12th International Manikin and Modelling Meeting
29-31 August 2018, St. Gallen, Switzerland

Visualisation of temperatures and heat fluxes in contact area of automotive seat

DOI: 10.5281/zenodo.1404489

Jan Pokorný, Jan Fišer, Róbert Toma, Miloš Fojtlín, and Miroslav Jícha

Brno University of Technology, Faculty of Mechanical Engineering, Energy Institute, Czech Republic

Introduction

The cabin mounted HVAC (heating, ventilation, air conditioning) is designed to provide comfort in the space of cabin. However, it is not sufficient to treat the microclimate in the contact area of a human body and a seat. For this reason, additional technologies (heating, ventilation) are embedded to the automotive seats. Their effects on comfort including thermal comfort are usually tested subjectively. Prior to the tests, engineers need objective data on the contact area to be able design the seat and its climate control algorithms. Therefore, experimental [1,2,3] procedures or procedures using simulation tools [4] to evaluate contact with the seat were established. These methods can help to bring more advanced solution how to control the seat temperatures using e.g. heat flux control [5]. In this paper, the benefits of heated and ventilated seats were investigated and compared with control seat for winter and summer conditions. The aim was to visualise and evaluate an effect of heating or ventilating of seat, i.e. measure heat flux and temperatures in contact area.

Methods

The experiments took place in the climate chamber at Netme Centre - Brno University of Technology for winter conditions (18 °C) and for summer conditions (ramp from 40 to 25 °C). The clothing was adjusted to the conditions (summer: T-shirt, trousers, shoes; winter: added sweater). The test person was stabilized for one hour in neutral environment (23 °C) and then entered the climate chamber, where was sitting on the automotive seat for 30 minutes. In summer conditions, there was additional preconditioning by 10 minutes walking at ambient temperature of 40 °C. It was measured the heat fluxes (HF) and contact temperatures (T) between human surface and the seat by using Mahoele blankets [6], which are double-sided meshes built form high accurate temperature probes, see Figure 1, left. The data were postprocessed in Matlab to obtain spatial and time dependent data relating to the thermal behaviour of contact area human/seat for 30 minutes period. The evaluation of heat fluxes by the blankets has limit that only heat dry losses (sensible) are measurable. Effect of moisture transport is not possible evaluate just by this method. Thus, the relative humidity (RH) was measured by additional RH+T probes (Sensirion SHT75 [7]) placed in contact area.

Results and discussion

The resulting images from blankets reveal the thermal behaviour of contact between human and seat. In Figure 1, there are visualized the contact temperatures with average values for the selected zones (back upper, back middle, back lower, seat and lower thigs) just at end of test (after 30 minutes sitting). The heat fluxes were evaluated in a similar way, and both results are stated in Table 1. In winter, the seat heating provided heat flux 30.5-41.7 W/m^2 with contact temperature rise about 2.9 – 5.7 °C compared with control seat in the same conditions. In summer, the seat ventilation with combination of HVAC system efficiently reduced average contact temperatures about 2.2-2.8 °C and drained 16.9 – 25 W/m^2 of sensible heat.
The presented data just illustrate difference between the seats for one test case and their values depends on the specific setup and construction of the tested seat. Also, there is variability between the test subjects, which should be considered as the shape of the human body and human weight. Moreover, parameters of clothing should be considered since more insulated clothing can reduce effect of seat heating and ventilation. The measured temperatures from Mahoele blankets and Sensirion probes corresponded well. It implies that for basic studies contact temperatures can be represented just by the point probe placed on the appropriate position instead of using blanket.

