limit the arduino sends in a positive 5 volt signal that acts on the relay and complete the circuit. Moreover the position of the gear also controls the working of the circuit. The entire system works only if the gear is in the neutral position. Thus when both the condition is satisfied the circuit get complete and the motor gets powered which runs the compressor. The ac unit works until the temperature reaches the set lower limit. The fan and the blower are powered by an external battery. For the flow of control to this entire unit an on button needs to be switched else the ac works as usual in a running condition.



3. COOLING LOAD CALCULATIONS

The purpose of cooling load calculation is to define sizing values for the cooling loads results from heat transfer processes through the building envelope and from the internal sources and system components.

The cooling load in a stationary automobile is represented by Q(tot)

Q total=Q met+ Q dir +Q dif +Q ref +Q amb

In this the heat addition due to automobile engine and exhaust is neglected

1) Metabolic load

Q_{met}= summation (MA) for all passengers

We assume 2 passengers

Q_{met}=85×1.805+55×1.805 =252.76W

2)Direct load

$Q_{dir}=\sum S \times z \times i_{dir} \cos\theta$

=1.5×0.5×390×cos(0) =292.5W

3)Diffused Load

$Q_{dif}=\sum S \times z \times i_{dif}$

=0.5×1.5×346.375 =259.77W

4)Reflected load

$Q_{ref}=\sum S \times C \times i_{ref}$

=1.5×0.5×86.271=64.7025W

5) Ambient load

Q amp= ∑S×U×(Ts-Ti)

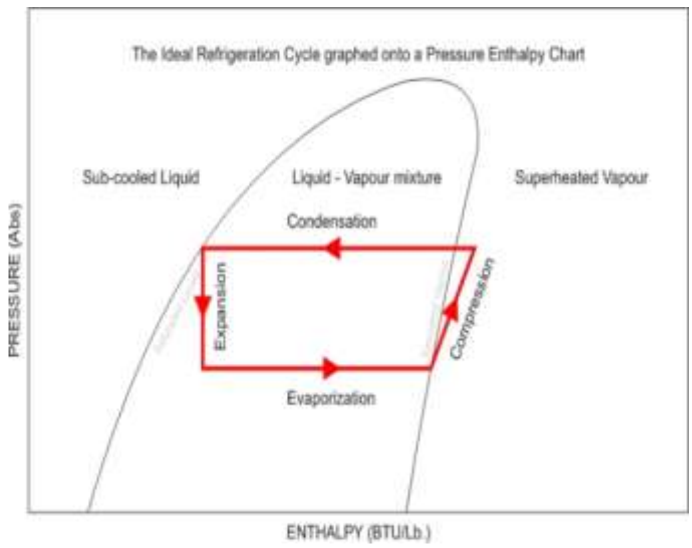
=2.5×0.22×(40-28) = 6.63

Total cooling load=Q met +Q dir + Q dif +Q ref + Q amb

= 252.76+292.5+246.375+64.7025+2.21

=854.5475W

4. DETERMINATION OF REFRIGERATING EFFECT



In a revolution the reciprocating compressor undergoes one compression stroke

Volume swept by the piston in a single strock = $\frac{\pi}{4} * d^2 * l$

D=7cm

Distance swept,l=8cm(Assumed values)

Volume swept = $(\frac{\pi}{4} * 0.07^2 * 0.08)$

=$307.87*10^{-6}$m^3

Density of R134 a in vapour state=2.6kg/m^3

Mass of refrigerant flowing per revolution=

$2.6*307.87*10^{-6}$=0.8gm per revolution.

