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Reduced Tail Emissions by Optimum Usage of Car Air Conditioners

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Abstract: In USA, nearly 6% of the total fuel consumption every year (i.e., 700 crore gallons of petrol) is due to the employment of air conditioners in passenger vehicles. Taking the refrigerant leaks into account, the environmental protection agency reported that each year, there is an additional 5 crore metric tons of carbon emissions added to the atmosphere beyond the general fuel use. The main objective of this project is to propose a way to deal with this grave issue in order to drastically reduce the tail emissions and increase the efficiency and mileage of a car by carefully altering its interiors. Simultaneously, the project has proven to be useful in improving the car performance and greatly diminishing the air pollution by making the proposed changes. The idea is to fit an automated mechanism which would be attached between the front and the back seats. It would consist of a transparent insulated sheet (with very low thermal conductivity) that would roll down whenever required so that the effective working volume for the air conditioner is significantly declined. This is particularly helpful if the driver is travelling alone or when only the front seats are occupied. The cut down of this volume is responsible for the optimal use of the air conditioner so as to attain the desirable results. On a normal day, the temperature inside a closed car can rapidly rise to a lethal level. In case the car is stationary, it is vital that insulation is provided beneath the metallic body. It helps in the increase in transmissivity and further declines the heat transfer. This results in a smart car divider which does not cool the entire vehicle but only the volume in use. Feasibility studies, theoretical and experimental results and system engineering were performed by the researchers, verifying the conceptual idea and carrying out the testing of the actual product.

Key words: Automated mechanism, car air conditioner, car performance, environmental protection, increased, mileage, insulating curtain, insulation, optimal usage, reduced tail emission

INTRODUCTION

According to, the Global Carbon Project co-led by the 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 projected 2.5% rise in burning of the fossil fuels. USA, China, the european union and India are among the world's largest emitters, producing about 58% of carbon emissions altogether. In the year 2013, India's emissions grew by 5.1%. In accordance to the Global Carbon Budget, if the future Carbon Dioxide (CO_2) emissions exceed 1200 billion tonnes there is a 66% chance that the global warming would exceed its dangerous 2°C limit resulting in catastrophe for many nations. This 1200 billion "quota" would be covered in only a short duration of 30 years if we continue to exploit the renewable resources at our current pace. After the economic liberalization of the early 90's, India witnessed an automobile boom which has a major role in polluting the environment (Fig. 1).

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 it became significant to search for innovative and efficient ways to curb the growing menace. It is recommended that industries adapt to new ideas, mainly based on renewables, before it is too late.

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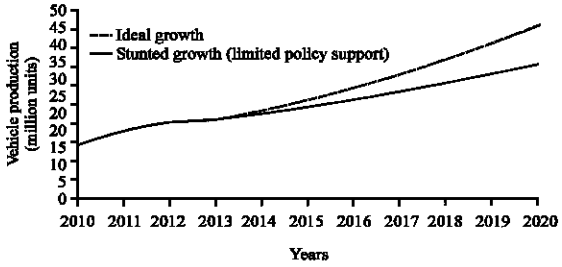

Fig. 1: Growth projections for India's auto industry; society if Indian automobile manufacturers, international agency; A.T. Kearney analysis

MATERIALS AND METHODS

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 (Farrington and Rugh, 2000). 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 (Hendricks, 2001). 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° 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.

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 min. 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 4.25 m by 1.67 m. The following observations are the result of the experiment.

RESULTS AND DISCUSSION

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 min from the ambient temperature of 37°C (Table 1). All the experiments were carried thereafter to lower this temperature. First, the air conditioner was operated for 4 min 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 (Kamar *et al*., 2012). The temperature was noted for a time interval of 2, 3 and 4 min. Then, the thermal insulating curtain of the thickness 0.225 mm or 225 μ 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 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 (UL Standards, 1979).

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 min 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.

