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NEXT GENERATION AUTOMOTIVE SEAT COVER TO IMPROVE THERMAL COMFORT USING THERMOELECTRIC EFFECT

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ABSTRACT

Thermal comfort is a condition of human mind that expresses physiological satisfaction with the thermal environment. To achieve this comfortable thermal environment almost all vehicles are equipped with heating, ventilation and air conditioning system. However the only heating, ventilation and air conditioning system is unable to circulate air all over the human body surface. The temperature of human body surface in contact with seat cover increases due to lack of air circulation between human body surface and seat surface. Next generation seat cover is developed to circulate the air between the gap of human body and seat cover. This seat cover blows air through the small holes of porous cushion material. This circulated air is cooled using thermoelectric effect. Circulating air absorbs moisture in the gap between the human body and seat surface. To validate the absorption of moisture experimentally, relative humidity of air between the gap before the fitment of seat cover and after the fitment of seat cover is measured. The experiment is carried out at three different time of the day, 9 am, 2 pm and 6 pm. 2-3% reduction in humidity is observed by using this next generation seat cover.

Keywords: *Ventilated Seat Cover, Peltier effect, Reduction in Human Perspiration.*

1. Introduction

Improved ergonomics has always been the key trait for drivers comfort especially on long drives. The continuous long journey increases the anxiety within driver's body making it prone to sleep. Hence it is advisable to make the driver's cabin as in excited state of mood as possible.

During the long journey driver is always seated in a seat at a constant position for a long period. The continuous contact with the seat surface increases sweating of human body at the back and the lower thighs. Sweating for a long period stimulates itching of skin and it becomes uncomfortable.

This paper relates to next generation automobile seat cover, wherein air may be drawn there through seat to enhance occupant comfort. The cool air ventilation seat cover relates to an external accessory fitment to seating system which is easy to install into a seat and which is easy to adapt to a wide variety of comfort solutions.

In summer when the car is left parked in direct sunlight, it is uncomfortable to enter the vehicle and start driving. When we left a car parked in direct sunlight the temperature in the vehicle is considerably increased making it uncomfortable to sit. In coastal cities, it is uncomfortable to travel is same seating position due humid air. This ventilated seat cover pass air flow between the gap of the human body and seat surface.

Ventilated seat cover typically is designed to enhance occupant comfort by passing air through the covering of the seat itself. It is fixed to the seat surface by using elastic bands and locks.

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2. Literature Review

Ventilated seat is a complex system. There are many parameters affecting the thermal comfort and is subjective in nature. The main purpose is to cool down seat surface with perforated cover. Compared with an HVAC system, seat ventilation system operates in a much more energy efficient manner. It also supports the HVAC by cooling the backside of the body. [10]

Rutkowski (2010) did research to quantify seat ventilation as a system. Different factors introduced mathematically to model a ventilated seat. Also, the energy dissipation discussed from a human body. The greatest energy dissipation came from lower back and under the thighs, and the buttocks had the least energy dissipation. It is also taken into consideration that the body should not be undercooled. An optimal temperature of the seat should be between 34°C to 36°C. [20]

When air is circulated in the ventilated seat, it is pleasurable in the beginning. But, once the person is cooled down, it can be less annoying. The most sensitive area of the human body is the lower back, where over cooling can cause cramps. The spot cooling can cause thermal. [22]

The theory of seat ventilation can be split into two parts. In one, the ventilated air is either actively cooled and in the other it is passively transported through the seat. The active cooling is mostly done with TEDs owing to their small size and strong cooling power. Most articles about seat ventilation investigate on their use, while the reality looks slightly different. Most OEMs used to implement active cooling systems, but are now deriving to a passive system with a fan. The passive systems again have two major subprinciples, which is either pushing or pulling air through the seat. Within these principles, neither is favored over the other based on airflow. Almost half of the OEMs use a push system, while the rest use a pull system. [9]

