Trim Packages Drive Passenger Comfort

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A HUMAN BODY AT REST in a vehicle generates a heat output of approximately 58W/m²K [1]. When driving, the additional mental and physical exertion increases this value to around 80W/m²K. An air conditioning system and/or a ventilation system needs to be designed to maintain skin temperatures within an acceptable range by providing sufficient quantities of air at an appropriate temperature.

The perception of thermal comfort is affected by the temperature, speed, and humidity of the air and by radiation. While radiation may have an effect on passenger comfort at low temperatures, it dominates at high temperatures. Interior components such as the instrument panel become too hot to touch if a vehicle is left exposed to the sun on a clear day. Equipping the vehicle with tinted or reflective windows can reduce the problem, but there are still questions regarding the possible effects that trim components, such as those manufactured by Rieter, might have on energy-savings and thermal comfort.

Using a 1998 Chrysler Voyager with six occupants (mannequins), a series of eight tests were performed for internal heating and cooling conditions. Experimental measurements were performed to determine flow rates into the cabin and the change in surface temperatures. Following testing, the materials used for the trim components were identified, and properties were taken from a combination of in-house tests and commercially available information. The transmissivity and surface properties of the clear and lightly tinted window glass were taken from the literature [2,3]. The data was then used for coupled simulations involving FLUENT and RadTherm®.

During the course of the simulation, the flow field was computed in FLUENT, and then convection coefficients and flow rates were exported to RadTherm. Because the surface meshes of the FLUENT and RadTherm models were of different density, a linear interpolation was used to transform the convection coefficient data from the fine CFD mesh to the coarse RadTherm mesh. This allowed the complex CFD convection model to be simplified into a thermal network to minimize calculation time. The mannequin surfaces were split into body segments upon which thermal boundary conditions were applied and the resulting comfort indicators computed using an Equivalent Homogenous Temperature (EHT) approach. Steady-state and transient calculations were used to evaluate the effects of proposed thermal trim modifications. A 50 km/hr driving condition was assumed for all cases.

As an example, the comfort of the occupants expressed by EHT values indicated that for a drive on a hot day with the sun shining in at 45° to the front windshield and 45° to the left side windows, the major effects were caused by transmission of solar radiation through the windshield and the distribution of the HVAC airflow. This resulted in extreme asymmetry of the EHT values for the front passengers. For the rear passengers, it was easier to create a comfortable environment because of more homogeneous air flow, the lack of direct solar radiation on the rear right passengers, and the absence of radiation emitted from the instrument panel.

A whole-body EHT improvement of 0.2°C (higher in upper body regions) was seen in the steady state condition when a reflective headliner foil treatment was applied for the 50km/hr hot condition. For hot city driving conditions, the difference doubled. For cold driving conditions, improvements were obtained when the headliner was used, and when double-glazed polycarbonate (3 mm airgap) windows were used instead of standard ones. ■

References:

1 Han, T.; Huang, L. A Model for Relating a Thermal Comfort Scale to EHT Comfort Index, SAE Paper 2004-01-0919, 2004.

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3 Bohm, M.; Holmer, I.; Nilsson, H.; Noren, O. *Thermal Effect of Glazing in Driver's Cabs*; JTI-rapport R-305;. JTI- Swedish Institute of Agricultural and Environmental Engineering: Uppsala, Sweden, 2002.