Calculations: The experiments performed revealed significant data that the authors utilized to estimate the amount of power saved and the reduction in carbon emissions. The three conditions that were tested to

Table 1: Experiment results

Air conditioner	Compartment	Insulation	Time (min)	Initial temperature (°C)	Final temperature (°C)	Difference in temperature (°C)
✓	×	×	2	42.7	33.2	9.50
			3		31.7	11.0
			4		30.2	12.5
✓	✓	×	2	42.7	30.3	12.4
			3		28.5	14.2
			4		27.6	15.1
✓	✓	✓	2	42.7	28.7	14.0
			3		27.9	14.8
			4		26.7	16.0

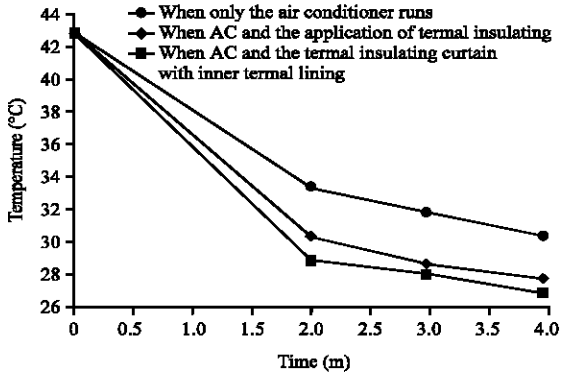

Fig. 2: Temperature (°C) vs. time (min)

decrease the temperature of the car were based on using; only the car air conditioner, the car air conditioner and the insulating curtain and the car air conditioner, insulating curtain along with the thermal lining. The trials were carried out in real time and later, analyzed and plotted using matlab to visualize the decrease in temperature in the respective cases (Fayazbakhsh and Bahrami, 2013). It was found out that the third trail consisting of the modified car with AC on thermal insulating curtain and insulation gave compelling results (Fig. 2).

We can easily make out that 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. Hence, the experiment succeeded in establishing its feasibility and gave note worthy results so as to establish the objective of the project. It indicates how minor changes in a passenger vehicle can bring about a major positive outcome without disrupting its functioning. Thus, we decided to make careful estimates about the power saved, reduction in carbon emissions and the overall economy of our suggested changes.

Power saving: On the usage of a regular air conditioning unit in the modern automobiles, power of around 3 kW is released. Thus, Power = 3 kWh. According to the readings for air conditioner to reach the temperature of 26.7°C. Time taken = 5.12 min. Power consumption = (3×5.12)/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 = (3×4)/60 = 0.2 kWh. So, the amount of power being conserved in 1 h 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 = 0.056×7,400,000 = 414,400 kWh.

Reduction in 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 CO_2/L (UL Standards, 1979). Average mileage of four-wheeler automobiles in Delhi (with AC on) = 17.6 km/L. 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 L carbon dioxide emission by one car = 2.39×2.84 = 6.789 kg. 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. Amount of petrol used for travelling = 25/17.6+25/19 = 1.420+1.315 = 2.736 L. Thus, Carbon dioxide emission from petrol = 2.39×2.736 = 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 = 0.25×7,400,000 = 1,850,000 kg.

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 petro l = Rs. 66.29/L. Let us assume as before that the car travels

50 km at an average mileage of 17.6 km/L with the AC on. Amount of petrol used for travelling = 50/17.6 = 2.84 L. 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. Amount of petrol used for travelling = 25/17.6+25/19 = 1.420+1.315 = 2.736 L. Thus, total amount of petrol saved = 2.84-2.736 = 0.104 L. Total amount of money saved in 1 day of travel = 66.29×0.104 = 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. 1000 to be attached inside the interior of the car. Thus, pay-back period = 1000/6.894 = 145.053 days, i.e., approximately 5 months. With a short pay-back period of about 5 months, the concept yields startling results with savings in terms of cost, making it affordable and profitable.

CONCLUSION

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/day by the usage of only 1 h. The pay-back period for the concept is 5 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. The researchers 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.

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