Another experiment with different covers was done with a Rami-blend foam placed inside a car seat. To measure the performance of the ventilation, four different test series were conducted. They consisted of simulations, manikin lab test, lab and road tests with human subjects. The test came to a conclusion that ventilation was especially useful for long term drives and that the skin wetness played a more significant role than the ambient temperature. Even before that experiment, Cengiz & Babalık mention the importance of the real road conditions, including traffic. [5]

3. Case Study Of Ventilated Seat Cover

Ventilated seat cover comprises of different layers through which air is circulated within the body and seat surface. The lower one being high strength nylon fabric sheet as a base. A non-conductive rubber sheet is stitched to the base sheet to avoid air leakage. 10 mm x 10 mm foam bars are pasted as a spacer and form duct for the air passage as shown in Fig. 2. The other side is pasted on the fiber sheet. Fiber sheet has the holes of 8 mm diameter in line with the duct and it forms the butterfly wing shape to perfect match with the human body contour. 5 mm thick nylon mesh is pasted on the fiber sheet for uniform circulation of air.

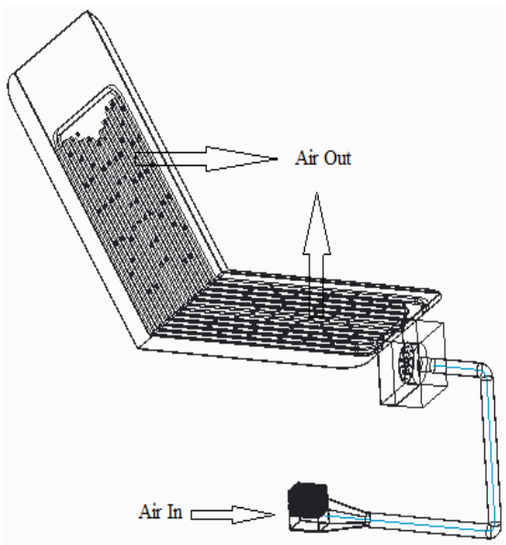

Fig..1 Layout of Ventilated Seat Cover.

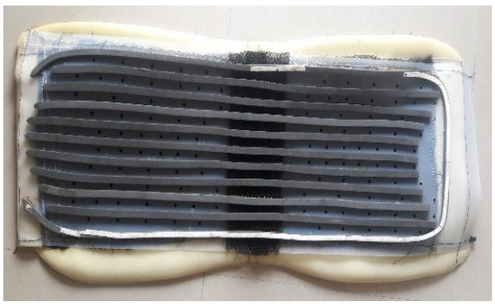

Fig..2 Seat cover duct.

At last, above all perforated fabric is stitched over the mesh and cushioned the bolsters of seat cover for added comfort. A DC centrifugal blower is placed at the start of duct as shown in Fig. 1. It is used as a prime mover of air to the system.

Table 1. Specifications of blower

Specifications of blower:	
Rated voltage	12 volt DC
Rated current	1.2 ampere
Speed	3200 rpm
Maximum air flow	34.90 CFM

Circulating air in the system is cooled using thermoelectric device. Thermoelectric devices work on thermoelectric effect. This effect gives one side of diode cooled and another side gets cooled when electric supply is passed through N-P type of diode. Thermoelectric device is an assembly of thermoelectric diodes. Thermoelectric device has tendency to cool down one side while it heats up the other side when electricity is passed through the device. TEC1-12706 is used as a Peltier thermoelectric device.

Table 2. Specifications of thermoelectric device.

Specifications of Thermoelectric device:	
Rated voltage:	14.4 volt DC
Rated current:	6.4 ampere
Delta max:	66 degrees

The heat sink is attached to both the sides of the Peltier module, the thermoelectric device. The heat exchanger body is made up of acrylic material as it is cheap to manufacture and customize. Axial fans are mounted at on both heat sink to blow air on the heat sink fin surface. Air blown on cold side losses its heat and sucked by the blower while air blown in the hotter side is exhausted to keep the temperature low on the hotter side of the module.

