S3.1.1 COMPUTATIONAL SIMULATION AND PREDICTION OF SOOT FILTRATION IN DIESEL PARTICULATE FILTER ON THE MICRO- AND MESO-SCALE

Liping Cheng, Andreas Griesser, Andreas Wiegmann
Math2Market

Diesel Particulate Filters (DPFs) are widely used in diesel after-treatment to remove particulate matter from exhaust gas. With the international emission standards becoming more and more strict and mandatory for more countries, the study of soot filtration process through the DPF becomes very important. Moreover, the advancement of computational power contributes to better investigation and understanding of the soot filtration phenomena using modelling and simulation techniques.

The pressure drop evolution incurred in diesel particulate filters during the soot loading cycle is an important quantity of interest for the automotive industry. It is influenced by the shape of the filter, the pore geometry in the filter walls and even the precise soot deposition patterns inside these pores. The goal of this study was to use computer simulation software (GeoDict®) to design a better DPF having lower pressure drop, higher filter efficiency and longer life time.

On the scale of the filter media, a ceramic filter medium is modelled using the GrainGeo module of GeoDict® software and the flow behavior and soot filtration were simulated using FlowDict and FilterDict modules [1]. The simulation steps contain computing the air flow through the filter media, tracking the transport of soot particles, simulating the deposition of soot particles and the conversion of deposited particles into a porous media, determining the soot layer packing density and the soot layer's viscous flow resistivity. The simulations provide all the details on deposition location and pressure drop over time.

In the current study, the depth filtration and cake filtration regimes can be clearly distinguished through the simulations (See Fig. 1). The simulation results show that initially a fast increase in pressure drop occurs during the depth filtration regime. Afterwards, it is followed by a long, slower pressure drop increase during the cake filtration regime. The simulation results agree very well with the experimental data provided by Fraunhofer IKTS [1, 2].

Modifications were carried out on the ceramic grains to shorten the depth phase and to reduce the pressure drop during cake phase. work confirms a key step in virtual material design. The prediction can be done for the new designed DPF with the parameters obtained from the simulation on the current existing one. The outcome of the simulation studies led to a granted patent for the particulate filter [3].

On the scale of the filter, a honeycomb structure is created taking the filter shape into account, including the shape and size of the channel, the thickness of the filter wall and plug. Meso-scale of simulation for flow and particle tracking can also be done to check the performance of the DPF filter.