Fuel effects on non-volatile particulate matter aircraft gas turbine emissions

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Particulate matter emissions from aircraft gas turbines are a concern for human health, environmental degradation and climate change. Understanding the effect of aromatics in the fuel on non-volatile particle matter (nvPM) emissions is important for establishing future regulations and for assessing potential emission abatement strategies that intend to change fuel feedstock. This work presents non-volatile PM mass and number emission indices (EIs, mass or number nvPM/ mass fuel) as a function of fuel aromatic content for two measurement campaigns (Aircraft Particulate Regulatory Instrumentation Demonstration Experiments (A-PRIDE) 7 and 8 with an aircraft gas turbine source run in the test cell of SR Technics, Zurich airport.

The nvPM sampling system and system operation corresponded to the recommended practice (SAE International, 2013). The fuel (JET A-1) total aromatics level was changed by a controlled injection of two aromatic solvents into the fuel supply line to the engine. The two aromatic solvents were Solvesso 150 and Solvesso 150ND, of which the first one contained 6 % by volume naphthalenes and the second one was naphthalenes depleted (< 0.3%). Besides the unmixed fuel that had a total aromatic content of 17.8% by volume, three fuel blending ratios ranging from 22.5% to 24.7% by volume in total aromatic content were tested for each solvent at various engine thrust points ranging from idle to take-off.

The results show an increase in nvPM mass and number EIs with increasing fuel aromatics content (Figure 1).

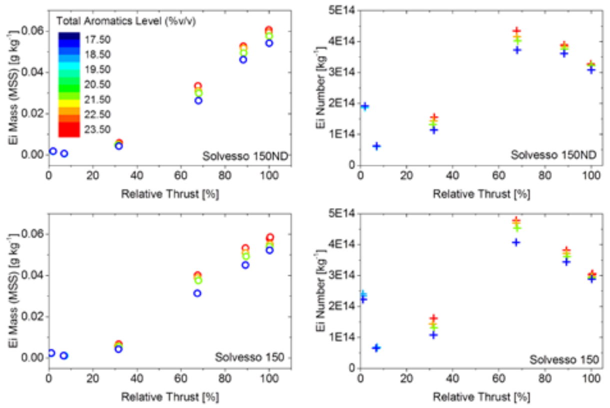

Figure 1. BC mass (circles) and nvPM number (crosses) EIs as a function of sea level static engine thrust and fuel total aromatics content (color coding) acquired during A-PRIDE 7. The top two panels correspond to the experiment performed with the naphthalenes depleted solvent (Solvesso 150ND); the bottom two panels show the experiment performed with Solvesso 150 that contained 6% (v/v) naphthalenes.

The most pronounced increase in EI (up to +100 % for mass and + 90% for number) was found at idling engine thrusts (4-7%), indicating that fuel aromatics have an impact on soot formation under this condition. At the engine thrust near take-off (100%), the nvPM EIs increased by 5 - 10 % for number and 10 - 20% for mass, indicating a less significant effect of fuel aromatics. Of the various fuel parameters tested, the EIs correlated best with fuel hydrogen mass content. A simple model that could be used for correcting fuel effects in emission inventories and in future aircraft engine nvPM emission standards was developed. The work presented here extends our previous findings from A-PRIDE 7 (Brem *et al.*, 2015) which covered thrust levels greater than 30% to the entire engine thrust range. The order of magnitude of the increase in emissions with the increase in fuel aromatics is in line with that study. A detailed analysis that includes the correlation of relative change in emissions with the change in fuel hydrogen mass content is ongoing and will be presented at the conference.

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