# Modeling of the deep granular bed filtration of nanoparticles

L. Wingert[1, 2, 3], A. Charvet[2, 3], N. Bardin-Monnier[2, 3], Denis Bémer[1], D. Thomas[2, 3]

[1] Institut National de Recherche et de Sécurité (INRS), F-54519, Vandœuvre-lès-Nancy, France
[2] Université de Lorraine, Laboratoire Réactions et Génie des Procédés, UMR 7274, F-54000, Nancy, France
[3] CNRS, Laboratoire Réactions et Génie des Procédés, UMR 7274, F-54000, Nancy, France
Keywords: Modeling, Nanoparticles, Granular bed, Clogging, Efficiency, Pressure drop
Presenting author email: loic.wingert@inrs.fr

The nanoparticles are generated by many manufacturing processes such as surface processing and coating (thermal spraying ...), machining (drilling, grinding ...), combustion (fire, blast furnaces ...), etc... The most efficient and widely used de-dusting methods for separating the particles from the carrier fluid are currently fibrous media. As an alternative, granular beds exhibit interesting performance, in terms of ultrafine particles collection efficiency, operation time by exploiting a high dust retention capacity, low cost and robustness.

During the clogging, the granular bed internal structure is continuously modified by the particles deposition affecting the pressure drop and the transport of the particles onto the collectors. Thus, this process is inherently non-steady and the forecast of the collection efficiency and the pressure drop evolutions is crucial to design and control this filtration process. Numerous investigators attempted to model this dynamic behavior. Tien et al. (1979) developed an interesting hybrid model for liquid suspensions of micron-sized particles splitting the clogging process in two successive steps involving two different collector concepts, i.e. a sphere and a constricted tube. Some simulations based on the particles trajectory analysis were also carried out (Pendse and Tien, 1982, Burganos et al., 2001). Unfortunately, lots of the developed models are often not really predictive or require time consuming calculations and do not concern the filtration of nanostructured aerosols.

A predictive model was developed to forecast the pressure drop and collection efficiency evolutions throughout the granular bed clogging by Brownian aerosols. As it was assumed in previous studies, the deposit is considered as a spherical shell all over the collectors surface. This uniformity feature of the deposit permits to define equivalent collector diameters depending on the collected mass of particles and to use them in the models of initial pressure drop and collection efficiency. From the results of clogging experiments, the deep bed filtration can be split in two phases. During the first one, the pressure drop and the efficiency remain constant or slowly decrease. Thus, it was decided to use as equivalent collector diameter the one of the sphere having the same volume as a collector and its deposit layer. The second clogging phase is characterized by a sharp increase of the pressure drop and the collection efficiency which becomes almost equal to 1. One of the most outstanding features of the nanoparticles being their specific area, this behavior was assigned to the increase of the collectors specific area because of the deposit accumulation. Consequently, a specific area equivalent collector diameter was chosen to model this second phase.

In line with the previous description of the deposit layer all over the collectors surface, a critical thickness was defined as transition criterion between the two phases of the deep bed clogging. A semi-empirical correlation could be found between this transition factor, the particles material density and the permeabilities of the deposit and the granular bed. These permeabilities can be obtained from theoretical pressure drop models of granular bed and nanostructured deposit.

A good agreement was found between the predictions of the model and the data from clogging experiments obtained by varying the operating conditions such as the superficial velocity, the collectors diameter and the particles size and material. A comparison between the model predictions and some experimental data is shown on the figure 1 (Collector diameter: 1 mm, Superficial velocity: 19.8 cm/s, Nanoparticles: Zn-Al).

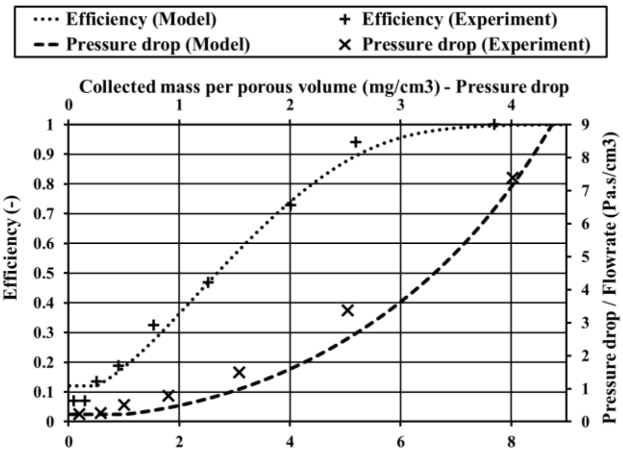


Figure 1. Comparison of the efficiency and pressure drop models with experimental data

Tien, C., Turian R.M., Pendse H. (1979). *AIChE Journal*, 25, 385–395.

Pendse, H., Tien, C. (1982). *Journal of Colloid and Interface Science*, 87, 225-241.

Burganos, V.N., Skouras, E.D., Paraskeva, C.A., Payatakes, A.C. (2001). *AIChE Journal*, 47, 880-894.