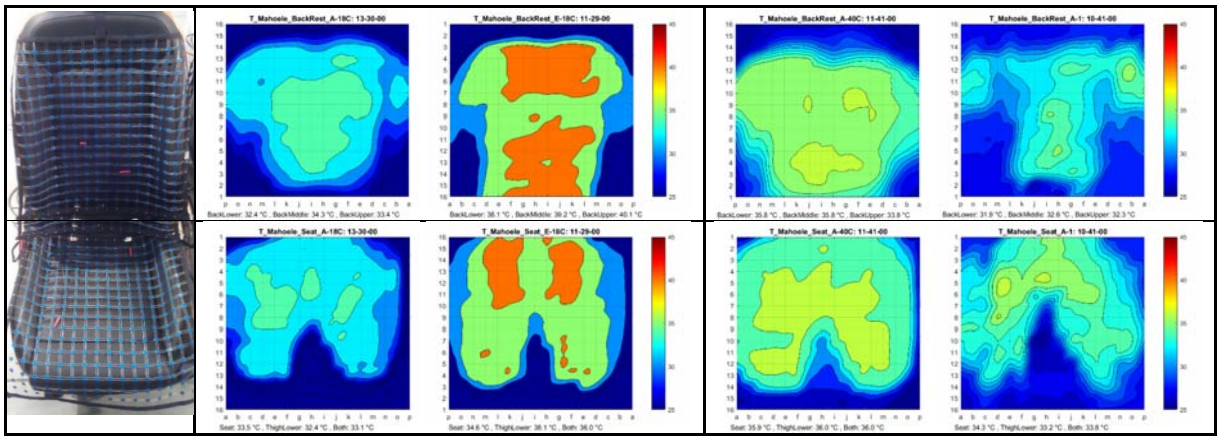

Figure 1. Blankets; control and heated seat (18 °C); control and ventilated seat (40–25 °C). After 30 minutes

Table 1. Comparison of average values for Seat and Backrest (T – Temp. °C, HF - Heat flux W/m^2)

Test case:	18 °C				40-25 °C			
Seat:	control		heating		control		ventilated	
	T	HF	T	HF	T	HF	T	HF
Backrest	33.4	1.6	39.1	41.7	35.1	15.1	32.3	-25.0
Seat	33.1	-2.5	36	30.5	36.0	8.6	33.8	-16.9

Conclusions

The objective method how to evaluate the seat heating and ventilation using blankets was presented for one specific test person. The visualizations shown differences between the heating/ventilation and control seats during winter/summer conditions. Obtained data can be used as boundary conditions (temperatures and heat fluxes) of thermophysiological models to simulate the effect of seats on human thermal state and comfort. The spatial distribution of temperatures and heat fluxes in contact area can help detect suitable places of probes for thermal regulation of automotive seat.

Acknowledgement

The research was supported by the project LO1202 Netme Centre Plus with the financial support from the Ministry of Education, Youth and Sports of the Czech Republic under the "National Sustainability Programme I" and the project of Brno University of Technology FSI-S-17-4444.

References

[1] A. Velivelli, D. Guerithault, and S. Stöwe, "Optimum Seat Cooling Distribution for Targeted Human Thermal Comfort®," *SAE Int. J. Passeng. Cars - Mech. Syst.*10(1):128-134, 2017.

[2] R. Martonka and V. Fliegel, "Measurement of the Temperature and Pressure Characteristics of the Car Seats - Relationship between Humans", *Applied Mechanics and Materials*, Vol. 827, pp. 375-378, 2016

[3] T. L. Madsen, "Thermal effects of ventilated car seats", *International Journal of Industrial Ergonomics*, Volume 13, Issue 3, 1994, Pages 253-258, ISSN 0169-8141.

[4] E. Norton, Blog - ThermoAnalytics [online]. [Accessed 30.4. 2018]. Available from: http://blog.thermoanalytics.com/blog/simulating-seats-with-human-comfort-in-mind

[5] Patent WO2017184779A1 - Climate controlled seat with a thermal conditioning device which is controlled by determining a heat flux [online]. [Accessed 30.4 2018]. Available from: https://encrypted.google.com/patents/WO2017184779A1?cl=tr

[6] Mahöle Messtechnik, *Innovative Messdatenerfassung* [online]. [Accessed 30.4. 2018]. Available from: http://www.mahoele.de/

[7] Sensirion AG [online]. *Digital Humidity Sensors (RH/T)* [online]. [Accessed 30.4. 2018]. Available from: http://www.sensirion.com/en/environmental-sensors/humidity-sensors/