Behavior Models of Virtual Impactors

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Abstract

A pocket-size portable particle size detector for diesel and cigarette smoke aerosols is being designed using particle size and composition methods. Aerodynamics, fluid properties, material composition and aerosol composition are taken into account. Testing methods for the design include using an impactor and virtual impactor with two quartz crystal resonators to determine particle composition using the change in resonant quartz crystal resonant frequency. Known formulas for cascading impactor were used and compared to results for virtual impactor (whose mathematical representation has yet to be developed). The impactors design will allow particles to pass through two channels or two major channels and a minor channel to separate particles of a specific diameter. These particles are deposited onto the quartz surface or remain in the minor channel which are used to determine particle size and concentration of particle sin aerosol. Principles of fluid dynamics are used to design the inflow channel and channel shapes. An inlet velocity and particle density are set so that while in laminar flow, 50% of the particles of a certain size (cutpoint efficiency) settle onto a collection plate or into a minor flow channel (cascading and virtual impactor respectively). Particle shape and chemical composition are deterministic as well as the shape of each system. Virtual impactors are designed so that 10% of the airflow goes to the minor channel while 45% goes to each remaining channel. These designs can cause turbulence and Reynold's number needs to be checked along with laminar flow as a COMSOL Multiphysics® parameter. MATLAB® is used to iterate through the solutions to determine the 50% cutpoint efficiency as well as to graph and interpret results. Inlet channel dimension and outlet channels can be changed using the MATLAB interface as well. COMSOL's Poincare Map, and built in integrations are used to count particles through each out let and to determine volumetric flow rates which can be controlled using new interface options. Streamlines are created to monitor turbulent flow and particle paths and the multislice option to determine air flow velocity. Small inlet channels require finer meshing to obtain accurate surface integration. Stokes Number and cutpoint efficiency are compared using theoretical, numerical, and derived results.

Reference

Hinds; Aerosol Technology, 2ed