Mobile Air Conditioning

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MOBILE AIR CONDITIONING

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ABSTRACT

The growth of automobile sector is phenomenal. The automotive air conditioning sector presents a huge opportunity for refrigeration and air conditioning industry. Factory installed air conditioning systems is becoming a norm. Car air conditioning has come a long way since the first comfort cooling system was installed in the year 1939. Many changes have been made since then in enhancing passenger comfort. Very few articles in air conditioning and refrigeration journals get published on this subject. As this field has very bright future, the paper tries to deal with special considerations, the air conditioning professional needs to consider over and above his routine, stationary air conditioning system designs.

INTRODUCTION

The mobile air conditioning includes air conditioning for all mobile equipments, like passenger cars, bus air conditioning, mobile homes (house on wheels), mobile electronic testing vans, battle tanks, containers, defense shelters, air crafts, space ships, and railways, mobile cranes, off highway equipment or any other special requirements.

This article deals with automobile air conditioning since it is the largest sector and growing at a faster rate than any other industry, as the country is fast developing its infrastructure facility.

Automobile air conditioning, with its fast and vast growth, presents a huge opportunity for the refrigeration and air conditioning industry.

The production of passenger cars in India, currently is 6.5 lacs per annum, and expected to grow rapidly at more than 25% rate per year. Since the opening of this sector for global players, we find majority of them are already making their presence felt in India.

Prior to the entry of Maruti car, the air conditioning unit installation by OEM was unheard, and those wanting A/C systems, had to go to service stations for getting assembled systems to be installed on their vehicles. Initially Maruti also had 15 to 20 % vehicles fitted with A/C systems from the factory. Today, more than 80% cars are manufactured with factory fitted air conditioning systems.

The car air conditioning system manufacturers are generally a distinct category and not the regular air conditioning refrigeration manufacturers commonly known to all.

The car air conditioning manufacturers do not have independent identity and are normally considered as auto ancillary component manufacturers.

If, however, one goes into further details, it would surprise every one to know that their turnover is much higher and exceeds that of most of the established and well known air conditioning and refrigeration manufacturers/contractors from the industry, since the volumes involved in automobile air conditioning are very much higher than other air conditioning applications.

Car A/C systems design have to take into account, very special considerations, not normally encountered in stationary installations and this paper tries to highlight these for the benefit of other air conditioning and refrigeration professionals, not normally involved in automobile air conditioning field.

BACKGROUND

At the beginning of the century, the only way to provide comfort cooling in an automobile was by ventilation. These ventilation systems were primitive as they did not filter dirt, dust or insects from the air. Thus, the quality of air circulating through the passenger compartment was poor. In 1940's gradual introduction of fresh air-heaters started to keep the interiors warm.

In 1930, Kelvinator fitted a customized Cadillac with 0.5hp unit powered by 1.5hp gasoline engine. Two flues on either side of the front seat took the air down to the fan, which circulated cool air through out the passenger compartment. The unit looked like trunk and fitted compactly on the back of the car.

The capacity of initial units was estimated to be around 1 ton since it was calculated on the basis of only recirculation mode .The temperature drop considered was only to the extend of 10^0F (5.6^0C) over the ambient conditions, since it was felt by the designers that any lower temperature could lead to thermal shock while entering from hot outside climate.

During 1930 General Motors developed a prototype of self-contained unit that was installed in the trunk of a Cadillac.

During the same period, Pacard Motors developed a complete air conditioning system for summer cooling and winter heating.

Between 1940 and 1942, Pacard motors equipped 1500 automobiles with air conditioning and General Motors installed around 300 systems in 1941.

Initial units had no provision for fresh outside air. Smokers in the car made condition of air unbearable. The System also did not have interior controls and the driver had to get out of car, open the hood and remove the belt to stop the cooling. The system had additional draw backs as it did not provide adequate quantities of cool air to the front passengers. The rear mounted evaporator, sometimes dripped the condensed water over the rear seat passengers. The A/C outlets were located in the rear of the vehicle, on the right and left side of the package tray, which resulted in passenger stiff necks as the cold air passed across the back of their heads and shoulders. Even positioning the outlets in the center with directional louvers did not substantially decrease the complaints. The cost of the units was also very high & could therefore be fitted only on most expensive luxury cars.

