Simulation of the inertial deposition of the aerosol particles in the fibrous filters considering particle rebounding

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Researchers have studied the particle movement characteristic through the fibrous filters (Hosseini et al, 2012; Wang et al, 2013; Qian et al, 2014). The particle trajectory and filtration efficiency of various fibrous structures were investigated in our previous work (Li et al, 2016). In the current work, we further studied the interaction between particle and fibrous surface using a self-developed Fortran code, and proposed an adhesion criterion to determine whether the particle will rebound from or adhere to the fibrous surface. The behavior of aerosol particles collision, adhesion and rebound on surface of collectors (fiber or deposited particle) are analysed. Effects of particles rebound characteristics in near field of collectors, on the morphology of particle deposit and the filtration efficiency of filter will be presented in the later work.

Fig. 1 shows a schematic of particle impact and rebound on fibrous surface. The critical incident velocity along the vertical direction V^* can be written as

$V^* = \left[2E\left(1-e^2\right)/\left(me^2\right)\right]^{1/2}$,

where m is the mass of the particle, e is the coefficient of restitution (Dahneke, 1971; 1975), E is the adhesion energy (depth of the attractive potential well) which is defined as $Hd/12z_0$, H is the Hamaker constant for the interaction of two bodies 1 and 2 in a medium 3 (Hamaker, 1937; Israelachvili, 2011), z_0 is the equilibrium separation of the two touching surfaces.

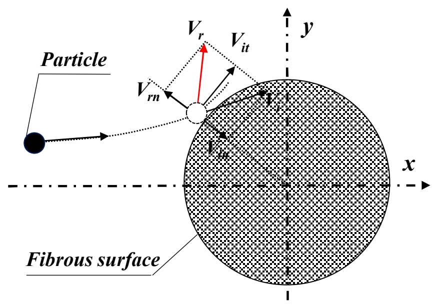

Figure 1. Schematic of particle impact and rebound on fibrous surface

Fig. 2 (a) shows that the critical incident velocity increases as the particle size decreases. Fig. 2 (b) shows that the rebounding velocity of soft particles (e = 0.95) is always larger than that of the hard particles (e = 0.98) at given diameters (Dahneke, 1971; Zhang and Nakajima, 2003). Fig. 2 (c) shows some particles with a larger vertical incident velocity (V_{in}) will rebound, while the others will adhere to the surface. It is assumed that the adhered particle will stay static and have no secondary movement. Fig. 2 (d) shows the temporary morphology of particles deposition. The adhesion and rebound on surface of fiber or deposited particles are all considered.

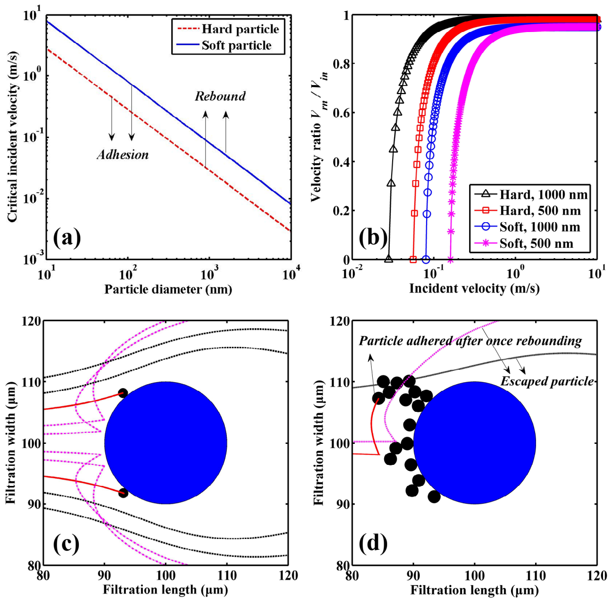

Figure 2. (a) The critical incident velocity as a function of particle diameter, (b) Velocity ratio (V_{rn}/V_{in}) of soft or hard particles as a function of incident velocity, (c) Particle trajectory considering particle rebounding, (d) Particle deposition considering particle rebounding.

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