Numerical and Experimental Investigation of Passenger Vehicle Windshield Defrosting and Demisting

by

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APPENDIX II  Standard requirements for Defrosting and Demisting System

I. SAE Recommended Practice SAE J902  A-1
   "Passenger Car Windshield Defrosting Systems"

II. FMVSS Standard No. 103  "Windshield Defrosting and Defogging Systems"  A-6

III. International Standard ISO 10263-5  A-8
     "Windscreen defrosting system test method"
An obstructed vision of the driver, particularly at eye level, is uncomfortable and indeed dangerous. The windshield defrosting and demisting system is an important safety aspect of passenger cars. The complexity of the windshield topography and the defroster nozzle geometry yields an inadequate defrosting and demisting action due to insufficient flow mixing as well as a poor momentum interchange in the critical visibility areas.

The present thesis describes an experimental and computational study of the defrosting/demisting problem. The study is carried out for full-scale vehicles and the computational simulation is validated against full-scale experimental data obtained on vehicle housed in a dedicated test chamber. The computational grid is three-dimensional and uses measured boundary conditions imposed on an unstructured mesh generated by the CFD code FLUENT. The computational results presented here are obtained for the defroster mode.

The experimental programme makes use of several devices. Thermal Anemometery technique is used to determine the velocity field in the vicinity of the defroster nozzles and near the interior of the windshield. Thermography is used to map the temperature contours on the windshield outer surface. Thermography, in addition to being non-intrusive, it shifts the problem from that of direct measurement of air temperature at a specific point in space to that of determining the air temperature ranges in the vicinity of the windshield.

This study shows the drawbacks of existing designs and outlines how the defrosting and demisting process could be improved through passive means and using the existing air handling system of the vehicle.
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NOMENCLATURE

$C_p$  specific heat at constant pressure

$E$  Energy (W)

$G_k$  The generation of turbulent kinetic energy due to the mean velocity gradient

$G_b$  The generation of turbulent kinetic energy due to buoyancy

$h$  Heat transfer coefficient

$K$  Kinetic energy (kg m$^2$/s$^2$)

$K$  coefficient of thermal conductivity (W/m$^2$K)

$L$  Characteristic length (m)

$M_t$  Turbulence viscosity

$n + 1$  value at the next time level, $t + \Delta t$

$n$  value at the current time level, $t$

$n - 1$  value at the previous time level, $t - \Delta t$

$Nu$  Nusselt number

$Re$  Reynolds Number

$S_{Mx}$  Body force effect in X-direction

$S_{My}$  Body force effect in Y-direction

$S_{Mz}$  Body force effect in Z-direction

$S_E$  Source of energy per unit volume

$t$  denoting the dimension time (s)
\( T \) Temperature (k)

\( u \) Velocity components in X-direction (m/s)

\( v \) Velocity components in Y-direction (m/s)

\( \gamma_M \) Contribution of the fluctuating dilation in compressible turbulence to the overall dissipation rate

\( w \) Velocity components in Z-direction (m/s)

\( \Delta H^{n+1} \) current solution for latent heat content

\( \Delta H^n \) latent heat content from previous iteration

\( \alpha \) under-relaxation factor

**Greek and other**

\( \phi \) a scalar quantity

\( \sigma_K \) Turbulent Prandtl number for K

\( \sigma_\varepsilon \) Turbulent Prandtl number for \( \varepsilon \)

\( \delta \) Partial derivative

\( \Delta \) Difference operation

\( \varepsilon \) Turbulence dissipation (kg m\(^2\)/s\(^3\))

\( \varepsilon \) Emissivity of the glass

\( \mu \) Viscosity (kg/ms)

\( \nu \) Kinematic viscosity (m\(^2\)/s)

\( \rho \) Density (kg/m\(^3\))
\( \phi \)  Angular displacement

\( \tau \)  Viscous stress

\( \Gamma \)  Diffusion coefficient