After the world war two, in 1947 independent manufacturers began installing air conditioners on all types of cars, creating a large after-market business. Low cost cooling aids like evaporative coolers were also marketed for those who could not afford factory installed vapour compression units. Window mounted evaporative coolers became popular in dry climate areas.

1950's saw the real come back for automotive air conditioning. Earlier A/C systems used R-22 refrigerant with hot gas bypass arrangement since the compressor did not have Electro-magnetic clutch. In 1953 nearly 29,000 units were shipped with factory-installed air conditioning. During this year General Motors developed an air conditioner that could be mounted under-hood in the engine compartment. This was much more efficient design and by 1955 nearly seven car manufacturers started installing under-hood mounted A/C units.
The popularity of automotive air conditioning soured in 1960s and nearly 15% cars rolled out from factories had factory installed air conditioners and by 1969 this percentage rose to 54%.

The refinements continued to be made during this period to render air conditioning systems quieter and more reliable. The system could be controlled in response to temperature setting selected by the driver. Proper velocity and temperature distribution of air was provided, and General Motors started marketing such systems as climate control systems. The weight of compressors reduced from 27Kgs to nearly 6 to 7 Kgs. The heat exchangers became compact and lightweight.

In 1977 and thereafter, car manufacturers, after considerable amount of screening, opted for R134a refrigerant as a likely replacement for R-12. By 1992, car makers started implementing the changes required for replacement of R-12 with R-134a.The new lubricants, new deccicants and the nylon lined hoses, fittings and rubber components had to be developed and utilized for making them suitable for new refrigerant R-134a.The refinements continued to be made in other areas as well.

CUSTOMER EXPECTATIONS

The customer's expectations have undergone major changes over a period and have advanced beyond just conducting the cool or warm air into passenger compartment. The level of comfort and cozy atmosphere inside the vehicle is a must but he also wants to adjust air volume, velocity and temperature over a wide range of climatic and driving conditions. Besides this it is essential that the system must be quiet, the controls easy to understand and operate. It must also cool down a hot vehicle and defrost the windows of a cold vehicle quickly.

DESIGN CONSIDERATIONS

The objective of the A/C system designer is to allow the safe operation of a vehicle in all kinds of weather by making a human body thermally comfortable and maintaining all glass areas free of fog or mist on the inside. The system design should also ensure that the compressor consumes minimum engine horsepower and is efficient over a wide range of RPM.

Keeping the customer's expectations in mind and taking into account design considerations, the specific areas need to be addressed are:

a. Initial fast cool down, in a hot vehicle.
b. Enough air circulation to all occupants without causing uncomfortable drafts or suffocation.
c. Uniform maintenance of temperature in the entire occupied area without noticeable temperature gradients.
d. Satisfactory temperature in all weather conditions in all seasons and over all driving conditions like city traffic or highway driving.
e. The system must be quiet, no undue disturbance felt due to irritating noise especially when using music system.
f. The vibrations should not be felt in any part of vehicle like Dashboard, floor gearshift etc. or get transmitted to passenger compartment when A/C. is switched on.
g. No undue jerks or loss of engine power when A/C. compressor cuts in or cuts out while clutch engaging / disengaging.
h. Controls easy to understand & operate without affecting the drivers concentration.
i. Must be energy efficient system without excessive additional fuel cost.
j. Should not affect vehicle engine / radiator cooling performance especially at a time of accelerating or driving at low speeds or while climbing gradients.
k. And last but not least the A/C. system should be cost effective.

As a system designer, this puts lot of restrictions on the options available and it is therefore essential to define at the start of the project, the parameters clearly, so that more importance is attached to these specific issues and less weightage is attached to other related parameters.

