Gaseous and Non-Volatile Particulate Matter Turboshaft-Engine Emissions using 30%, 50% and 100% HEFA Sustainable Aviation Fuel

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In this work, the reasons for the reduction in soot particles when using SAF's with different mixture proportions (30%, 50% and 100% HEFA-SPK) are explained based on a measurement campaign carried out on a helicopter engine (Allison 250-C20B) in summer 2023. The gaseous and particulate matter emissions were analyzed at different load levels of the engine. The change of the load level is linked to changes in gaseous and particulate matter (PM) emissions. The emission indices (EI's) for the gas phase are reduced at higher loading points during higher combustion chamber efficiency due to better fuel atomization and higher temperatures. The difference in the gaseous EI's between the fuel-SAF mixing ratios used are negligible for all regulated gaseous compounds (CO, UHC, NOx) and were compared to previous studies [1].

But there is a clear change of the number, mass, properties and formation behaviour of the soot particles using different fuel-SAF mixing ratios. The non-volatile particulate matter (nvPM) number concentration was reduced by up to 80% using 100% SAF compared to standard Jet A-1. Due to the change of the particle diameter, the particle mass reduced up to 40%. Using (low aromatic) synthetic fuel shifts the mode of the particle number size distribution (PNSD) by 50% in diameter (e.g. geometric mean diameter mode for Take-Off for PNSD using 100% SAF: 30nm; compared to Take-Off using Jet A-1: 60nm).

This behaviour can be explained primarily due to the composition of the HEFA fuels. For a detailed comparison of the soot particles the number concentration (CPC), size distribution(SMPS+DMS), mass (gravimetry) and appearance (SEM) were determined.

[1] M. Rohkamp, A. Rabl, B. Gündling, M. R. Sarji-Bozorgzad, C. Mull, J. Bendl, C. Neukirchen, C. Helcig, T. Adam, V. Gümmer and A. Hupfer. 2023. Detailed Gaseous and Particulate Emissions of an Allison 250-C20B Turboshaft Engine. Journal of Engineering for Gas Turbines and Power. GTP-23-1459. https://doi.org/10.1115/1.4063693