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ELECTRIC, FUEL CELL, AND HYBRID VEHICLE, FUELS AND LUBRICANTS, HEAT TRANSFER, FLUID AND THERMAL ENGINEERING, VISION AND SENSORS

Research on Non-isothermal Jet Air Supply Method for Human Thermal Comfort Regulation in Commercial Vehicle Based on Localized Air Conditioning System

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Abstract

Uneven heating of the human body in the cabin is one of the main reasons for poor thermal comfort. In this study, five small thermoelectric cooling devices were used to build the automobile localized air conditioning system to improve body temperature uniformity by the method of multi-point air supply. The cooling capacity of each thermoelectric cooling device can be changed independently so the localized air conditioning could work with a non-isothermal jet air supply method to optimize each thermoelectric cooling device outlet temperature based on thermal simulation analysis results aimed at better body heat flux balance and lower power consumption. The air temperature and skin temperature test were done to verify the simulation as well. The maximum deviation of the predicted stable air temperature was 0.82 ℃. The maximum deviation of the predicted skin temperature was 1.83 ℃. The subjective evaluation experiment of human thermal comfort was carried out, and the average overall thermal comfort vote of the volunteers was changed from 1.02 to − 0.44 after the localized air condition turning on, which showed that the temperature adjustment had a good effect on improving the heat balance and the thermal comfort of the human body.

Keywords Thermoelectric cooling · Localized cooling · Human thermal comfort

List of Symbols

A	Surface area, m^2
AC	Air conditioning
$c_{i,j}$	Specific heat capacity, J kg^{-1} K^{-1}
C_1, C_2	Model constants
COP	Coefficient of performance
G_k	Turbulence kinetic energy production term
I	Operating current of thermoelectric module, A
k	Turbulent kinetic energy, J
K	Thermal conductance, W K^{-1}
LAC	Localized air conditioning
$m_{i,j}$	Mass, kg
P	Electric power of TED, W
P_1–P_4	The electric power of TED1–4, W
Q	Total cooling capacity of all TEDs, W
Q_1–Q_4	The cooling capacity of TED1–4, W
Q_{c}	The refrigeration power of the module's cold end surface, W
$Q_{\mathrm{cond},i,j}$	The heat generation power of the heat conduction, W
$Q_{\mathrm{conv},i,j}$	The heat generation power of the heat convection, W
Q_{h}	The heat generation power at the hot end of the module, W
$Q_{\mathrm{rad},i,j}$	The heat generation power of the heat radiation, W
$Q_{\mathrm{solar},i,j}$	The heat generation power of the solar radiation, W
$Q_{\mathrm{surface},i,j}$	The heat generation power of the surface absorbed radiation, W
R	Electrical resistance, Ω
S	Source term
T	Outlet air temperature, ℃

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