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Particle Size Characteristics of Aerosol Jets Produced by A Low Powered E-Cigarette

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Abstract : Electronic cigarettes, also known as e-cigarettes, may have become a tool to improve smoking cessation due to their ability to provide nicotine at a selected rate. Unlike traditional cigarettes, which produce toxic elements from tobacco combustion, e-cigarettes generate aerosols by heating a liquid solution (commonly a mixture of propylene glycol, vegetable glycerin, nicotine and some flavoring agents). However, caution still needs to be taken when using e-cigarettes due to the presence of addictive nicotine and some harmful substances produced from the heating process. Particle size distribution (PSD) and associated velocities generated by e-cigarettes have significant influence on aerosol deposition in different regions of human respiratory tracts. On another note, low actuation power is beneficial in aerosol generating devices since it exhibits a reduced emission of toxic chemicals. In case of e-cigarettes, lower heating powers can be considered as powers lower than 10 W compared to a wide range of powers (0.6 to 70.0 W) studied in literature. Due to the importance regarding inhalation risk reduction, deeper understanding of particle size characteristics of e-cigarettes demands thorough investigation. However, comprehensive study on PSD and velocities of e-cigarettes with a standard testing condition at relatively low heating powers is still lacking. The present study aims to measure particle number count and size distribution of undiluted aerosols of a latest fourth-generation e-cigarette at low powers, within 6.5 W using real-time particle counter (time-of-flight method). Also, temporal and spatial evolution of particle size and velocity distribution of aerosol jets are examined using phase Doppler anemometry (PDA) technique. To the authors' best knowledge, application of PDA in e-cigarette aerosol measurement is rarely reported. In the present study, preliminary results about particle number count of undiluted aerosols measured by time-of-flight method depicted that an increase of heating power from 3.5 W to 6.5 W resulted in an enhanced asymmetricity in PSD, deviating from log-normal distribution. This can be considered as an artifact of rapid vaporization, condensation and coagulation processes on aerosols caused by higher heating power. A novel mathematical expression, combining exponential, Gaussian and polynomial (EGP) distributions, was proposed to describe asymmetric PSD successfully. The value of count median aerodynamic diameter and geometric standard deviation laid within a range of about 0.67 µm to 0.73 µm, and 1.32 to 1.43, respectively while the power varied from 3.5 W to 6.5 W. Laser Doppler velocimetry (LDV) and PDA measurement suggested a typical centerline streamwise mean velocity decay of aerosol jet along with a reduction of particle sizes. In the final submission, a thorough literature review, detailed description of experimental procedure and discussion of the results will be provided. Particle size and turbulent characteristics of aerosol jets will be further examined, analyzing arithmetic mean diameter, volumetric mean diameter, volume-based mean diameter, streamwise mean velocity and turbulence intensity. The present study has potential implications in PSD simulation and validation of aerosol dosimetry model, leading to improving related aerosol generating devices.

Keywords : E-cigarette aerosol, laser doppler velocimetry, particle size distribution, particle velocity, phase Doppler anemometry
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