Reduce the Cabin Heating Effect of Passenger Cars During Parking by Thermoelectric Cooling

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***Abstract*— The increase of the air temperature inside car cabins, when parked under sun light, has some negative impact such as low thermal comfort and some health risk for the passengers, increased fuel consumption when restarting the air conditioning for reducing the indoor temperature and lowering the quality of the cabin materials like plastics, foams or artificial leather, rubber, synthetic fiber etc. The above reasons constitute a good motivation for studying an efficient ventilation system also for reducing house effect in the cabin. According to the above reasons, the idea proposed an original solution for cabin heat removal from parked cars by using an intelligent solar modulated system equipped peltier modules. It is proposed a thermoelectric system composed of two pairs of peltier modules, solar panel and four pair of cross flow fan. The peltier modules, placed under the car roof cabin between the steel plate and the indoor insulation and the fans placed just under the roof indoor insulation. The cabin was exposed to the sun radiation (600-800 W/m2) with no wind. Indoor temperature was measured with no ventilation. The data was used to design the positions of peltier modules.**

Keywords*— *Carcabin, Solar Radiation, Health risk, Cabin Heat removal, Peltier module

I. INTRODUCTION

The increase of the air temperature inside car cabins, especially when parked under intense solar radiation, has some negative impact such as low thermal comfort and some health risk for the passengers, increased fuel consumption when restarting the air conditioning for reducing the indoor temperature and lowering the quality of the cabin materials like plastics, foams or artificial leather, rubber, synthetic fiber etc. Concerning the health risk for the passengers, research was performed in order to highlight the risk of human exposure to volatile organic compounds (VOC) especially in the case of new cars. Even if some studies state that “the smell of the new car “wears off in a matter of weeks or months, the process of VOC elimination, also responsible for the indoor air quality, is not confirmed [2]. For example, the toluene and xylene concentration inside cars declines from 200 to 60 μg/m^3 and from 250 to 30 μg/m^3 respectively in 20 days but these VOC remain present. Also, research shows that for some VOC the concentration varies in time and is dependent on indoor temperature, humidity, ventilation efficiency, age of the car (where poor sealing allows exhaust gases to enter the cabin) and other conditions such as climate etc. [3].

In close relation with the above, we know that in an automobile of 1000 kg weight, about 100 kg consists of plastics around 50% of the total internal components including safety subsystems, doors and seat assemblies. Also, 13 types of polymers are used in an automobile - 66% of these are polypropylene (32%), polyurethane (17%) and PVC (16%) [4]. Statistics estimate that people spend about 7% of their day commuting between home and workplace, or even more if vehicle’s cabin is in fact their workplace (the case of professional drivers). Hence automobile drivers are exposed to organic hydrocarbons [5]. Concentrations reported in the passenger cabins are about 13 to 560 μg/m^3 for benzene, 33 to 258 μg/m^3 for toluene, 20 to 250μg/m3 for xylene and 3 to 23 μg/m^3 for trimethylbenzene [6].

For new cars, studies report average concentrations values of 11.8 μg/m3, 82,7μg/m^3, 21.2 μg/m^3 and 89,5 μg/m^3 for BTX - benzene, toluene, o-xylene and m, p-xylene respectively [7]. In used cars, BTX concentration values are higher and relevant deterioration of data was reported for more than 11.000 km [8]. Concerning the passenger’s thermal comfort, some research was performed in order to evaluate the interaction between the human body and indoor cabin conditions. For this, a “human body defragmentation’’ in 16 static elements was proposed for which mass and heat exchange was measured between these elements and cabin components. It was reported that non-uniform air and temperature distribution are the cause for local high discomfort for passengers.

Concerning the fuel consumption, it is known that when restarting the air conditioning system over a parked period under high solar radiation, the car engine will request more fuel than under normal conditions (related to rated engine temperature). Hence high engine fuel consumption will be registered until indoor conditions become suitable for passenger comfort.

The above reasons constitute a good motivation for studying an efficient ventilation system also for reducing house effect in the cabin. According to the above reasons, this paper proposes an idea for cabin heat removal from parked cars by using a solar modulated system equipped with Peltier modules

2. MATERIALS AND METHODS

Whenever a car is parked under direct sunlight, the inside temperature can soar to dangerously threatening levels. The principle behind this phenomenon is called Greenhouse Effect. Sunlight travels from the sun in the visible part of the spectrum (white light). The sunlight is absorbed by the surface of the car (e.g. dashboard and the carpet). Since sunlight is radiated energy, the impact surface heats up due to absorption of this radiated energy. Sunlight falls on the carpet and plastic parts within the car and then they re-radiate that energy in infrared spectrum. Now, water vapor and CO in the air within your car will absorb this re-radiated IR energy and thus, the

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heat gets accumulated continuously. This heat is trapped inside the car as there is no exit point.