In any design, one would appreciate, it is always a trade off, and if one wants to gain something one should be willing to loose something.

Unlike standard air conditioning plant designs, where the installation is specific for the city/area, while installing vehicle air conditioning system, the car manufacturer does not know in which part of the country the car is going to be sold and the designer has to therefore consider very wide range of climatic conditions for load estimation.

PRINCIPLE OF OPERATION

Before going into the design aspects we shall look at the specific terms used in automobile air conditioning systems.

The vehicle's AC system is commonly referred to as **"HEVAC"** or **"HVAC"** system and handles three fluids; air, water-coolant, and refrigerant.

The **"HE" or "H"** portion consists of heater, water valve, controls and plumbing and handles fluid streams of air and water.
In heat mode following functions are carried out
1. Warm up
2. Defrost
3. De-mist

The **"V"** portion consists of air ducts, air handler comprising of casing, inlet outlet ducts, baffles, air mix doors, actuators, blower and motor. It handles only air stream as a fluid.

In ventilation mode following function is carried out

Air flows through the inlet cowl, through the unit, into the compartment.

The **"AC"** portion consists of refrigeration cycle components such as compressor– mounted on the engine block, condenser with it's fan and motor mounted in front of radiator and air handler housing evaporator, metering device (Expansion valve), in addition to **"HE"** and **"V"** components described above.

Piping (plumbing) through which refrigerant fluid circulates connects the refrigeration components. The refrigerant in turn cools/dehumidifies air and such treated air is circulated in the passenger cabin for achieving comfort conditions. The total system is therefore called as **"HVAC"** system and handles all three fluid streams such as water, refrigerant and air.

HVAC system makes human body comfortable both in the summer and winter and keeps the windows defrosted and de-misted.

In short the function of "HVAC" unit during hot climatic conditions is to absorb heat from the passenger compartment into the refrigeration system, i.e. in to the refrigerant, move it through the system, and finally reject heat to atmosphere.

FACTORS INFLUENCING LOAD ESTIMATION

The elements which constitute the heat gain inside the compartment, which is normally called the heat load on the AC system, are:

1. Heat ingress in to the passenger compartment from ambient air through conduction, convection and radiation- Sensible & Latent heat
2. Body leakage- Air infiltration load as also due to ram air when vehicle is moving. (Significant)
3. Heat pick up in the return air through duct up to evaporator inlet
4. Sun load (50% Approx. of total load) through glass areas and

20% through Roof

5. Passenger body heat-approx. 220 Watts for Driver & 100 Watts per passenger
6. Heat gain through engine firewall
7. Road heat and exhaust heat through flooring
8. Heat generated by blower- motor

In order to calculate contribution from each of these elements, it is a complicated process and accuracy is questionable due to complexity of materials making up the car body and different modes of heat transfer involved.

Instead the effect of all these parameters can be reflected if we consider the equation using overall heat transfer coefficient and the temperature differential between the passenger compartment and ambient air (ΔT), and outside body surface (A_o).

$Q = U_o * A_o * \Delta T$ or $Q = m * c_p * \Delta T$

In order to establish correctly the overall heat transfer coefficient it is essential to calculate evaporator duty/load, by using the equation

$$U_o = Q \div A_o \cdot \Delta T$$

To establish evaporator load following are the industry norms as basis of design

1. 55 MPH (89km/h) vehicle speed
2. Ambient temperature (38 °C) Dry bulb / (24 °C) Wet bulb
3. (13 °C) Evaporator air outlet temperature
4. (5.6 °C) subcooling, at condenser outlet
5. (14.4 °C) superheat, at evaporator outlet
6. 20 bar (2000KPa) Discharge pressure, corresponding to 67°C saturation temperature.
7. 2.8 bar (280KPa) Suction pressure, corresponding to minus1.7°C saturation temperature.
8. R 134a refrigerant
9. Cooling load on basis of **100% fresh air**
10. Approximate air quantity 300 cfm (500 cum per hr.)
11. Inlet duct temperature pick up- (5.6 °C)

After estimating the cooling load and overall heat transfer coefficient, the designer has to take into account following aspects as well.

