

Heating Ventilating And Air-Conditioning (HVAC) System Using Thermoelectric Couple (TEC)

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Abstract

The conventional HVAC system uses refrigerant that harms the environment and depletes the ozone layer. The commonly used refrigerants are CFC's and HFC's. Though HFC's has less effect over the ozone layer as compared to the CFC's but it still plays a role in depletion of ozone layer. A huge time would be required to make the complete system eco-friendly. Moreover the other factors like extra power consumption and the matter of fact that HVAC starts only with after starting of engine gave rise to the development of "HVAC USING TEC". To overcome the problems encountered in conventional HVAC a novel concept is presented in the paper.

1. Introduction

The aim of automotive air conditioning is to control the temperature and humidity of the atmospheric air and circulate the same in automobile so that the comfortable feeling is obtained by the passengers. The air conditioning system is able to achieve this in conjunction with the heating and ventilating system.

The automotive air conditioning system consist of

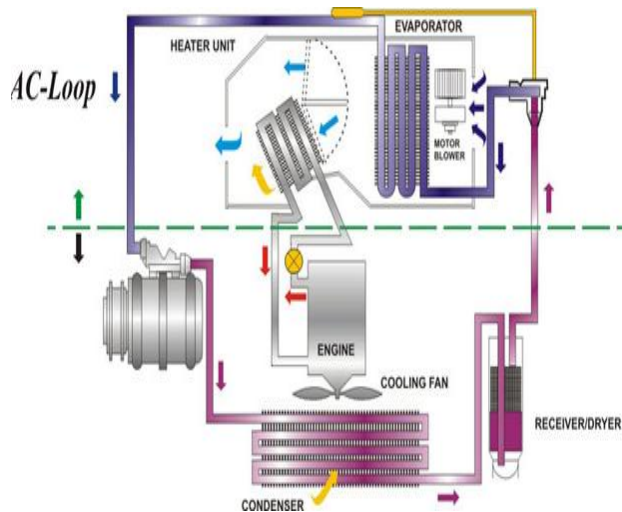
- A refrigeration system
- An air circulation and distribution system
- A control system

The layout of refrigeration system is shown in the fig. It includes the compressor, condenser, evaporator,

receiver-dehydrator and connecting lines besides one or more of the following depending design of system: expansion valve, orifice tube, suction throttling (ST) valve, positive operating absolute valve (POA), evaporator pressure regulator (EPR), temperature tube (thermal sensor) ,high pressure cut off switch and cycling compressor switch. The simplified system shown in the fig. includes the expansion valve and thermal sensor in the form of temperature tube. The commonly used refrigerant in the older cars has been Freon 12. However, being ozone depletion it has been replaced by another that is R134a.

The refrigerant vapour from the evaporator is compressed to high pressure by the compressor which is driven by means of a belt from the engine pulley, through an electromagnetic clutch. The clutch serves to engage and disengage the compressor as required. A variable-displacement ac compressor is used some times to match compressor capacity to varying cooling requirements. The high pressure refrigerant vapour from the compressor is then discharged to condenser, which is a simple heat exchanger fitted in front of the cooling condenser. Air is caused to flow across the condenser by ram air while driving and by action of the engine fan or electric fan. Cooling of the refrigerant vapour in the condenser converts it into liquid still at high pressure. This liquid is then collected in a receiver from where it passes through a dehydrator to extract moisture. Dry refrigerant liquid is then made to pass through a expansion valve mounted at the inlet side of evaporator. The process of expansion to low pressure makes the refrigerant to evaporate and thereby cool the evaporator. A sensing device, called temperature

tube signals the diaphragm in the expansion valve to vary its orifice size depending upon the refrigerant temperature at the evaporator outlet thus achieving automatic temperature control.



2. Disadvantage of conventional HVAC

- Compressor is driven by the crankshaft of the engine. It consumes 5 to 10% of engine power
- Present HVAC System reduces the mileage of the vehicle.
- An air conditioning system can consume as much as 8 h.p. with a unit capacity of 3 tones or 9072 kcal/hr. approximately. SO, due to these the pickup of vehicle decreases.
- Battery provides 12V current to the blowers and electromagnetic clutch of compressor for engaging the compressor.
- cost of present HVAC System is very high.
- HFC is quit hazardous for human body & ozone layer which leads to global warming.
- Repairing cost of HVAC System is very high.
- Proper maintenance is very necessary because this system can affect human body & Environment.

- Present HVAC system required very large space in the engine compartment and dashboard.
- if any component fails to perform well then the whole HVAC system will either not function properly or not function at all.

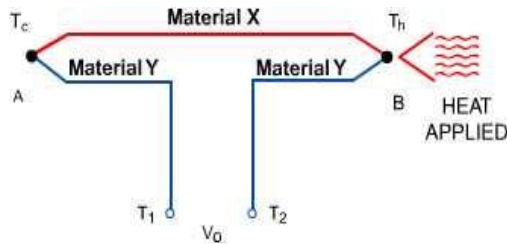
3. HVAC (Heating ventilating air conditioning) Using TEC (Thermo electric couple)

Principle:- A thermoelectric (TE) cooler, sometimes called a thermoelectric module or Peltier cooler, is a semiconductor-based electronic component that functions as a small heat pump. By applying a low voltage DC power source to a TE module, heat will be moved through the module from one side to the other. One module face, therefore, will be cooled while the opposite face simultaneously is heated. It is important to note that this phenomenon may be reversed whereby a change in the polarity (plus and minus) of the applied DC voltage will cause heat to be moved in the opposite direction. Consequently, a thermoelectric module may be used for both heating and cooling thereby making it highly suitable for precise temperature control applications.