Speed of the compressor=1500rpm

Number of revolution per second =1500/60=25

Mass flowing per second=mass per revolution*number of revolution per second = 20 gm per second

T_1 = 297K, T_3 = 305K, T_4 = 297K, T_2 = 318K

P_1 = 6.4bar, P_2 = 7.8bar (obtained from p-h chart)

H_1 = 575 KJ/kg, H_3 = H_4 = 443KJ/kg, H_2 = 613KJ/kg

Total refrigerating effect = M(H_1-H_4) = 2.6KW

5. EXPERIMENTAL SETUP AND PROCEDURES

The project involves the coupling of an air conditioning system with electronic control unit. The entire AC unit used in the project is the one from Maruti 800. Instead of using an engine to run the compressor we make use of single phase DC motor. This entire system is coupled with an electronic control unit which forms the entire project system.

5.1. Motor

The compressor of the AC unit is run by a single phase DC motor instead of powering it with an engine. After charging the AC unit the 2 other motor unit with .5 and 1.5 HP was tried. The motors couldn't run the compressor and the AC unit. Later a 2HP single phase DC motor was used to run the AC unit. In an actual case the compressor is run at various engine speeds. The tonnage of the AC unit depends on the speed and it is nearly on an average of 0.75 TONNE. A 2HP motor is sufficient to run that compressor.

Fig 3.1 motor

5.2. Compressor

Fig 3.2 Compressor

The compressor used is piston type compressor. The following are the details of the compressor:

Compressor type: 10517c

Refrigerant compatibility:R134a

Specification: 25.5*19.5*22.5 cm /pcs.

The compressor is run by a single phase DC motor of 2HP. In actual case the compressor is running at various speeds depending on the engine speed.

5.3. Evaporator

The evaporator is the part of a Maruti 800 AC car with dimensions 7.5*7.5*2.5mm^3. The bare tube evaporators are made up of copper tubing or steel pipes. The copper tubing is used for small evaporators where the refrigerant other than ammonia is used, while the steel pipes are used with the large evaporators where ammonia is used as the refrigerant.

Fig 3.3 Evaporator

5.4. Condenser

The condenser is also from a Maruti 800 AC car with dimensions 25*25*12.5 cm The purpose of a condenser in the cycle of compression refrigeration is to change the hot gas being discharged from the compressor to a liquid prepared for use in the evaporator. The condenser accomplishes this action by the removal of sufficient heat from the hot gas, to ensure its condensation at the pressure available in the condenser. The heat is shifted to another medium, like water or air, to cool the condenser.

5.5 Condenser coils

Condenser coils are available in single or multiple circuits to meet any condensing or heat reclamation project. Replacement "L" shaped,"U" shaped or round condensing coils can be manufactured to your specifications. Separate integrated sub-cooling circuits can also be designed into the coil.

Fig 3.5 condenser coils

5.6 Blower

Air conditioner blower or fan Fig 3.9 is one of the key components that is needed as part of the air conditioning system. The function of the blower is to produce air movement to the space that is being conditioned. A DC supply powered blower is used for cooling the condenser coils. This blower is powered by a 12 volts battery. It is attached to the condenser coils. The specifications are: 12V and 30cm diameter. There are basically four types of fan that are commonly used in the HVAC equipment. They are the propeller fan, centrifugal fan, vane-axial fan and tube-axial fan

Fig 3.6 Blower

5.7 Expansion device

A capillary tube is a long, narrow tube of constant diameter. The word "capillary" is a misnomer since surface tension is not important in refrigeration application of capillary tubes. Typical tube diameters of refrigerant capillary tubes range from 0.5 mm to 3 mm and the length ranges from 1.0 m to 6 m. The pressure reduction in a capillary tube occurs due to the following two factors:

1. The refrigerant has to overcome the frictional resistance offered by tube walls. This leads to some pressure drop, and

2. The liquid refrigerant flashes (evaporates) into mixture of liquid and vapour as its pressure reduces. The density ofvapour is less than that of the liquid. Hence, the average density of refrigerant decreases as it flows in the tube. The mass flow rate and tube diameter (hence area) being constant, the velocity of refrigerant increases since m=ρVA.

