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[Home](#) > Influences of Free Stream Conditions on Vehicle Thermal Management ? An Analytical Study

Influences of Free Stream Conditions on Vehicle Thermal Management ? An Analytical Study

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During the development phase of a vehicle, several thermal tests have to be conducted in order to validate the design and ensure all vehicle level functional objectives are met. Physical tests are performed both in controlled climatic drive cells and on the road at specific test sites. These tests must be done under specified conditions, since the test data is influenced by various environmental conditions and data correction methods have to be used to interpret the test results. For road trip tests, the results are influenced by several uncontrollable factors, such as ambient temperature, tail and cross wind, free stream turbulence etc. In climatic drive cell tests, some conditions can be controlled but still some conditions such as boundary layer thickness, inlet turbulence level etc, are not consistent with those when driving a vehicle at various test locations. It is therefore important to understand the effects of these free stream conditions on vehicle thermal management. It can help us better interpret the test results and accurately evaluate vehicle thermal performance. Underhood/underbody (UH/UB) CFD analysis is now widely used in the vehicle aero/thermal development. An analytical investigation of the influences of the free stream conditions on vehicle thermal management is presented. The goal of the paper is to systematically study and understand the sensitivity of different thermal aspects such as cooling airflow, underhood and underbody temperatures etc. to various free stream conditions. A baseline is first simulated under an actual road trip test conditions. The free stream conditions have been then changed one at a time. The effects of these free stream condition changes on cooling airflow and thermal protection are obtained and analyzed.

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