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The Underhood Thermal Management and Cooling Drag Effects of an Active Grille Shutter Prototype for Light Duty Vehicle under Simulated and Real Test Environments

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Abstract: In this study, it is aimed to implement a methodology of analyzing the engine compartment thermal performance and the engine cooling drag of a light duty vehicle. The work comprises two phases; the preliminary phase is to obtain air and thermal flow under-the-hood using CFD tools. The second phase is to develop an AGS (Active Grille Shutter) prototype and the control of the active system with respect to driving conditions.

In second phase, extensive indoor and road testing has to be done for having temperature effects caused by AGS prototype usage.

The study has been started from reviewing the literature and patents which are related to under hood vehicle thermal management and AGS concepts.

For 3D flow analysis, aerodynamic under hood CFD model has been generated. All vehicle surfaces and subsystems obtained as CAD data. Engine compartment has been transferred from CAD PLM system and main power train components modeled. The engine cooling module (including radiator, CAC, fan shroud, fan), AIS, exhaust manifold and DPF subsystems have also been added to 3D model. Warping mesh technique was used for grid generation. Different mesh densities have been applied for engine, body and front grille surfaces.

For simulation setup, predefined vehicle speeds have been selected for both AGS-(ON) and AGS-(OFF) conditions.

In the literature, there are three types of fan model that is used in CFD analysis. As a fan modeling approach momentum source model is chosen. It has advantages over MRF model in terms of computational cost also it gave relatively reliable results.

As results, one can obtain detailed visualizations in pressure, velocity and temperature distributions inside the engine compartment and also streamlines can be visualized for better understanding of the flow characteristics.

Ram air pressure contribution has been extracted for under hood components beginning from front grille to exit plane of DPF. For various vehicle speeds the pressure differential can be analyzed for AGS cases. Also the simulation temperature map in engine compartment has been extracted for better understanding of thermal condition.

Keywords: Active grille shutter, Under hood flow, Vehicle thermal management (VTM), Momentum source model, CFD.