

Environmental Protection by Optimum Utilization of Car Air Conditioners

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ABSTRACT: According to N.R.E.L.'s findings, 700 crore gallons of petrol is used annually to run the air conditioners of passenger vehicles (nearly 6% of total fuel consumption in the USA). Beyond fuel use, the Environmental Protection Agency reported that refrigerant leaks from auto air conditioning units add an additional 5 crore metric tons of carbon emissions to the atmosphere each year. The objective of our project is to deal with this vital issue by carefully modifying the interiors of a car thereby increasing its mileage and the efficiency of its engine. This would consequently result in a decrease in tail emission and generated pollution along with improved car performance. An automatic mechanism, deployed between the front and the rear seats, consisting of transparent thermal insulated sheet, would roll down as per the requirement of the driver in order to optimize the volume for effective air conditioning, when travelling alone or with a person. The reduction in effective volume will yield favourable results.

Even on a mild sunny day, the temperature inside a parked car can quickly spike to life-threatening levels. For a stationary parked car, insulation would be provided beneath its metal body so as to reduce the rate of heat transfer and increase the transmissivity. As a result, the car would not require a large amount of air conditioning for maintaining lower temperature, which would provide us similar benefits. Authors established the feasibility studies, system engineering and primarily theoretical and experimental results confirming the idea and motivation to fabricate and test the actual product.

KEYWORDS: Automation, Car, Cooling Insulating Curtains, Heat Optimization, Insulation, Reduction in Tail Emission, Mileage.

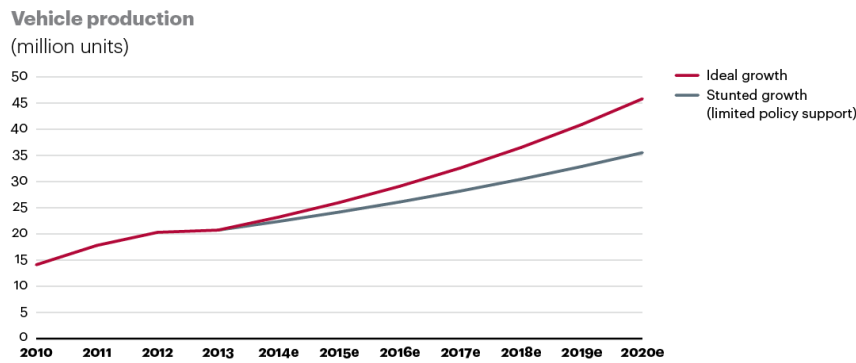
I. INTRODUCTION

According to the Global Carbon Project co-led in the UK by researchers at the Tyndall Centre for Climate Change Research at the University of East Anglia and the College of Engineering, Mathematics and Physical Sciences at the University of Exeter, there is a 2.5% projected rise in burning fossil fuels. China, USA, EU and India are the largest emitters accounting for about 58% of emissions together. India's emissions grew by 5.1% in 2013. The Global Carbon Budget shows that future CO₂ emissions cannot exceed 1200 billion tonnes or else there is a 66% chance of global warming exceeding 2 C limit (since preindustrial times). At the current rate of CO₂ emissions, this 1200 billion "quota" would be used up in only 30 years. After the economic liberalization of the early 90's, India witnessed an automobile boom which has a major role in polluting the environment.

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Sources: Society of Indian Automobile Manufacturers, International Energy Agency; A.T. Kearney analysis

Fig. 1 Growth projections for India's auto industry

Today, most of the people cannot travel in cars with their windows down. Air conditioning in cars have become a necessary than a luxury. It significantly increases the load on the engine, increasing fuel consumption and tail emission. India, being a signatory in Kyoto Protocol, is constantly trying to find new ways to reduce environmental degradation. According to the statistics, Delhi is the most polluted city in the world. This lead to the thought process where we tried searching for innovative and efficient ways to curb the growing menace. We recommend industries to adapt to the ideas before it is too late.

II. PROJECT FORMULATION

The main reasons of increasing temp in a moving and stationary car were identified. It was found out that the usage of air conditioners have a direct impact on the mileage, performance and tail emission. To reduce the impact, an insulating curtain was thought of to optimize the conditioned air in the vehicle. Most of the cars are driven in the presence of only the driver and the curtain acts as a barrier between the front and the rear seats. It regulates air in the front portion of the car only. The time and fuel required to cool down the entire car is much more than the cooling of only the front portion. For a stationary car, the effect of sheet metal and insulation plays a crucial role. India, being a tropical nation, imports cars from the countries which are cold and do not witness a high temperature rise. These cars have no or little insulation as there is no such requirement. But in India, where the peak temperature in summers reaches almost 45-50 degree Celsius, it is important to provide the cars with insulation to keep the temperature in the car under control. Different materials were deployed between the metallic body and the inside roof of the car to calculate the resultant insulation. The insulation was helpful to curb temperature inside the car while moving and even while it is parked.

