ABSTRACT

This study has investigated particle collection efficiency experimentally of a single round nozzle inertia impactor using porous metal substrate. The collection efficiency was also compared to that of a impactor that uses flat plate substrate. The diameter of the porosity of the porous disc is 100 μm, 40 μm, 20 μm, and 5μm, and the nozzle diameter is 2.6 and 3.6mm, with the tested flow rate from 1.5 to 3 LPM. The range of nozzle Reynold number is from 753 to 1563 and the resistance factor of the porous disc is from 4.94×10^{9} to 1.02×10^{11} $(1/m^{2})$. This study used an ultrasonic aerosol generator to create polydisperse particles and used an aerodynamic particle sizer to measure particle concentrations at the upstream and downstream of the impactor and determine the collection efficiency. Test results is show that for liquid oleic acid particles, for larger Reynold number and smaller resistence factor of the porous disc, porous disc with pore sizes of 100 μm and 40 μm not only produces smoother collection efficiency curves than that of flat plate substrate, but also result in smaller cut-off aerodynamic diameters. The reason is that partial airflow penetrates into the porous disc to increase the collection efficiency. Owing to its large resistence factor, porous disc with smaller pore sizes (20 μm and 5 μm) does not have too much airflow penetration into the disc and our experimental results show its collection efficiency is not too much from that of the flate plate.

For solid KCl particles, when $\sqrt{St}$ is greater than $\sqrt{St_{50}}$, the uncoated porous disc with larger pore sizes (100 μm and 40 μm) has higher collection efficiency. For example, when $\sqrt{St}$ is greater than 0.8, the efficiency of the porous disc(100 μm and 40 μm) can be as much as 70% to 85% , which is much higher than 45% of the aluminum foil. That is, solid particle bounce is reduced when using porous disc.

Using the porous disc with pore size of 100 μm and 40 μm and coated with silicone oil of about 70 mg in mass, the particle collection efficiency can reach 90% to 95% when $\sqrt{St}$ is greater than 1, which is a substantial improvement in the collection efficiency of the uncoated disc. This is the case for clean disc.

When the loaded particle mass of the coated porous disc is 0.24 mg, the efficiency still remain as high as 90%～95% for $\sqrt{St}$ ＞0.8. In comparison, the collection efficiency drops sharply when $\sqrt{St}$ ＞0.8 for uncoated porous disc or aluminum foil at the loaded mass of 0.24 mg. The reason for such high efficiency when using coated porous disc with large pore sizes (100 μm and 40 μm) is because the capillarity effect of the pore structure. Due to the capillarity effect, silicone oil is absorbed into the deposited particle layer, which can prevent solid particles bounce and increase the particle collection efficiency. In contrast, silicone oil coated on aluminum foil, silicone oil would be covered by the deposited particle layer quickly, therefore, solid particles would bounce from the deposited particle layer and decrease the collection efficiency. This results in particle collection efficiency as low as 45% for $\sqrt{St}$ ＞1.0.