Airflow Sciences Corporation

Defrost System Development

Case Study

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Specific areas of automobile windshields are required by law to be cleared of ice after a certain period of defroster operation. Manufacturers typically evaluate defrost systems late in the vehicle design process by testing prototype vehicles in large refrigerated chambers known as “cold rooms”. This design procedure was standard practice until 1988. In that year, Airflow Sciences Corporation (ASC) introduced the first analytical method for designing defrost systems while the vehicle is still on the drawing board.

The design process utilizes the latest advances in computerized flow simulation known as Computational Fluid Dynamics. A time-dependent simulation computes the rate at which heat is transferred from the warm defrost air through the windshield glass and, finally, to the ice. Patterns of ice melting on the windshield can be determined as a function of time. As an input, the program requires a description of the air velocities on the interior surface of the windshield. These data can be determined through numerical simulation of the defrost system or by direct measurement. The most cost-effective method is chosen based on the circumstances in each case.

Figure 1 - Test apparatus for measuring air velocity on windshields

When required, direct measurement of velocities begins with fabrication of a fiberglass windshield replica. A series of small holes are drilled through the fiberglass in a rectangular grid pattern. The windshield and the defrost duct to be evaluated are positioned in a test fixture just as they would be in a production vehicle. With the defrost system operating, a small probe is inserted through one of the holes in the windshield. The probe carries a highly sensitive instrument which accurately measures air velocity on the inner surface of the windshield. A computerized data acquisition system reads and stores the velocity data for each hole. The data acquisition system and test fixture are shown in Figure 1.

In a recent study, ASC evaluated a production defrost duct designed by a major automobile manufacturer. The defrost patterns for this duct are shown in Figure 2. To design defrost ducts with superior performance, ASC’s engineers draw on their expertise in gas dynamics and heat transfer as well as ex-tensive experience in automotive climate control system design. The shape of the duct, the number of exit nozzles and the nozzle aim points can all be varied to optimize defrost performance. The resulting duct designs are often a radical departure from the more traditional ducts still in use throughout the industry. The difference in performance, however, speaks for itself. ASC designed a new duct to replace the production duct discussed above. The ice melting times in Figure 3 show a dramatic improvement, with the windshield almost entirely clear within 15 minutes - half the time of the old production duct.

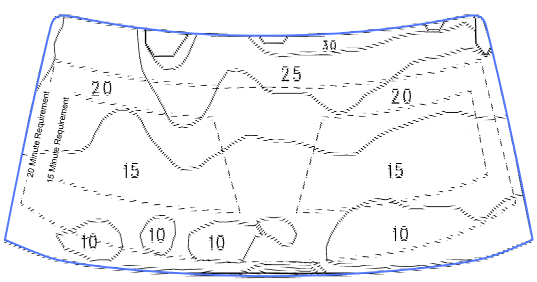

Figure 2 - Ice melting pattern and times for traditional defrost duct

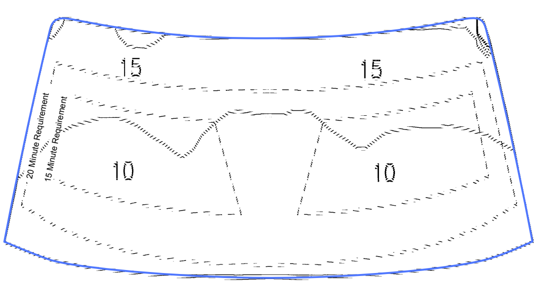

Figure 3 - Defrost performance for a duct designed by ASC

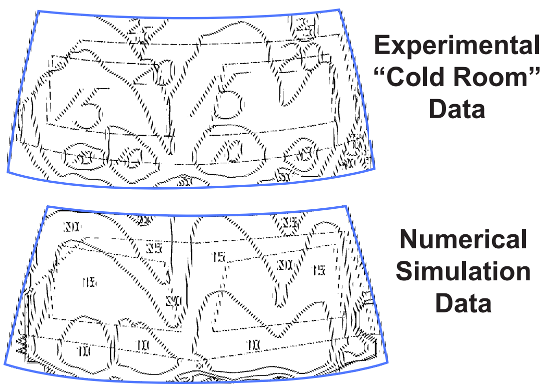

Figure 4 - Comparison between experimental test data and simulations

Using this analysis method, several ducts or defrost system operating conditions can be evaluated in a single day. High performance defrost systems are determined at an early stage of vehicle design so expensive redesigns near production time can be avoided. The technology has been thoroughly validated by comparing simulation results and cold room data (Figure 4).