A. Execution

The car was tested under four conditions to access the amount of time required to cool down its interior temperature. The ambient temperature was noted as 37°C. Without air conditioner, insulation and compartment, the temperature of the car rose to 42.7°C in mere 5 minutes. Readings were computed with or without the air conditioner, insulation and compartment in various time intervals and temperature difference was recorded. This made us realize the effect of compartment and insulation in the car. The car used has interior dimensions 4.25m by 1.67m. The following observations are the result of the experiment.

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S.No.	Air Conditioner	Compartment	Insulation	Time (in min)	Initial Temperature (°C)	Final Temperature (°C)	Difference in Temperature (°C)
1.	✓	✗	✗	2	42.7	33.2	9.5
				3		31.7	11
				4		30.2	12.5
2.	✓	✓	✗	2	42.7	30.3	12.4
				3		28.5	14.2
				4		27.6	15.1
3.	✓	✓	✓	2	42.7	28.7	14
				3		27.9	14.8
				4		26.7	16

Table 1. Difference in Temperature at various conditions

III. EXPERIMENTAL RESULTS

A significant difference in temperature was observed by the use of the introduced methods. The parked car reached the temperature of 42.7°C in 5 minutes from the ambient temperature of 37°C. All the experiments were carried thereafter to lower this temperature. First, the air conditioner was operated for 4 minutes and the temperature decreased by 12.5°C. It should be noted that the car used for the above observations was stationary. The heat transfer rate for a moving car would be greater than the stationary car. The temperature was noted for a time interval of 2, 3 and 4 minutes. Then, the thermal insulating curtain, of the thickness 0.225mm or 225 microns, was used to make the compartment between the front and the rear seats. Installing the compartment gave compelling results. The front compartment of the car witnessed a decrease of 27.6°C. There was a major 15.1°C temperature difference when compared to the earlier observation by using only the air conditioner. Hence, it was determined that the use of thermal insulating curtains (which has a much lower heat transfer coefficient as compared to other tested materials such as PVC and cotton) would further result in a greater temperature difference. This difference makes a direct impact on the fuel consumption of the car as the ambient temperature is achieved much faster in the second case. For computing the effect of thermal insulation, Polyurethane foam or PUF was deployed on the interior body of the car excluding the doors and windows. The PUF acted as the insulation between the roof and the interior on the car. The actual placement of the PUF will be between the outer roof and the inner roof of the car which would result in a better thermal insulating surface. It was noted that the change in the temperature gave promising results when compared to the case of the compartment only. In this experiment, the difference of the temperature drop in 4 minutes turned out to be 16°C. The insulation was placed exactly between the roof and the metallic body of the car but on its interior roof.

IV. CALCULATIONS

The amount of power saved and reduction of carbon emissions were calculated by the implementation of the project. All three conditions were plotted on the graph to visualize the decrease in temperature in the cases. It was found out that the modified car with AC on, thermal insulating curtain and insulation gave compelling results.

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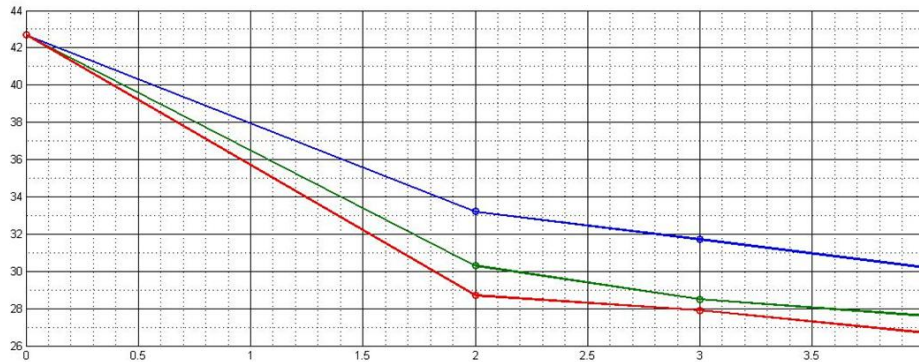


Fig. 2 Temperature vs Time graph for Table 1

- Blue: Only air conditioner runs
- Green: Application of thermal insulating curtain
- Red: Application of thermal insulating curtain with inner thermal lining

Here, the temperature steadily drops for the last curve which represents the air conditioning unit attached to the thermal insulating curtain along with the inner lining of polyurethane foam inside the cabin of the car.

A. Power Saving

On the usage of a regular air conditioning unit in the modern automobiles, power of around 3kW is released. Thus, Power = 3kWh

According to the readings, for air conditioner to reach the temperature of 26.7°C,
Time Taken = 5.12 min

Power Consumption = $(3 \times 5.12) / 60 = 0.256$ kWh

For the car using thermal insulating sheets along with the cabin insulation installed, the temperature of 26.7°C is reached at a lower time.

