Abstract

The main function of the Air Intake System (AIS) is to supply the engine with clean air. When driving during rainy conditions, an amount of water may enter this system and it is necessary to reduce this amount to a minimum level. This thesis presents a holistic methodology in order to simulate the phenomena of droplets injection and water film development in the AIS of a passenger car.

The aim of the film simulation in AIS using the wall film model in OpenFOAM, an open source Computational Fluid Dynamics (CFD) framework, is to investigate the formation and transport of water film which was generated by a particle injection model and to propose possible drainage improvements. The wall film model is solved on a 2-D surface mesh that is discretized in both directions tangential to the surface, but is only one cell thick in the direction normal to the surface. The surface mesh is extruded from the boundary mesh of the larger, gas-phase domain. This approach simplifies the implementation by separating the gas-phase physics from the water transport physics and minimizes communication overhead between the two meshes.

In order to estimate the appropriate value of water mass flow rate, we developed a holistic process which consists of three main parts: Firstly, air flow rate in the AIS inlet, which was calculated taking into account the engine size, the maximum engine rpm and the car speed. Secondly, the aerodynamics simulation in a specific passenger car, which was performed using a state-steady solver in OpenFOAM, in order to compute the field of velocities and pressures in the under-the-hood area of the car, near the AIS inlet. Thirdly, the rain simulation, which was implemented and the amount of water mass flow rate in the AIS inlet, which was estimated taking into account the possible realistic conditions of heavy rain.

Afterwards, the water film simulation in AIS was implemented. The outcomes of film simulation led to the suggestion of the possible drainage improvements of AIS. The OpenFOAM code was used for all the steps of the simulations (pre-processing, processing and post-processing).

This work is part of the research that NIKI Ltd and TWT GmbH are conducting on the area of CFD simulation. NIKI Ltd and TWT GmbH are long term partners with leading automotive companies such as BMW, Audi and Daimler.