3. DESIGN AND EXPERIMENTAL SECTION

The primal motive of this project includes: - improving fuel economy of a vehicle by shifting complete thermal load on to the thermoelectric devices rather than the conventional compressor-based systems and improving the human comfort inside a parked vehicle. The possible outcome of this project can improve fuel efficiency which can end up in drastic amount of saving in local (proprietary) or national economies. The prototype model was designed in the CAD software, Solid edge. The dimension of the SUV, Mahindra Thar was selected and scaled down and was used to make the prototype. The dimension of the prototype is: Overall length = 1.45 m, Total height = 0.75 m, Overall width = 0.50 m, Height of the bonnet = 0.33 m

Finally, complete content and organizational editing before formatting. Please take note of the following items when proofreading spelling and grammar:

3.1 Material Specifications

Prototype made out of the following selected materilas as Square tube (0.5 inch), G I sheet (2 mm), G I sheet (5 mm), Glass (4 mm).Solar panel : 12 V, 120W solar panel (Luminuous),Thermo couple : K type thermo couple (2 Nos.)

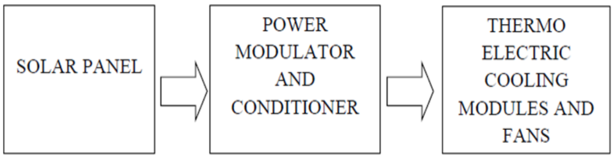

Fig 3.1. Proposed design of the system

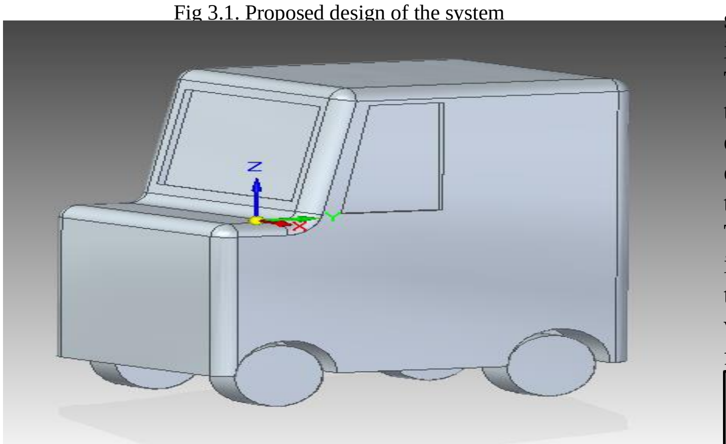

Fig 3.2. CAD model of the prototype

3.2 Experimental section

The prototype was tested in the summer season in Kerala. The cabin was exposed to an average solar radiation of 600 - 800 W/m^2, with no wind. The testing time was with an interval of 15 minutes from morning 10.00 AM to 4.00 PM. Indoor temperature and humidity were measured with no ventilation. In the cabin, the temperature and humidity were measured at the level of the driver; the outdoor thermometer for measuring the temperature of the steel roof was positioned at 5mm distance from it. The measurements had a 15 min frequency. The data corresponds to the values of the indoor temperature provided by the literature (60-65)^0 C which is reached in about 70 min. after the moment of parking the vehicle.

4. RESULTS AND DISCUSSION

4.1 *Finding the temperature rise for an equal interval of time in a car*

It was observed that after 60 minutes the gap was 1.5 0 C and got the peak value of 40.7 0 C at 2.15 PM. It is also clear that the ventilation system must start after about 25 min after parking the car. The following graph shows the variation of recorded temperature with respect to the time interval.