Time Taken = 4 min

Thus, Power consumption = $(3 \times 4) / 60 = 0.2$ kWh

So the amount of power being conserved in 1 hour with the help of the project material and analysis is,

Power Saved by one car = $0.256 - 0.2 = 0.056$ kWh

According to the Road Transport Year Book, as on March 31, 2012, there were 7.4 million vehicles registered in Delhi itself.

Thus, Total Power saved by automobiles = $0.056 \times 7,400,000 = 414,400$ kWh

B. Reduction of Carbon Emissions

It would make a huge difference if the mechanism would be installed in the automobiles around the globe. Apart from saving fuel, it would be greatly beneficial to help curb the environmental pollution and the carbon emissions in the city and the country in totality.

Emission factor of petrol = 2.39 kg CO₂/litre

Average mileage of four-wheeler automobiles in Delhi (with AC on) = 17.6 km/litre

If we assume a car to travel the distance of around 50 km in a day with an average mileage, then the carbon emissions will be:

Amount of petrol used for travelling = $50 / 17.6 = 2.84$ litres

Carbon dioxide emission by one car = $2.39 \times 2.84 = 6.789$ kg

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Because of the thermal insulating curtain and the insulation provided in the car, the AC would be used for lesser time and not throughout the journey. Let us assume that the AC is functional only half of the time (50% of total time) in the car, then,

Amount of petrol used for travelling= $25/17.6 + 25/19 = 1.420 + 1.315 = 2.736$ litres

Thus, Carbon dioxide emission from petrol= $2.39 \times 2.736 = 6.539$ kg

Decrease in carbon emission by one car= $6.789 - 6.539 = 0.25$ kg

Total decrease in carbon emissions by automobiles in Delhi = $0.25 \times 7,400,000 = 1,850,000$ kg

C. Economy of the project

By using the modified car, the reduced usage of car air conditioners will result in the saving of power, emissions and cost as well. This would make the project accessible and affordable for common people.

Here, we will be computing the pay-back period and the savings of the car owner.

Average cost of petrol= Rs.66.29/litre

Let us assume as before that the car travels 50km at an average mileage of 17.6 km/litre with the AC on. Then,

Amount of petrol used for travelling= $50/17.6 = 2.84$ litres

As stated before, the use of thermal insulating curtain and the insulation provided would reduce the functioning time of the AC. Assuming that the AC is functional only half of the time (50% of total time) in the car, then

Amount of petrol used for travelling= $25/17.6 + 25/19 = 1.420 + 1.315 = 2.736$ litres

Thus, total amount of petrol saved = $2.84 - 2.736 = 0.104$ litre

Total amount of money saved in one day of travel= $66.29 \times 0.104 = \text{Rs.6.894}$

The modification of the car is affordable and feasible for all classes of 4-wheeler owners. It would take a maximum of Rs.2000 to be attached inside the interior of the car. Thus,

Pay-Back Period= $2000/6.894 = 290.107$ days i.e. approximately **10 months**.

With a short pay-back period of about 10 months, the concept yields startling results with savings in terms of cost, making it affordable and profitable.

V. CONCLUSION AND FUTURE ENHACEMENTS

Project is found out to be sustainable, implementable and feasible. It has the potential of lowering the current usage of fuel consumption worldwide, limiting the effect of automobiles on the environment. It is computed that reducing the use of air conditioners have a cogent and direct impact on the mileage, fuel consumption and tail emission. By diminishing the tail emissions, the amount of vehicular pollution will trim down. By using the modified interiors of the car, it is determined that we can save 414,400 kWh of power and reduce the present emissions by 1,850,000 kg per day by the usage of only one hour. The pay-back period for the concept is 10 months only. The installation of insulating curtain mechanism is feasible and effective. Thermal insulation can be provided by the manufacturing companies beforehand or can be installed later under the upper roof of the car. The project has a huge scope in the future as minimal modification in the car is giving striking results. We are ready to collaborate with willing industries for development of the product. It is vital to find alternative and simpler ways to effectively minimize the present fuel consumption. It will have a cogent impact on the sustainability of life on our planet; a step ahead.

REFERENCES

- [1] Valerie H. Johnson, "Fuel Used for Vehicle Air Conditioning: A State-By-State Thermal Comfort-Based Approach", Society for Automotive Engineers, Inc., 2002-01-1957, 2002.
- [2] Terry J. Hendricks, "Optimization of Vehicle Air Conditioning Systems Using Transient Air Conditioning Analysis", Society for Automotive Engineers, Inc., 2001-01-1734, 2001.
- [3] R. Farrington and J. Rugh, "Impact of Vehicle Air-Conditioning on Fuel Economy, Tailpipe Emissions, and Electric Vehicle Range", NREL Report No. CP-540-28960, September 2000.
- [4] Commercial Item Description, Plastic Sheet, Polycarbonate, A-A-59502, 9 June 2000.
- [5] Mohammad Ali Fayazbakhsh and Majid Bahrami, "Comprehensive Modeling of Vehicle Air Conditioning Loads Using Heat Balance Method", SAE Technical Paper 2013-01-1507, 2013.