

POWERFLOW FOR HVAC SYSTEM PERFORMANCE



3DEXPERIENCE®

Applicable industries: Automotive, Commercial Vehicles, Off-Highway Equipment & Trains

HVAC units and distribution systems are integral parts of the cabin climate control function. To ensure the comfort of the driver and passengers, the right amount of conditioned air at desirable temperature and humidity levels should be delivered to the target locations. Adequate flow delivery is also important for the safe operation of a vehicle that requires proper demist and defrost capabilities.

At the same time, the energy required for flow delivery should be minimized for better fuel economy, but the adverse effects of the associated acoustic noises should be limited. To achieve these goals, the design of the ducts and registers of the climate control system is carefully evaluated and optimized for greatly varying ambient conditions as part of the vehicle development process.

Technical Challenges

Due to the tight packaging in vehicle interiors, the available physical space for HVAC units and distribution systems is very limited. Designers of climate control systems are often required to work around the geometrical restrictions imposed by other vehicle interior components, often without up-front understanding of the impact of potential design changes on system performance.

In addition, complex physics such as flow turbulence, thermal mixing, and radiation play important roles in determining airflow distribution, fan power requirements, and air temperature stratification inside the vehicle cabin. However, visualization and measurement of such physical effects are difficult in real vehicle applications.

System optimization in a climatic wind tunnel or through road testing for widely varying ambient conditions requires significant time and effort, particularly when some of the testing must be conducted for transient conditions. The evaluation matrix tends to be large due to various operating modes (defrosting, ventilation, bi-level, and footwell) of an HVAC system.

SIMULIA Solutions

PowerFLOW provides an accurate way to predict the flow and thermal characteristics involved in HVAC units and distribution systems, which often have very complex geometries. These include turbulent flow effects and thermal mixing, as well as comprehensive heat transfer through all three modes — conduction, convection, and radiation.

For design evaluation, you can analyze the pressure drop and flow splits in the distribution systems and airflow patterns through multiple outlets. For thermal analysis, you can calculate air temperature distribution, including the effect of the heat transfer between the HVAC system components and the neighboring components. In addition to flow and thermal analyses, you can perform aeroacoustics noise analysis involving the fans and flows through the distribution system (such as ducts and registers).

The insights and knowledge obtained from the analysis can be applied efficiently in order to optimize the HVAC system. Because the volume mesh generation is fully automatic in the PowerFLOW process, multiple geometric variations (such as different mixing flap positions in a duct simulation) can be evaluated with minimal effort by simply exchanging the surface geometry of the relevant part in the case setup.

The SIMULIA solution for HVAC units and distribution systems offers the following benefits:

- PowerFLOW can capture the flow changes due to small differences in geometries, leading to meaningful design evaluations for better flow distributions.
- Rotating geometry such as fans and blowers are simulated with either sliding mesh or multiple reference frames (MRF).
- Thermal analysis, including all three heat transfer modes (convection, conduction, and radiation) is supported.
- A fully automated, two-way coupling process between PowerFLOW and PowerTHERM provides a comprehensive heat transfer analysis.

When the radiation effect is not important, you can use only PowerFLOW for thermal analysis, combined with the proper wall boundary conditions (such as thermal resistance) as a lower cost alternative.