The MERMOSE project: Characterization of particulate emissions of a commercial aircraft engine and a combustion chamber section

D. Delhaye[1], F.-X. Ouf[2], D. Ferry[3], O. Penanhoat[4], S. Peillon[2], F. Salm[2], X. Vancassel[1], I.K. Ortega[1], C.Guin[1], C. Focsa[5], N. Harivel[4] and D. Gaffie[1]

[1]Onera – The French Aerospace Lab, F-91123 Palaiseau, France
[2]Institut de Radioprotection et de Sûreté Nucléaire (IRSN), Gif-sur-Yvette, 91192, France
[3]Aix-Marseille Université, CNRS UMR 7325, CINaM, 13009, Marseille-France
[4]SNECMA/SAFRAN Group, Moissy Cramayel, 77550, France
[5] PhLAM, UMR CNRS 8523, Université de Lille 1, 59655 Villeneuve d'Ascq Cedex, France
Keywords: Aircraft engine, combustion aerosol, size, mass, number
Presenting author email: david.delhaye@onera.fr

Aircraft engine soot emissions may impact the aviation radiative forcing, either directly or indirectly by promoting the formation of contrails (Lee et al., 2010). In order to better understand all the processes involved in the formation of condensation trails, and their subsequent impact on climate change, the French government funded several research projects since 2011. The first of them, MERMOSE (http://mermose.onera.fr/) aims at providing comprehensive characterization of particulate matter properties, including reactivity, from a modern aircraft gas turbine engine.

During this project two field campaigns have been performed behind a complete SaM 146 aircraft engine at Snecma test bench and a section of its combustion chamber at ONERA. ONERA, IRSN, Snecma and CNRS (CINaM, PhLAM) made gas and particles measurements at various engine thrusts, from 30% to 100% of the maximum take-off thrust.

The experimental set-up was composed of two sections. The first one was dedicated to gas measurements achieved following the certification guidelines (ICAO, 2008). The second section enabled soot sampling for laboratory characterizations (TEM, OC/TC ratio, XREDS, FTIR, laser and ionic desorption mass spectrometry, Raman spectroscopy) and on line measurements of soot properties (size distribution, mass and number concentration, surface area density) by means of different instruments (SMPS+C, SMPS+E, DMS 500, MAAP, PPS, CPC, NSAM).

Comparison along engine thrust setting between the SaM 146 engine and a section of its combustion chamber shows a relatively good agreement for particulate matter number and modal diameter (figure 1).

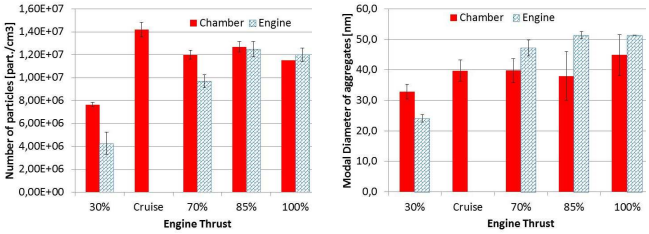

Figure 1. Emissions of the SaM 146 engine and a section of its chamber: (left) Number of particles for different engine thrusts – (right) Modal mobility diameter of aggregates for different engine thrusts.

The concentration of emitted particles is close to 10^7 part/cm^3 for engine thrust larger or equal to 70%. The modal mobility diameter of soot has been found in the range of 25 to 50 nm.

Concerning Organic Carbon/Total Carbon ratio (OC/TC), we observed quite similar trends for high thrust settings but results at 30% exhibit quite important discrepancies (figure 2). For the high engine thrust case, the organic fraction of carbon is in a range of 10 to 20%.

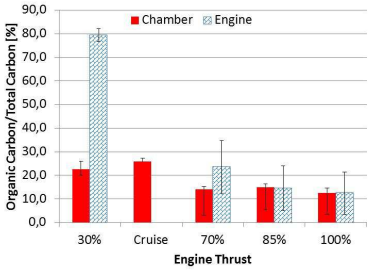

Figure 2. Organic Carbon/Total Carbon ratio for a SaM 146 engine and a section of its chamber for different engine thrusts.

The comparison between the engine and a section of its combustion chamber emissions allowed us to establish a new set of data for a modern engine and similarities of differences for various emission properties.

This work was supported by the MERMOSE project for the characterization of emissions by aircraft engines and funded by DGAC (French Civil Aviation Authority).

ICAO, (2008). International Standards and Recommended practices, annex 16, volume II Aircraft engine emissions, 3rd edition.

Lee, D.S., G. Pitari, V. Grewe, K. Gierens, J.E. Penner, A. Petzold, M.J. Prather, U. Schumann, A. Bais, T. Berntsen, D. Iachetti, L.L. Lim, R. Sausen (2010). *Transport impacts on atmosphere and climate: Aviation. Atmospheric Environment*, **44**, 4678-4734.