XX Fluid Mechanics Conference KKMP2012,
Gliwice, 17-20 September 2012

INFLUENCE OF FILTER MEDIA LOADING ON THE FILTRATION EFFICIENCY AND PRESSURE DROP

Rafał PRZEKOP , Arkadiusz MOSKAL
Warsaw University of Technology, Faculty of Chemical and Process Engineering, Warsaw, Poland
E-mail: rprzekop@ichip.pw.edu.pl

Key words: lattice-Boltzmann, Brownian Dynamics, multiphase flow

Collection of aerosol particles in the particular steps of the technology of their production, and purification of the air at the workplace and atmospheric environment, requires of the efficient method of separation of particulate matter from the carrier gas.

There are many papers published last years (Karadimos and Ocone, 2003, Przekop and Podgórski, 2004, Oh et al, 2004) in which the deposition of particles on fibrous collectors is considered, using classical continuum approach for description of the process. Such an approach is not convenient for studying the influence of particles deposition on the filters performance (filtration efficiency, pressure drop), when one has to introduce nonstaedy-state boundary conditions.

The lattice-gas, and lattice-Boltzman methods, which are based on the cellular automata concept, enjoyed rapid development and provided an interesting alternative to traditional numerical techniques for solving the Navier-Stokes equation, Przekop and Gradoń (2011).

Description of particle motion in a fluid requires the knowledge of the velocity field of fluid and particle position at any site of the space and moment of time. For the purpose of this work the lattice-Boltzmann model describes fluid dynamics, while the solid particle motion is modeled by the Brownian Dynamics.

In continuum regime the bounce-back boundary condition is used on the solid level. This means that when a fluid particle enters the solid site, it changes its moving direction for the opposite one. This method naturally leads to zero-velocity at the solid level. Our model involves two parameters r, s, representing the probability for a particle to be bounced back and slipped forward, respectively (Succi, 2002).

Determination of structures of deposited particles on the filter fibre requires the knowledge of a history of the individual particle and its position and velocity vectors. The Lagrangian method of analysis should be used for description of the process. Particle trajectory is calculated for the generalised Besset-Boussinesque-Ossen equation.

The aim of this study is to model the influence of filter media loading described by the amount of deposited matters, its spatial distribution and morphology described by porosity and fractal dimension on filter performance.

Figure 1 shows the pictures of dendrite formed by particles of 1 μm diameter on the fiber of diameter 2 μm observed from the upflow. The main direction of gas flow was normal to the axis of the fiber. The superficial air velocity was 0.1 m/s. The time interval between next pictures is 15 s. As one can see, during the filtration process, more and more particles is deposited on the fiber in the same period of time. Also one can observe that initially slender structures become to be more compact during the filtration process, as the free spaces in dendrite are loaded with depositing particles. These qualitive observations are consistent with quantitive data. The filtration efficiency is initially approximately constant with some fluctuations and after the initial stage of filtrations starts to grow rapidly. Also the increase of dendrite fractal dimension and decrease of its porosity in time can be observed.

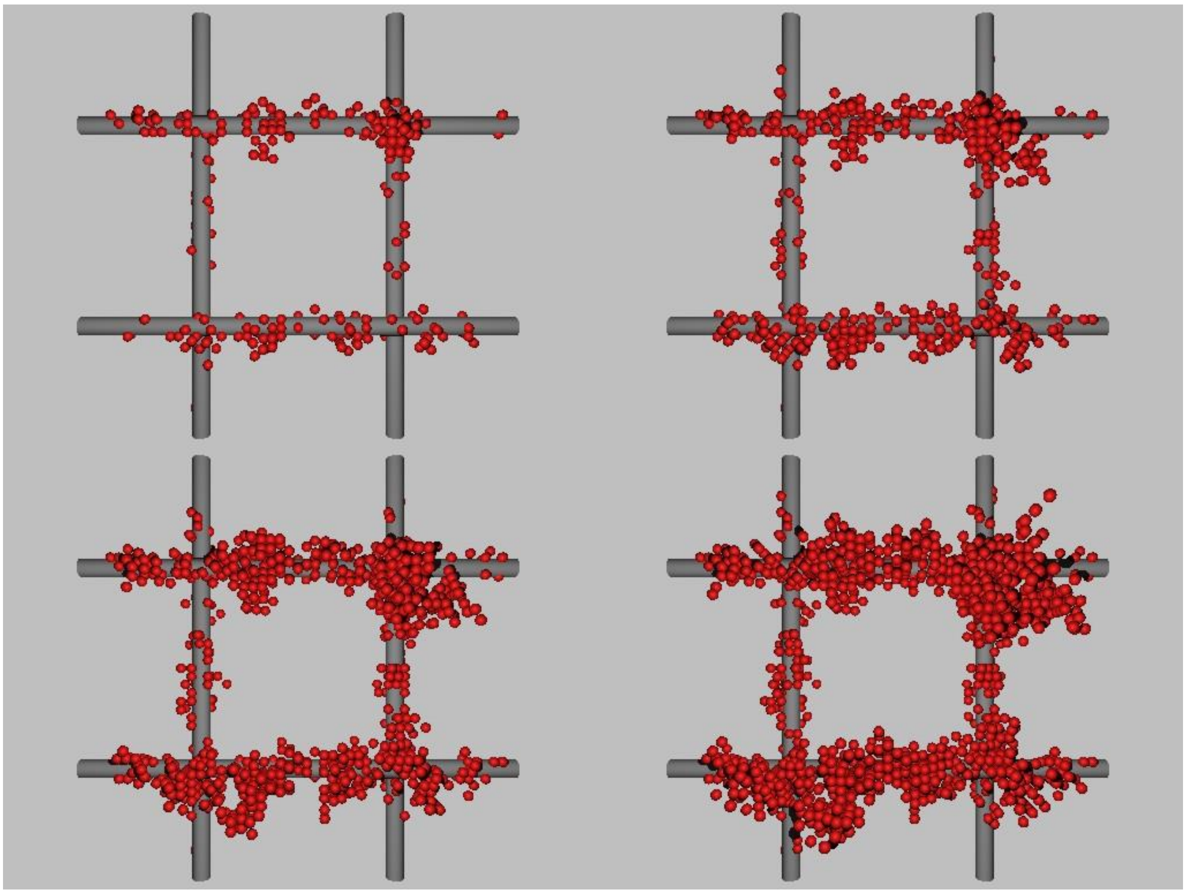

Fig. 1 Stages of dendrite growth

.

Acknowledgement
This work was supported by governmental funding's for scientific research in the years 2010-2013 (grant No. N N209 023739).

References

Karadimos, A. and R. Ocone (2003): *The effect of the flow field recalculation on fibrous filter loading: a numerical simulation*, Powder Technology, Vol. 137, pp. 109-119.

Oh Y.W., K.J. Jeon, A.I. Jung and Y.W. Jung (2002): *A simulation study on the collection of submicron particles in a unipolar charged fiber,* Aerosol Science and Technology, Vol. 36, pp. 573-582.

Przekop, R. and L. Gradoń (2011): *Non-steady-state aerosol filtration in nanostructured fibrous media*, Philosophical Transaction of the Royal Society A, Vol. 369, pp. 2476-2484

Przekop, R. and A. Podgórski (2004): *Effect of shadowing on deposition efficiency and dendrites morphology in fibrous filters,* Chemical and Process Engineering, Vol. 25, pp. 1563-1568

Succi, S. (2002): *Mesoscopic modeling of slip motion at solid-fluid interfaces with heterogeneous catalysis,* Physical Review Letters, Vol. 87, art. no. 96105