Law of thermocouple:-

- **SEEBECK EFFECT:** When a temperature gradient is applied across a homogeneous conductor (such as a piece of wire or a bar of metal), a voltage potential is induced.

When heat is applied to one of the two conductors or semiconductors, heated electrons flow toward the cooler one. If the pair is connected through an electrical circuit, direct current (DC) flows through that circuit.

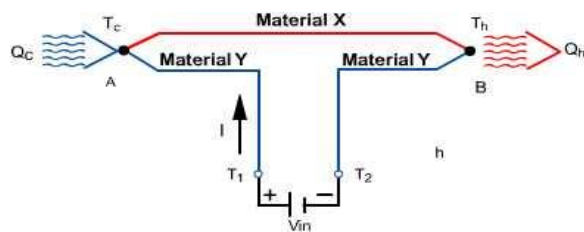


In a typical temperature measurement application, thermocouple A is used as a "reference" and is maintained at a relatively cool temperature of T_c . Thermocouple B is used to measure the temperature of interest (T_h) which, in this example, is higher than temperature T_c . With heat applied to thermocouple B, a voltage will appear across terminals T1 and T2. This voltage (V_o), known as the Seebeck emf, can be expressed as: $V_o = \alpha_{xy} \times (T_h - T_c)$

Where:

V_o is the output voltage in volts
 α_{xy} is the differential Seebeck coefficient between the two materials, x and y, in volts/ $^{\circ}$ K
 T_h and T_c are the hot and cold thermocouple temperatures, respectively, in $^{\circ}$ K

- **PELTIER EFFECT:** When current is passed through a junction of two different metals, the heat is either evolved or absorbed at the junction.



If a voltage (V_{in}) is applied to terminals T1 and T2 an electrical current (I) will flow in the circuit. As a result of the current flow, a slight cooling effect (Q_c) will occur at thermocouple junction A where heat is absorbed and a heating effect (Q_h) will occur at junction B where heat is expelled. Note that this effect may be reversed whereby a change in the direction of electric current flow will reverse the direction of heat flow. The Peltier effect can be expressed mathematically as:

$$Q_c \text{ or } Q_h = p_{xy} \times I$$

Where: p_{xy} is the differential Peltier coefficient between the two materials, x and y, in volts I is the

electric current flow in amperes Q_c , Q_h is the rate of cooling and heating, respectively, in watts.

- **THOMSON EFFECT:** When an electric current is passed through a conductor having a temperature gradient over its length, heat will be either absorbed by or expelled from the conductor. Whether heat is absorbed or expelled depends upon the direction of both the electric current and temperature gradient. This phenomenon, known as the Thomson Effect, is of interest in respect to the principles involved but plays a negligible role in the operation of practical thermoelectric modules. For this reason, it is ignored

4. Construction and working of HVAC (TEC) model

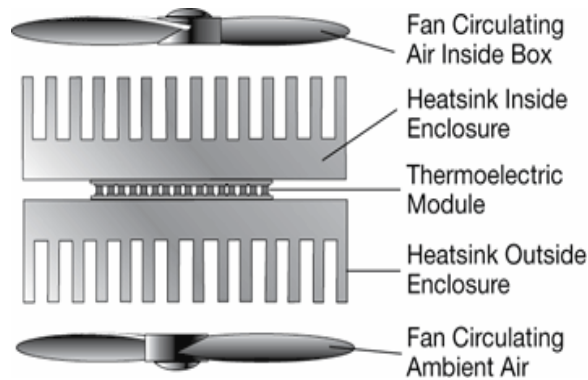
The new HVAC system consist of

- Thermo-electric plate
- Heat sink
- Electric blower
- Various electrical accessories.

Thermoelectric plate is sandwiched between two heat sink made up of aluminium with a suitable pressure depending upon the material of thermo electric plate. The various types of material available are bismuth, potassium, platinum, rhodium nichrome etc. The two blowers are mounted on the either side of the heat sinks.

When the voltage is applied to the thermoelectric plate through the battery one side of thermo electric plate gets hot and other side gets cold. The blower that is mounted on cold side takes the air from atmosphere and that air passes over the plate which in turn becomes cold and is supplied to the passenger compartment. The blower mounted on the other side takes away the heat from the hotter side and releases into the atmosphere. And if the polarity of the thermoelectric plate is changed with the help of electric switch the hot side becomes cold and vice-versa. With the help of this heating effect can be

obtained in the passenger compartment. The dummy model is shown in the figure below.



5. Advantages of HVAC (TEC) model

- A TE module works with less moving parts so they are maintenance free.
- The overall thermo electric system is much smaller than the conventional mechanical one.
- The heating and cooling phenomenon is obtained by just changing the polarity. No separate unit is required.
- Unlike a mechanical refrigeration system, TE modules generate virtually no electrical noise and can be used in conjunction with sensitive electronic sensors. They are also acoustically silent
- With TE it is possible to cool one specific component or area only, thereby often making it unnecessary to cool an entire package or enclosure.
- Conventional refrigeration system cannot be fabricated without using chlorofluorocarbons or other chemicals that may harm the environment. Thermoelectric devices do not use or generate gases of any kind.

6. Conclusion

In today's scenario air-conditioning is not considered as part of luxury but its necessity in day to day for a healthy life, so it cannot be considered as an option. But seeing the global warming today environment safety can also not be neglected. So HVAC (TEC) model is a better alternative to the current mechanical system which is eco-friendly.

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