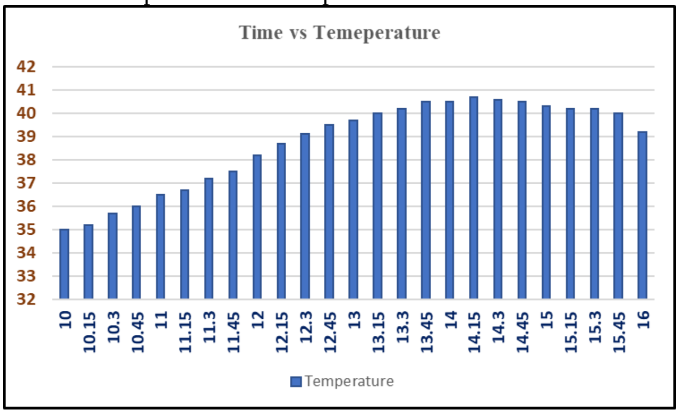

Fig 4.1. Variation of the recorded temperature w.r.t time interval

4.2 *Effect of thermoelectric cooling*

The thermoelectric effect is the direct conversion of temperature differences to electric voltage and vice versa. A thermoelectric device creates voltage when there is a different temperature on each side. Conversely, when a voltage is applied to it, it creates a temperature difference. At the atomic scale, an applied temperature gradient causes charge carriers in the material to diffuse from the hot side to the cold side. This effect can be used to generate electricity, measure temperature or change the temperature of objects. Because the direction of heating and cooling is determined by the polarity of the applied voltage, thermoelectric devices can be used as temperature controllers.

The maximum temperature difference of 4.10 C between the inside temperature and the outside temperature obtained when the prototype is put under sun without wind. The recorded variation of temperature inside the car cabins are ploted in the following graphical representation.

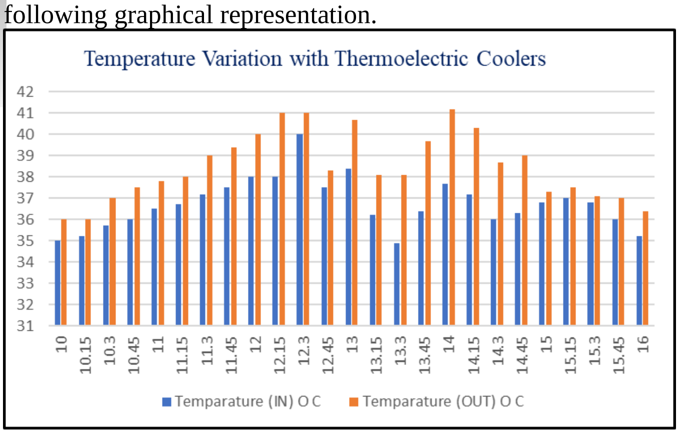

Fig 4.2 The gap between tinside ,toutdoor with thermoelectric coolers

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From the above plot, it can see that the inside temperature is low when compared to the ambient temperature at a time.

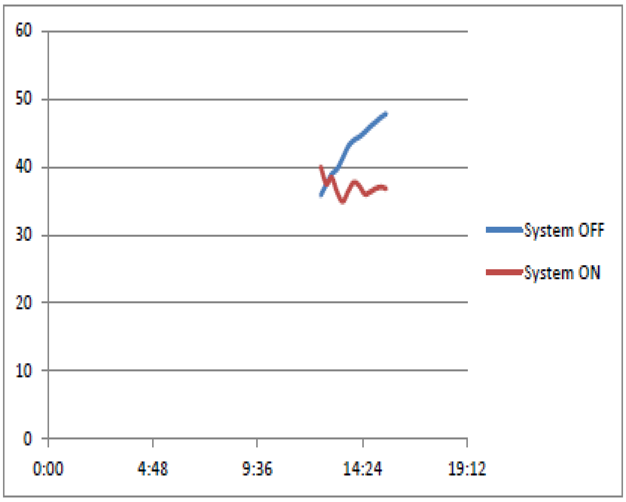

Fig 4.3 The variation in indoor temperature with the system switched OFF & ON

From the above graph it can be seen that the temperature is reduced and after some time it is almost becoming a constant value. Thus with the obtained results, it is infer that, with a more efficient thermoelectric modules then it can maintain the interior temperature at a fairly comfortable temperature. If such an efficient system implemented in an automobile, the usage of the A/C can be reduced, which intern reduces the fuel consumption and the amount of pollutants emitted. Also it can assist the A/C when in use. The amount of fuel saved and the quantity of pollutants have been calculated with an assumption that an average of 20 % fuel is consumed for the A/C and 2.3 kg of CO_2 is formed from the burning of 1 litre fuel (petrol).

5. CONCLUSİONS

This project presents a solution for designing an intelligent and modular solar energy system for heat removal from parked car cabins. It proposes a thermo electric cooling system composed of two pair's peltier modules and two pairs of fans. The car roof was cut and all the peltier modules was placed at different locations. A heat sink and fan were fixed on the hot side of the module. Similarly, a fan was fixed at the cold side of the module. The cabin was exposed to the sun radiation with no wind. The indoor temperature was measured with no ventilation and was found to be lower than the ambient temperature.

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