Micrometer aerosols removal by periodic shock waves

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Dynamics of micro- and sub-micrometer aerosols in flows under periodic shock waves is a process having important technological applications (Rudinger, 1980). Normally aerosols coagulate in acoustic fields and under the influence of shock waves. Coagulation of aerosols in shockwaves was studied by Temkin and Ecker (1989) and in a resonance tube in a non-flowing air by Shuster et al. (2002). In the present study the possibility of employing low intensity shock waves in flowing air for removal of aerosols from the gas phase is considered.

Periodic shock waves have been generated in a resonance tube by a moving piston at the bottom of the tube (see Figure 1). The piston frequency of the moving piston was controlled and when it reached the resonance value, low intensity periodic shock waves appeared. The intensity of the waves was controlled by the piston diameter. The pressure amplitude was measured by the pressure sensor Endevco 85306-15. In normal conditions when the speed of sound in air was 340 m/s, the first resonance frequency in a 365-cm long tube was around f_r ~ 46.6Hz. Weak shock waves were registered within the frequency range of 43.0-50.7 Hz. The maximum pressure difference across the shock front, ΔP , during one period, was 45 kPa in a shock wave regime and 22 kPa in a continuous sound wave.

Air with aerosols was supplied from to the tube from the bottom and was discharged through a top. The aerosols were formed as oil droplets generated by NUCON Model SN - 10 Aerosol Generator. The size of the droplets was 75% below 0.5 μm in diameter and the remaining drops were below 2 μm. The air flow velocity in the tube varied from 0.1 to 0.32m/s. The aerosol concentration was measured before and after the resonance tube by Climet CI-6300 particle counter.

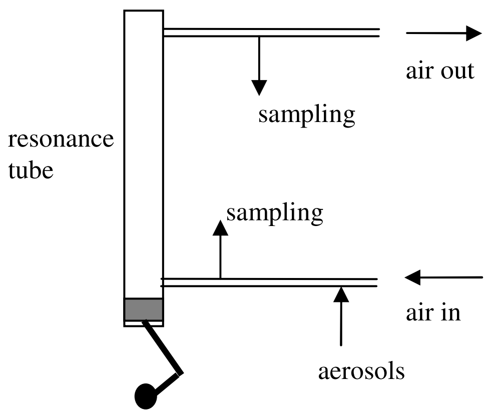

Figure 1 – General schematic of the experimental setup

The cleaning efficiency, η, is defined as $\eta = \frac{n_{in} - n_{out}}{n_{in}}$, where n_{in} is the aerosol concentration at the tube inlet and n_{out} – at the outlet. The results of the tests are presented on Figure 2. As can be seen from the figure, the efficiency grows with increasing shockwave intensity. For the pressure drop of 45kPa it was about 97%. We will note that such a relatively high efficiency was achieved for drops having sizes that are most difficult for removal.

It was found that the oil droplets deposit on the tube wall. A possible explanation of this effect can be that very intensive secondary flows, generated by periodic shock waves, similar to acoustic secondary flows, bring the aerosol particles to rigid walls (Moldavsky et al., 2006).

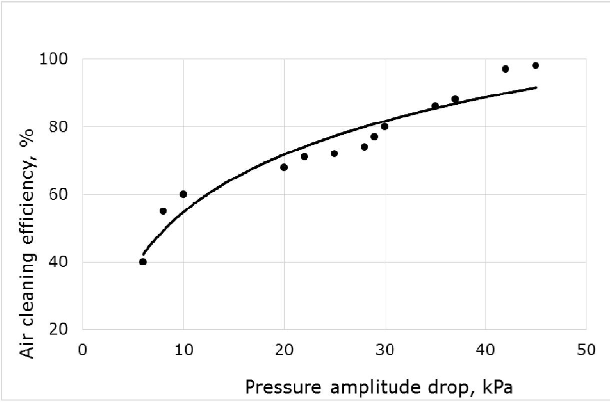

Figure 2 - Cleaning efficiency as a function of the pressure drop on a shock wave. Air velocity 32cm/s, Piston amplitude 2.2cm.

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