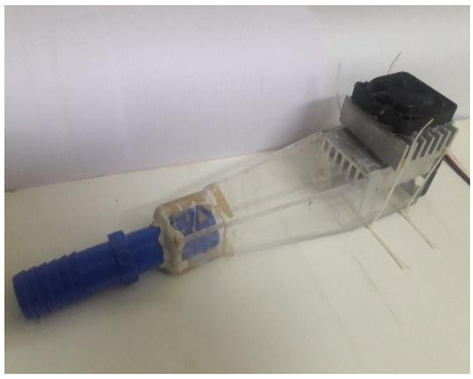

Fig. 3. Heat exchanger.

4. Experimentation

Experimentation includes the assembly of ventilated seat cover in the car seat and taking the dry bulb temperature and wet bulb temperature at three times in a day at 9 am, 2 pm and 6 pm. Experimentation is conducted on the continuous driving condition with windows rolled down and air conditioning kept off in first case. The driver is advised to drive the vehicle at given timings. The thermometer is placed in the gap between human body surface and ventilated seat cover surface. First the system is kept off and temperature reading is taken once the stable temperature reading is obtained. Next, the system is turned on and let the temperature readings be stable to note down. The ambient temperature reading is taken from thermometer placed in the interior of the car.

Fig. 4. Experimental set-up.

In second case, air conditioning is kept on with windows rolled up. Air conditioner is set to maximum cooling. Temperature reading is taken once the stable temperature reading is obtained. Next, the system is turned on and let the temperature readings be stable to note down. The ambient temperature reading is taken from thermometer placed in the interior of the car.

5. Observation

Case 1: The case 1 is further divided in the three cases; morning, afternoon and evening.

Case 1.1: Morning condition without using air conditioning.

In this case, the experimentation is carried out at 9 am time of the day. The average temperature shown by the thermometer was 28 degree celsius.

Case 1.2: Afternoon condition without using air conditioning.

In this case, the experimentation is carried out at 2 pm time of the day. The average temperature shown by the thermometer was 36 degree celsius.

Case 1.3: Evening condition without using air conditioning.

In this case, the experimentation is carried out at 6 pm time of the day. The average temperature shown by the thermometer was 32 degree celsius.

To calculate the change in the relative humidity, the initial and final reading of wet bulb temperature of gap between the human body surface and seat cover surface is given in table.

Table 3. Experimental temperature readings.

Time of day	Ambient Temperature (°C)	Initial Wet Bulb Temperature (°C)	Final Wet Bulb Temperature (°C)
9 am	28	25.8	22.4
2 pm	36	28.5	26.5
6 pm	32	27.8	25.3

Case 2: Case 2 is sub divided into three cases: morning, afternoon and evening.

Case 2.1: Morning condition using air conditioning

In this case, the experimentation is carried out at 9 am time of the day. The average temperature shown by the thermometer was 20 degree celsius.

Case 2.2: Afternoon condition using air conditioning

In this case, the experimentation is carried out at 2 pm time of the day. The average temperature shown by the thermometer was 24 degree celsius

Case 2.3: Evening condition using air conditioning

In this case, the experimentation is carried out at 6 am time of the day. The average temperature shown by the thermometer was 23 degree celsius.

To calculate the change in the relative humidity, the initial and final reading of wet bulb temperature of gap between the human body surface and seat cover surface is given in table.

Table 4. Experimental temperature readings.

Time of day	Ambient Temperature (°C)	Initial Wet Bulb Temperature (°C)	Final Wet Bulb Temperature (°C)
9 am	20	18	14.8
2 pm	24	22.6	20.1
6 pm	23	20.6	18.1

Relative humidity in both the cases is selected from relative humidity chart. The initial and final relative humidity readings of case 1 are given the table.

Table 5. Initial relative humidity vs final relative humidity of case 1

Time of day	Initial Relative Humidity (%)	Final Relative Humidity (%)
9 am	52	50
2 pm	53	51
6 pm	54	52

The initial and final relative humidity readings of case 2 are given the table.