The cooling capacities as a general guideline for various sizes are as under

Small cars like Maruti, Indica, Santro	4500 kcal/hr
Medium size cars Sumo, Bolero, Honda city	5500 kcal/hr
Large cars Like Safari, Qualis,	6000 kcal/hr
Small buses 10 to 15 passengers up to 5 M long	8000 kcal/hr
Medium size buses 6 to 8 M length 22 passengers	14,000 kcal/hr
Large buses 10 t0 12 M long 38/45 passengers	22000 kcal/hr
Extra large Buses like Volvo	30000 kcal/hr

SYSTEMS

For passenger cars the system normally used globally is under the dash mounted Evaporator blower unit, compressor mounted on the engine block and condenser mounted in front of the radiator, either using separate fan with its own motor or if the radiator is big and radiator fan is powerful, no separate condenser fan is used, like in Qualis vehicle. Many large cars have an option of additional evaporator mounted in the middle, behind driver's seat, to provide additional cooling for rear seat passengers.

The bus air conditioning systems are either

a. Integrated – where the evaporator is mounted inside the bus at the rear or front, compressor mounted on engine and condenser with its fan mounted on the roof top.
b. Other popular design is roof top units. These are condenser/evaporator combination and there is a separate power pack mounted under the chassis between the wheels. The power pack comprises of diesel engine and compressor.
c. If the vehicle engine is powerful to meet the requirements of A/C compressor, then separate power pack is not required. The engine could be front mount or rear mount.

In passenger car, an A/C system designer has hardly any say since the cars are manufactured in the car plant.

In bus air conditioning system, an A/C system provider has a much important role to play. He should guide the bus body builder to take necessary steps such as making the bus body leak proof, providing adequate insulation for roof and flooring as well as fire wall and proper ducting for efficient air distribution,

Besides providing adequate cooling capacities, the A/C. designer also must look at the air flow management, unfortunately he does not have a luxury of availability of airflow areas or geometry described in textbooks or as can be recommended on new building construction projects. At the start up, he has to follow the vehicle designers styling requirements. The pressure drop in Air ducts could be therefore significant.

In automobile applications, he has to negotiate styling requests for aesthetic AC outlets & control appearance, The evaporator / blower / heater unit has to be located in such a manner that it should not be visible to driver / co-passenger and at the same time must operate with a much narrow and twisting duct work that is far from any ideal design requirements.

The engineer has also to package the compressor, its drive, plumbing, condenser & its fan in a hot restricted space, without overlooking maintenance / ease of service requirements.

While selecting compressor and its speed, he has to ensure that compressor uses minimum engine power and be efficient over a wide range of RPM.

Keeping all these issues in mind, the designer also cannot afford to forget the cost aspect and has to package the system and selection of components to meet the targeted costs.

Till the vehicle is launched, he has also to be prepared to incorporate design changes speedily during first phase of vehicle launching which are a norm with most automobile manufacturers especially with regard to routing of piping and compressor and other mounting brackets.

The designer has to consider effective A/C. operation in following modes of vehicle

c

1. Cool down
2. fic
3. Highway
4. Idle and
5. Gradients /Ghat sections

Now going in to further more specific issues, the A/C designer must also take into consideration following points.

1. The complete range of performance of the compressor for all speeds at which it will be driven for all ranges of suction and discharge pressures it is likely to encounter.
2. The performance map of evaporator for all air quantities in different fan modes, air temperatures and evaporation temperatures. Especially ensuring that the evaporator icing problems are never to be encountered.
3. The complete performance characteristics of the condenser over full range of air quantity provided.
4. The performance interaction between individual components of the system over the full range of operation. Stable operation of systems depends upon the performance inter-actions between the individual components of the system over the full range of operating conditions to which the components will be exposed. It should be remembered that the system is as powerful as its weakest component.

