THE BENEFITS OF DESIGNING FILTER MEDIA USING PORE SCALE COMPUTER MODELLING

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In this presentation, three examples of using pore scale computer modelling for the design, development and optimization of filter media and filter elements are presented. They are all based on the GeoDict® software package. GeoDict® is currently the most complete solution for multi-scale 3D image processing, modelling of materials, visualization, material property characterization, simulation-based material development, and optimization of processes. The GeoDict® filtration package is developed to simulate filtration processes and improve and design filters for various applications, such as air, water, oil, diesel/gasoline particulate filters, etc.
First, the simulation- based development of a metal wire mesh media is presented. Realistic woven models can be generated and used for geometrical analysis. By comparing simulation results with experimental data, it is shown that the predicted value of the largest penetrating particle agrees very well with Whitehouse Scientific's sphere challenge test. Weaves are often modified to smaller pore sizes by calendaring. This type of processing can also be modelled. Metal small wire diameters are quite hard to see with bare eye. However, enlarged models can be presented using 3D printing technology.

Second, the development of an optimized micro-structure of a sintered ceramic filter media for soot filtration is presented and discussed. The goal of this case-study was to use computer software to design a better DPF. That means the DPF should ideally have a lower pressure drop, higher filter efficiency and longer life time. One key parameter that governs the DPF performance is the ceramic filter media. To study the influence of this parameter, ceramic filter media are modelled as 3D structures. Moreover, the flow behavior and soot filtration are simulated [1]. The simulation results agree very well with the experimental data provided by Fraunhofer IKTS [1, 2]. Modifications were carried out to shorten the depth filtration phase and to reduce the pressure drop during cake filtration phase. This work confirms a key benefit of virtual material design. The outcome of the simulation studies led to a granted patent for ceramic particulate filters [3].

Third, the simulation-driven development and optimization of gradient filter media prototypes is presented and discussed. For the same amount of fibers used, a constant, linear and exponential distribution of fiber density across the filter media are investigated. For same initial pressure drop, the non-constant distributions exhibit vastly improved dust holding capacity compared to the constant distribution.

References:
[1] L. Cheng, S. Rief, A. Wiegmann, J. Adler, L. Mammitzsch and U. Petasch, "Simulation of Soot Filtration on the Nano-, Micro- and Meso-scale", Proceedings of 11th World Filtration Congress, 17.-19. April 2012, Graz, Austria.
[2] J. Adler and U. Petasch, Effect of membranes in exhaust particulate filtration. Advances in Ceramic Armor, Bioceramics, and Porous Materials: Ceramic Engineering and Science Proceedings Vol. 37 (4), Ed. Jerry C. LaSalvia, Ed. Roger Narayan, Ed. Paolo Colombo, John Wiley & Sons, 2016, pp. 139-147.

[3] Patent No. DE102012220181 A1 http://www.google.com/patents/DE102012220181A1?cl=en