MICRO-SCALE AND FULL-SCALE CFD SIMULATION OF AFTER-TREATMENT DEVICES FOR INTERNAL COMBUSTION ENGINES

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In the field of internal combustion engines honeycomb monoliths are the most adopted substrates for the manufacture of catalytic after-treatment devices. However, in the last years, the interest towards novel types of substrate is increasingly gaining attention, in order to reduce the pressure drop and the noble metal loading compared to the traditional solutions. In this context, open-cell foams are regarded as a promising alternative due to their properties of high porosity, high specific surface and tortuous structure, which results in enhanced gaswall interactions. In this work, CFD simulations are applied to describe the emission conversion mechanism at different scales. In particular, a detailed CFD approach is applied at the micro-scale, in order to determine the substrate properties in terms of permeability, heat transfer and mass transfer properties. The reactant conversion on the catalytic surface is studied considering both mass transfer limited regime and kinetically controlled regime. The thermal balance of the substrate is taken into account in order to consider the effect of the wash-coat temperature on the reaction kinetics. In a second stage, the results obtained at the micro-scale level are up-scaled to carry out full-scale simulations of the real after-treatment device. Different configurations are considered, in order to find out the optimum design to better exploit the potential of the particular substrate. Solutions based on open-cell foam and honeycomb substrates are compared, in order to highlight their specific benefits and drawbacks.