   Capacity is not determined by any one component, but a change in any component affects the system balance capacity.

5. The free draining of condensed moisture on the coil to avoid accumulation in the evaporator box thereby spilling on the floor carpet and or generating stinking smell fungus / bacterial formation.
6. Keeping evaporator coil clean by way of filters / wire mesh to ensure dirt / dust / leaves / rats and other pests / insects preventing from entering t he A/C unit.

Even after taking into account so many factors, as mentioned earlier, there are always some unavoidable trade offs from the designer's angle and he has to make all concerned aware of the same so that all issues are understood clearly and decisions taken collectively, involving engineers from various disciplines including marketing and customer support departments.

POSSIBLE TRADE OFFS

1. Air is a medium that picks up heat from car cabin & brings it to evaporator coil for heat rejection. In the process, air gets cooled & is circulated through passenger cabin to provide comfort.
   This means more the air flow, faster is the cooling & more uniform temperature in all the parts of interior space, without hot or cold spots.

   Also, only large air volume at higher temperature will not do as it would not produce desired comfort condition.

   This means large volume of air at lower air temperature from coil will be more preferred system for faster cool down & lower cabin temperatures.

2. Higher airflow would mean higher noise level. It could be beyond acceptable limit & hence a compromise has to be done between airflow & noise level. Benchmark for typical vehicle could be air quantity of 100 to 150 liter / sec approx. depending on vehicle interior volume & noise level below 68 dBA.

3. Similarly, a lower air out let temperature from grill (less than 4^0 C) would mean Evaporator coil temperatures nearing freezing point of 0^0 C & chances of coil Freeze-up / increase in ice formation.

   Ice formation must be avoided at all costs. Since if ice formation tendency starts, due to blockage of coil, the air quantity starts reducing, there is less surface area available for heat transfer & hence less cooling capacity leading to further drop in evaporating temperature & increased ice formation. Once ice formation starts, one cannot stop it unless the system is shut down. It is called snow- balling effect & can choke the coil completely leading to no airflow.

   Many would have observed this phenomenon especially with after-market under-slung installed kits & passenger feels air conditioner wiring is burning, since smoke coming out is noticed at air outlets. It is nothing but air with suspended frost. The cooling also suffers. If driver switches off A/C. for 15 – 20 minutes, allowing coil to melt all ice, the A/C then starts functioning normally. An average grill temperature of 6-9 ^{0}C is ideal which ensures that coil performance is in safe range & no danger of ice formation exists. Hence insisting for lower temperature at grill could be a misleading situation. What one must look for is lower grill temperature without affecting nominated airflow, which means coil is not icing & blocking airflow. **Only lower grill temperatures without adequate air flow will not lead to passenger comfort as the required temperature in the cabin cannot be reached without sufficient air quantity.**

The other danger of operating at low evaporating air temperature is the antifreeze thermostat would tend to clutch / de-clutch compressor very frequently if the compressor has not been selected properly & is oversized for the duty.

4. The selection of compressor speed is important. If most of the driving is in city traffic conditions, a higher pulley ratio may help so as to get higher compressor speed when engine is near idling speed.

The danger however is, if the same vehicle is running on highway, it may lead to excessive compressor RPM beyond recommended limits, reducing the life of compressor due to extra wear. As against this, if one designs the pulley ratio keeping highway operation in mind, the cooling performance gets adversely affected in city traffic conditions due to inadequate cooling due to lower engine / compressor speeds.

Sometimes this is taken care of by fast idle speed arrangement, but if the engine power is inadequate at idle speed, the engine struggles to take compressor load. Most of the drivers experience this, especially with the cars having engines with lower horsepower ratings/ displacements.

A choice however has to be made in the beginning as you never know who is going to buy the car & where it is going to be operated for most of the time, leading again to some trade off.

