

# POWERFLOW FOR INTAKE PORT SIMULATION



**3DEXPERIENCE®**

## Air Intake Systems

Internal combustion engines in vehicle applications draw fresh air from the surroundings through the air intake system. The design of the air intake system is a critical factor influencing engine performance. One important engineering criterion to evaluate the performance of the air intake system is the Rise over Ambient (RoA) value, which is the magnitude of the air temperature increase at the engine intake port over the ambient condition. Engine manufacturers usually specify an upper design limit for proper engine operation. In addition, a lower RoA value is better for engine performance due to better thermodynamic efficiency. It is a common practice to report an RoA value that is averaged over a predefined vehicle driving cycle.

### 1.1. Technical Challenges

The air intake system consists of several key components including the intake snorkel, air box, air filter, and tubes. Because they are located in the underhood environment exposed to the hot air coming from the heat exchangers, you must place the intake snorkel properly to avoid drawing excessively hot air. In addition, you must control the heat transfer via conduction and radiation from the neighboring hot components into the intake air to keep the RoA value under the design limit. Furthermore, you should consider other vehicle design requirements such as water/snow ingestion and noise characteristics when optimizing the air intake system.

Given the complexity of the flow and temperature fields in the vehicle underhood, it is difficult to satisfy these engineering goals by designing the air intake system entirely based on limited measurement data available through physical testing. Typically, several prototypes must be built and tested before an acceptable design can be found through trial and error. In addition, last-minute design changes add significant cost to vehicle development. Therefore, it is very desirable to have a simulation methodology to predict the RoA value so you can optimize the air intake system in the early vehicle development stages. The simulation methodology must be sophisticated enough to capture the complex physics involved in the underhood flow prediction, but computationally efficient enough to handle the relatively long physical time scale associated with a vehicle driving cycle.

### 1.2. SIMULIA Solution

The SIMULIA RoA fluid flow simulation methodology uses PowerFLOW to calculate the flow and air temperature fields. All the geometry details of the underhood components can be fully resolved. For the common scenario where the heat rejected from heat exchangers is a primary source of the elevated air temperature in the underhood region, you can couple PowerCOOL with PowerFLOW. The setup and simulation processes for a PowerFLOW/PowerCOOL-coupled run are integrated seamlessly. Depending on the vehicle driving cycle pattern employed in a particular RoA study, you might need to perform several coupled simulations to represent a few vehicle operating conditions on the cycle.

The underhood fluid flow simulation results are interpolated to define the time-dependent flow and temperature boundary conditions. Given that a typical driving cycle for an RoA study spans more than a few minutes, a subset of the full geometry model including only the air intake system's key

components (snorkel, air box, air filter/cleaner, and tubes) is created for the second step to achieve maximum computational efficiency. Using the available geometry and boundary conditions, along with material property information, the RoA simulation is handled by PowerTHERM, a conduction and radiation solver. The transient PowerTHERM simulation calculates the air temperature history at the intake port, and estimates the average RoA value for the given driving cycle accordingly.

Using the SIMULIA simulation approach, you can:

- Estimate the RoA value for a predefined driving cycle in an early stage of the vehicle development process and compare it against the design limit imposed by engine requirements.
- Identify the root causes of elevated intake air temperature (such as flow leakage and recirculation, excessive thermal radiation, and conduction from other hot components), and use the information to design appropriate countermeasures (for example, seals, heat shields, and changes to the intake system configuration).
- Optimize the underhood component layout to determine the best location for the snorkel inlet.