Impact of soot physico-chemical properties in sampling line losses measurements

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Aeronautic test rigs where either combustion chambers or complete engines are tested often require a sampling line to connect the sampling probe and the measurement instruments. The measurement of particles lost through the line is essential to interpret the results obtained in different tests.

In this work we have studied the loss in the sampling line of the combustion test rig K8 located at DGA Aero-engine Testing. We have focused this study on the impact of the physico-chemical properties of soot surrogate used in the loss measurement. We have used a spark generator (GFG 1000, PALAS GmbH) and a combustion aerosol standard generator (CAST, Jing GbmH) to generate carbon particles with different physico-chemical properties. In the case of GFG PALAS, the produced particles are amorphous carbon aggregates with very low content of organic carbon. On the other hand, CAST produced soot particles by combustion of kerosene, thus the particle morphology is closer to the real soot particles emitted by an airplane engine. CAST soot was used as is, and also after treatment through a catalytic stripper to reduce its organic content.

We used two SMPS (Grimm GbmH) to monitor particle size distribution before and after the line. In first place the line was tested using carbonaceous particles produced by PALAS GFG generator using 5.7 lpm Ar, 10.0 lpm of air and a spark frequency of 60 Hz. Fig. 1 shows the particle size distribution obtained before entering into the line and after. As can be seen, though particles are lost across the line, size distribution shape does not change.

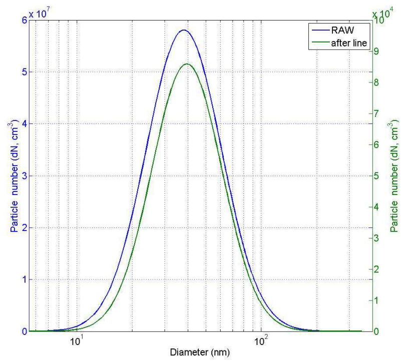

Figure 1. Fitted particle size distributions produced by PALAS GFG generator before (blue line) and after (green line) the sampling line used

In second place we tested the line with CAST generator using 0.03 lpm propane flow, 60 mbar partial pressure of kerosene, 20 lpm of quenching flow and 2 lpm of air flow. The generated soot was injected directly in the sampling line (Fig. 2 right panel) or passing through a catalytic stripper to reduce the amount of organic material (Fig. 2 left panel). In both cases a shift in the particle size distribution is observed. For particles treated with the catalytic stripper, the maximum shifts from ~18 nm to ~49 nm. In this case the loss of particles is quite significant, thus this shift might be due to the preferentially loss of smaller particles. Particles introduced directly in the sample line also present a shift in the maximum from ~82 nm to ~164 nm. In addition a second peak appears at around 30 nm.

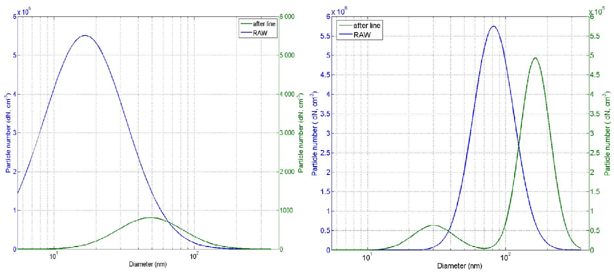

Figure 2.Rigth panel: Fitted particle size distributions produced by CAST generator without catalytic stripper before (blue line) and after (green line) sampling line. Left panel: Fitted particle size distributions produced by CAST generator with catalytic stripper before (blue line) and after (green line) sampling line.

In this case the shift is most likely produced by re-condensation of organic vapours when the sample exits the line, heated at 60°C, and enters the SMPS at room temperature. In the case, as particles were not treated with the catalytic striper, the higher amount of organic content lead to the appearance of a second size distribution, most probably linked to nucleation of organic vapours.

This study illustrates the importance of the physico-chemical properties of the particles used to measure line losses as the results obtained are clearly different for different particles types.

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Jing, L. (2003) *7th ETH Conference on Nanoparticle Measurement,* ETH Hönggerberg Zürich.