5. Another most important factor to be remembered is that the cooling load is not constant and varies depending on many factors like, ambient temperature / humidity conditions, occupancy / glass area / insulation of the body & dash board, fresh air requirement / colour of car etc. The cooling requirement is also highest when vehicle is standing in open under the direct impact of solar rays.

The soak temperature inside the vehicle could be higher than ambient temperature by 25^{0}C to 30^0 C.

The air conditioner provided must therefore achieve fast cool down and also be able to meet lower heat load requirement on steady drive conditions, without constant cycling.

The car A/C compressors normally do not have any capacity control arrangement unlike compressors for land installations, where capacity of the system can be reduced by cylinder unloading or switching on / off one or more compressors in multi compressor installations or many other capacity control methods.

In car A/C, the only parameter to which compressor responds is Air on or off temperature from evaporator coil. When desired temperature is reached, the thermostat de-clutches the compressor thereby shutting off cooling which loads to increase in occupied space temperature, again cutting in compressor giving cooling. Thus the compressor either gives full capacity or no capacity at the operating speed and as can be expected, selection of an oversized compressor would lead to more frequent on / off operation reducing the life of clutch / compressor and putting undue stresses on engine.

The load pattern and compressor output that is dependant on vehicle speed & is therefore totally independent in automobile operation. If load is high and if you are driving at lower speed system cooling performance is adversely affected.

Similarly if the load is low, and you are driving a higher speed, the compressor and system is delivering much higher output than needed and the system will constantly cycle on / off.

This phenomenon is noticed when, due to sudden acceleration / deceleration A/C compressor gets engaged / disengaged, leading to jerky operation.

On many occasions we experience that while overtaking, we are expecting certain engine performance & if at the same time if A/C compressor cuts in, we feel sudden momentary loss of power due to extra compressor load especially on smaller horsepower vehicles and visa-a-versa. This is due to A/C system operation is controlled by temperature alone while engine/compressor speed is dependant on driving conditions.

The foregoing analysis shows that the wide range of compressor capacity caused by varying speeds and carrying operating conditions require some means of control to maintain good capacity during pull down and road driving conditions, and yet to prevent coil icing up during highway operations.

The ideal situation would be to have the compressor capacity always matching with cooling requirements of the car without the use of a cycling clutch or any other device.

Some compressor manufacturers provide variable displacement compressor designs with automatically adjustable capacity or hot gas bypass arrangement.

When the demand is high the compressor works with full stroke. As the cooling load requirement diminishes, the compressor starts to de-stroke thereby reducing the compressor output to match the requirement. This thus eliminates the need of compressor thermostat cutting clutch off/on. The advantages of variable displacement are significant by way of smoother ride / passenger comfort and reduced fuel consumption & power required to drive the compressor and less wear.

Majority of car air conditioners use reciprocating compressors, these could be wobble plate / swash plate design with inline pistons. The compressor could be fixed displacement or variable displacement as mentioned above.

The other types of compressors are Rotary design / Scroll designs.

The Rotary / Scroll compressors are more compact compared to reciprocating compressors, lighter in weight, less noisy, less vibrations and consume less power.

The latest trend is therefore to switch over to scroll compressors, the only drawback being they are still more expensive compared with other types. Most of the compressor manufacturers in the world are currently engaged in development of scroll compressors and as the volumes would increase the cost will come down.

The other major components are evaporators / condensers and these heat exchangers are available in tube and fin design, serpentine, parallel flow & plate and fin designs. The efficiencies as well as costs go on increasing in the same order.

The expansion device is 4th major component without which no A/C system would function. The types available are Orifice tube, Thermostatic expansion valve, Block valve, and Electronic expansion valves operating with PLC's. Here again the performance & cost goes on increasing in the same order. As the cost of electronic components is falling, the more & more use of electronic controls would be obvious in future.

EMERGING TRENDS

We would now conclude this article by touching upon some of emerging trends / future technologies and the areas in which the designers / scientists are currently working globally.