5.8 R134a Refrigerant

R134a is also known as Tetrafluoroethane (CF3CH2F) from the family of HFC refrigerant. With the discovery of the damaging effect of CFCs and HCFCs refrigerants to the ozone layer, the HFC family of refrigerant has been widely used as their replacement. It is now being used as a replacement for R-12 CFC refrigerant in the area of centrifugal, rotary screw, scroll and reciprocating compressors.

5.9 Programming Procedure

The functioning of the control unit of automatic climate control system is complete governed by the programme code port. The automatic climate system is designed to work between 2 temperature limits. An upper temperature limit and a lower temperature limit. When the temperature inside the cabin crosses the upper temperature limit the entire AC unit starts working and stops when the temperature drops below the lower temperature. The control is governed by the programming code in the control unit. The working of the programming code is in the following manner. In the program the temperature limits within which the system works The control unit is powered by an AC source. Every instant the probe of the control unit reads the inside cabin temperature as analogue signals. This analogue signals `get processed in the arduino and gets converted into corresponding measure or value of temperature. This value of temperature is compared with the upper temperature limit and the system starts working once the temperature goes below the lower temperature limit the system starts working. The temperature range is set as per the need and depending on the ability of the refrigerant R134a. Thus this programming procedure governs the starting and stopping of the entire system.

Time required for cooling with increase in atmospheric temperature

Atmospheric Temperature(in °C)	Time(in minutes)
33	2
35	2.4

36	3
38	3.43
39	4.03

5.10. Control circuit

In our project the main device is a micro controller based kit. It is used to control the whole unit of this project. The micro controller is connected to the control unit. The control unit is connected with the smps to get the power supply. Microcontrollers are destined to play an increasingly important role in revolutionizing various industries and influencing our day to day life more strongly than one can imagine.

5.11. Arduino board

An Arduino board is a one type of microcontroller based kit. The first Arduino technology was developed in the year 2005 by David Cuartielles and Massimo Banzi. The designers thought to provide easy and low cost board for students, hobbyists and professionals to build devices. Arduino board can be purchased from the seller or directly we can make at home using various basic components. The best examples of Arduino for beginners and hobbyists includes motor detectors and thermostats, and simple robots.

5.12 Sensor (LM 35)

In general, a temperature sensor is a device which is designed specifically to measure the hotness or coldness of an object.**LM35** is a precision IC temperature sensor with its output proportional to the temperature (in °C).With LM35,the temperature can be measured more accurately than with a thermistor. It also possess low self-heating and does not cause more than 0.1 °C temperature rise in still air.

6. RESULTS

We made a miniature model of an automobile to execute our concept of automatic climate control system where the compressor of the AC is run by a 2 HP DC motor. The heat flux entering the cabin as calculated by cooling load calculation that is 854.57W and by ansys analysis that is 935W are comparable. The ansys analysis was done on the same model as that of a miniature by assuming a covering of known heat transfer co-efficient. As per the calculation done on the amount of refrigerating effect required as observed from load calculation which is 2.6 kW we installed an AC of 0.75 ton capacity. The AC unit is designed to work between a lower temperature limit and an upper temperature limit. The limits are 24 ℃ and 32 ℃. As designed the AC started working when the inside cabin temperature crossed 32 ℃ and continued working till 24 ℃. It stops working when the temperature goes below 24℃.The heat flux entering the cabin at an outside atmospheric temperature of 35℃ is 854.57 W. It takes about 2 minutes and 40 seconds to cool the cabin to 24℃. Similarly 3 minutes for 36℃ , 3 minutes and 40 seconds for 38℃ and 4 minutes for 39℃. Thus it is observed that as the atmospheric temperature increases, the time required for cooling the cabin increases.

7. CONCLUSIONS

The rise in temperature is a reason for various biological problems due to the partial burning of plastic inside the cabin. The automatic air conditioning system is a solution to this uncomfortable condition in the car. In addition to the prevention of biological damages the electronic devices are also protected. From the observations as tabulated the time required for cooling increases with increase in atmospheric temperature.

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