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Implementation of Novel Numerical Approaches to Optimize the Efficiency of Toxic Gas Scrubbers

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Extended Abstract

In this paper the implementation of SPH method and LBM for CFD simulation of industrial toxic gas scrubbers is presented. Toxic gas scrubbers are used to reduce the contents of toxicities and contaminations in exhaust gases produced by various industries, e.g. mineral material processing, oil and gas refineries.

With the help of CFD simulations, producers are provided with a thorough insight of the gas and/or liquid flow. Moreover, they are also able to observe interaction of these fluids with a porous pack inside the scrubbers. This factor is vital in order to optimize the efficiency of absorbers.

Scrubbers can be categorized in two different types, active and passive packs, depending on the toxicities, contaminations and particles which are supposed to be absorbed in a porous pack. In active pack scrubbers the porous pack undergoes chemical reaction with flowing toxic fluids. On the other hand, the passive packs do not face any chemical reactions. From another perspective, scrubbers can furthermore be divided according to the geometry of packs, i.e. into structural and non-structural pack scrubbers.

An optimised designed pack is one that offers a highest residence time for gases in addition to the uniformed interaction of almost all parts of porous pack with fluid flows. Enough residence time is required to ensure that the chemical reactions can be completed and/or to trap particles in the voids or in the droplets. A uniform flow can guarantee the optimal lifetime of the pack. Thus, maximal maintenance time possible for pack replacement or recovery period can be achieved.

However, no matter what type or geometry of the packs inside the scrubbers, the CFD simulation of porous media and its interaction with multiphase fluid flow in large industrial scale constitutes almost always highly complex problems. Considering great differences between the dimensional size of the scrubbers compare to the size of porosities of the pack, an extremely extensive mesh is necessary. This may be very complicated as ordinary CFD methods are still not efficient enough to solve such problems at reasonable computational costs. Even newest studies in this field are based primarily on analytical and experimental methods [1-5].

In the present study, LBM has been used to discretise the air and porous pack media. Smoothed particle hydrodynamics (SPH) has been used for simulation of water sprinklers. The use of LBM drastically decreases the computational time for equipment in industrial scales compare to the ordinary CFD methods. In addition, SPH as a particle-based method helps to simulate water spray much easier. Combining LBM with SPH enables to simulate the interaction of air, porous pack and water droplets, a real challenge for common mesh-based methods. The hardware in use here is GPU instead of CPU which is one of the factors that allows to reduce the computational time on a dramatic scale. The simulations, performed by using these novel approaches, give a valuable insight how to change geometry, dimensions or parameters in a way that not only increases residence time but also optimises the uniformity of a fluid flow through porous media.

Finally, the results delivered are going to be used in a company specialized in the design and manufacturing of toxic gas absorbers and scrubbers. In near future numerical results may be compared with the real industrial ones in order to acquire validated and fully verified outcomes.

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