The CFC refrigerants contributing to ozone depletion were banned with adaptation of Montreal Protocol in 1987 & resulted in subsequent phasing out of CFC's in developing countries.

The automobile industry predominantly has adopted HFC 134a as a choice refrigerant for air conditioning systems in place of CFC 12.

The lobby of environmentalists is suggesting phasing out of these new refrigerants also due to their global warming potential. The Kyoto protocol includes R134a in its basket of limiting consumption of these gases & hence study of alternative refrigerants in place of R134a for automotive air conditioning is assuming greater importance.

The R134a has global warming potential (GWP) of 1300, implying that if it leaks, it is equivalent to leaking 1300 times the same amount of Carbon dioxide.

The new refrigerants & gases are now evaluated on the basis of (TEWI) Total Equivalent Warming Impact index for comparison & attempts to use natural refrigerants is gaining renewed interest.

Many car A/C manufacturers are studying use of CO_2 as a refrigerant. CO_2 systems operate at significantly higher pressures (5 times higher than R134a) systems & would demand new compressors to withstand these pressures. It would also demand higher quality fittings to eliminate leakage. Leakage due to elevated levels of CO_2 can also affect the comfort & health of driver & vehicle occupants. Extremely thin yet very strong aluminum tubing can be made available to replace heavy steel tubing. Such tubing has already been developed. The system would become much more compact compared to existing systems.

Almost all the car manufacturers have prototype cars ready with CO_2 based systems. Eckhard Groll, Member ASHRAE, an associated professor of mechanical engineering at Purdue University states, " I have driven a BMW with a carbon-dioxide air-conditioning system, and it was very comfortable."

The consortium in Europe is working on project RACE for car air conditioning using CO_2 as refrigerant.

The other natural refrigerants like air, HFC's or even water are being explored to replace conventional refrigerants in stationary & mobile air-conditioning applications.

There are more than 300,000 cars in Australia using hydrocarbon as refrigerant for air conditioning systems.

Scientists in US also believe that they are close to developing a cooling system for vehicles based on magnetic refrigeration. This is based on magneto caloric effect. The ability of some metals to heat up when magnetized and cool down when removed from magnetic field.

The air conditioning using this system would run on electrical power produced by alternator thus reducing load on power train & making car more efficient. The process can also be reversed in order to heat the vehicle.

This technology could be ideal for use in electrical cars.

Automobiles are gradually consuming more electrical power, and as the current delivered by alternators increases, the need for higher voltage is becoming urgent. Most of the auto manufacturers are therefore gradually migrating to 42 Volts electricals. This would enable to use more electrical devices,. Two major components like electrical driven compressor and blower motors can be used besides use of resistance heaters, for positive temperatures.

Manufacturers are also working to get rid of belts in the car and trying to produce a car without belts.

TI Group in Europe is working on automotive systems using concentric tube. The patented design of this new, two in one tube, called the co-tube, offers significant benefits to vehicle manufacturers.

The normal system uses supply & return pipes to carry pressurized liquid & vapour refrigerant & with the limited space, packaging becomes problematic many times.

This type of plumbing would save space, reducing packaging & improve performance, strength & flexibility.

The Chrysler's Jeep Cherokee, already uses this Technology & more would follow.

The upgradation of major components with latest technologies will be another subject, as mentioned earlier. Compressor designs are undergoing changes like variable displacement reciprocating & scroll compressors. Increased used of Scroll technology being preferred by automobile manufacturers. Development of orbital Vane Rotary compressors etc is also being attempted. New heat transfer areas to make heat exchangers more compact, more silent blower, new refrigerants, alternate technologies & increased use of electronic controls would be future ingredients of automobile A/C systems.

The developments are taking place so rapidly that it may not surprise a new Technology never thought of before may become popular in the near future & therefore investment in new Technology and R & D activity is a must if one wants to retain & remain in the forefront as mobile air conditioning system designer/manufacturer.

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Date : 28th December 2003 **Ramesh Paranjpey**