Numerical Simulation with Particle Transport to compute self- and third party Soiling of Motor Vehicles

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Abstract

One of the most challenging issues in today's automotive industry is the self- and third party soiling of motor vehicles. At present, it is common practice to investigate particle deposition in wind tunnel experiments. For this purpose, car manufacturers typically employ a freely-positionable spray device with an aerofoil profile allowing engineers to create specific rain situations. Within the CAE design process, vehicle soiling is primarily solely investigated in the post- processing of a CFD simulation, i.e. by setting mass points which follow the streamlines and which – depending on the length of the integration step – may or may not deposit on the vehicle's surface. However, as a result it is generally impossible to derive the water film evolution on the surface of the motor vehicle.

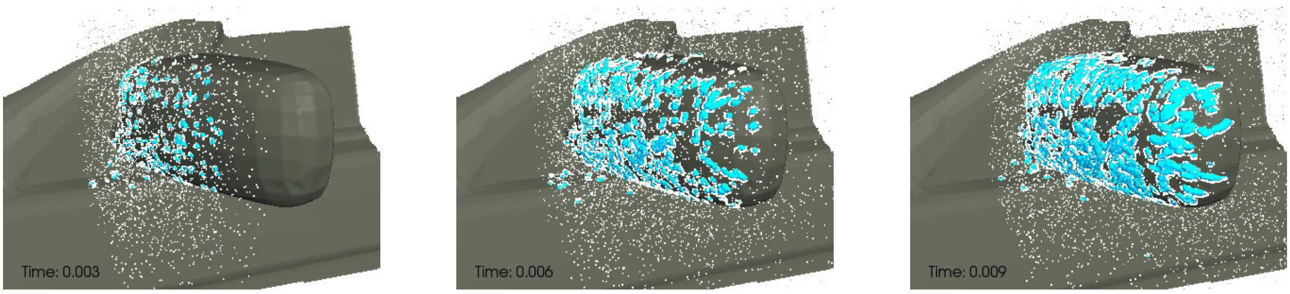
The present development considerably improves the entire process. First of all, the treatment of the particles is no longer conducted with a statistical parcel model but is now fully deterministic, including collision modeling. Secondly, new wall models replace the hitherto simplistic ones, including wall film evolution.

Therefore the already included OpenFOAM®-solver *dieselFoam* was taken as a starting point with respect to its organized and well conducted particle tracking algorithms [1]. In contrast to the statistical spray/parcel model, the developed technique is fully deterministic since the parcels no longer consist of a conglomerate of particles. Instead, each parcel is now a single particle. With respect to the large number of particles that need to be considered during a soiling simulation, it is as yet not possible to conduct soiling simulations on a full car body. However, the improvement of accuracy levels represents a major benefit of this method. Beyond this, full car body simulations are very likely going to be realizable in the next decade with increasing computing power.

Furthermore, the outcome of particle collision is determined more accurately as there is no longer a need for employing statistical collision models ("O'Rourke" [2], "trajectory" [1]) as is currently the case in present OpenFOAM®-distributions. Therefore, new collision models were implemented ([3], [4]) and suited to the actual application.

Moreover, new models for the collision with walls needed to be implemented since the present OpenFOAM® distribution only offers the options of "reflect" and "remove" [7] and does not meet the industrial needs and requirements. In contrast, according to [5] and [6], the new models are able to distinguish between deposition and reflection. In case of deposition, the volume of the deposited particle is additionally transformed in a source term for the waterfilm evolution on the car body's surface. Thereby it is possible to track the development of water films on the surface of the car body.

In the future it is planned to improve the water film evolution up to a level that allows a detailed description of the drying of the suspension/dissolution in order to depict the soiling by e.g. salt on the windshield.



Key words: Particle Transport, Particle Deposition, Film Development, Soiling, Lagrange, VoF

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