Table 5. Initial relative humidity vs final relative humidity of case 2

Time of day	Initial Relative Humidity (%)	Final Relative Humidity (%)
9 am	53	51
2 pm	54	51
6 pm	52	50

6. Conclusions

Hence, ventilated seat cover reduces the human body temperature more efficiently in case of air conditioning on by blowing cool air in the gap between human body surface and ventilated seat cover. The circulating air is cooled using thermoelectric effect.

The ventilated seat cover gives the reduction in relative of circulating air by 2-3 % with and without using air conditioning system of vehicle. This cooled air circulation reduces perspiration rate of human body skin increasing the thermal comfort of occupant.

References

1. *Atieva Inc (2015), "Vehicle seat ventilation system", US 2015/0140915.*
2. *Bayrische Motoren Werke Aktiengesellschaft, (2011), "Actively ventilated vehicle seat", US8038222.*
3. *Bell L (2008), "Cooling, Heating, Generating Power, and Recovering Waste Heat with Thermoelectric Systems. Science,Vol 321 (5895), 1457-1461.*
4. *Societa Consortile per Azioni C R F (2009), "Seat, in particular a vehicle seat, with means for deviating a ventilation flow based on coanda effect", US 7527329.*
5. *Cengiz T and Babalık F (2007), "An on-the-road experiment into the thermal comfort of car seats", Applied Ergonomics, Vol. 38(3), 337-347.*
6. *Choi H, Yun S and Whang K (2007), "Development of a temperature-controlled car-seat system utilizing thermoelectric device", Applied Thermal Engineering, Vol. 27(17-18), 2841-2849.*
7. *Abdulmunaem H Elarusi (2016), "Optimal Design of a Thermoelectric Cooling/Heating System for Car Seat Climate Control (CSCC)", Master's Theses. Michigan University,720.*
8. *Ferreira M and Tribess P (2009), "User's perception of thermal comfort in ventilated automotive seats", SAE technical paper, Vol. 36, 0043.*
9. *Gentherm Automotive Systems (China) Ltd., (2013). Ventilation System. WO 2015/100591.*
10. *Ghosh D, Wang M, Wolfe E, Chen K, Kaushik S and Han T (2012), "Energy Efficient HVAC System with Spot Cooling in an Automobile - Design and CFD Analysis", SAE International Journal of Passenger Cars - Mechanical Systems, Vol.5(2), 885-903. http://dx.doi.org/10.4271/2012-01-0641.*
11. *Hyundai Motor Company (2011), "Heating and cooling system for vehicle seat", US 8061824.*
12. *IGB Automotive Ltd (2015), "Thin ventilated seat for a vehicle and items of furniture", US 9061617.*
13. *Johnson Controls Technology Company (2004), "Air distribution system for ventilated seat", US 6786541.*
14. *Johnson Controls Technology Company (2005), "Ventilated seat", US 7229129.*
15. *Giering K (1996), "Specific heat capacities of human and animal tissues", SPIE Vol. 2624, 188-189.*
16. *Kongsberg Automotive A B (2005), "Seat with temperature control and ventilation and safety system for a vehicle", US 6892807*
17. *Lear Corporation (1999), "Ventilated vehicle seat assembly", US 5927817.*
18. *Chein R and Huang G (2004), "Thermoelectric cooler application in electric cooling", Appl Therm Eng, Vol. 24, 2207-17.*
19. *Raibhan Bhosale and Nicolas Vogt (2016), "Next generation of ventilated front seats improving the cooling performance of front seats for Volvo cars", Department of Product and Production Development Division of Product Development, Chalmers University of Technology, Gothenburg, Sweden.*
20. *Rutkowski P (2010), "Thermal Comfort Modeling of Cooled Automotive Seats", SAE Technical Paper 2010-01-0552.*
21. *Thomas Lund Madsen (1994), "Case study on Thermal effects of ventilated car seats", International Journal of Industrial Ergonomics, Vol. 13, 253-258.*
22. *Walgama C, Fackrell S, Karimi M, Fartaj A and Rankin G (2006), "Passenger Thermal Comfort in Vehicles - A Review", Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering, Vol. 220 (5), 543-562. http://dx.doi.org/10.1243/09544070d00705*