PHD THESIS SUBJECT 2022

Title :
Experimental study of soot formation and oxidation mechanisms by optical in-situ methods : effects of combustible and pressure.

Keywords : Optical metrology, soot, aerospace combustion, oxidation

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Soot emissions generated during combustion have important consequences for the environment and health and are a matter of concern for the emitting sectors, in particular the sectors linked to human transport. The aeronautical sector is thus concerned and will be subject to increasingly restrictive standards in the coming years. These emissions are also responsible for the formation of clouds (contrails) which can have an effect on the climate.

Soot oxidation is a key process in the destruction of these nanoparticles. It is estimated that around 90 % of soot is oxidized during the combustion process itself (Stanmore, Brilhac et al. 2001). However this, still poorly understood, phenomenon is similar efficient as surface growth, which has the inverse effect, which leads to the issue that the balance between these two phenomena is difficult to model. It is thus crucial to gain a better understanding of the phenomenon of oxidization. The latter is influenced by the local temperature, the presence of oxidizing species but depends also on the chemical composition (Song, Alam et al. 2006) and the degree of disorder of the carbon nanostructure of the soot particles (Yehliu, Vander Wal et al. 2012). These is thus a varying reactivity in time since the nature and composition of soot is evolving during its formation (maturity). Finally, the oxidizing species play different roles. It is notably suspected that O2 penetrates inside the soot primary spheres, inducing a kind of « internal combustion », while OH attacks the particle on the surface. Therefore, a better understanding of the oxidation modes requires to **take into account the morphology** of the particles and in particular the ratio surface/volume (specific surface) which is almost never considered. Moreover, it is also observed that the **fuel** (Jeon and Park 2018) and the **pressure** (Commodo, Karataş et al. 2020) play a major role, both parameters that need to be adapted to the context of soot generated by aircraft engines.

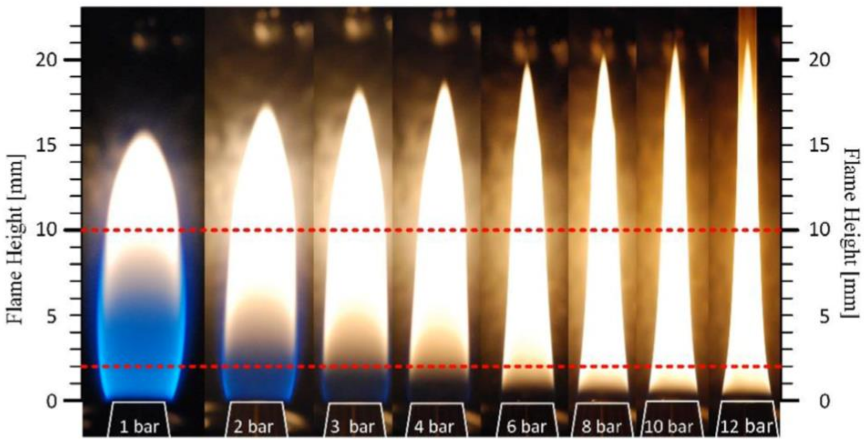

Figure 1 : Effect of pressure on an ethylene diffusion flame (Commodo, Karataş et al. 2020).

The aim of the present thesis is thus to improve our understanding of soot oxidation mechanisms in flames. Two axes of experimental developments will be worked on. The first one consists in developing and applying high level laser based diagnostics on a two stage combustion device (Yon, Ouf et al. 2018). This approach will allow to isolate the oxidation mechanisms and to take into account the maturity evolution and the role played of the fuel. The second part consists in developing and applying an innovative spectral light scattering technique in a high pressure combustion chamber (to be designed). This will allow to study the impact of pressure on the soot particle formation processes with unique access to information concerning the particles' size by an optical in-situ approach.

Profile of the candidate**:** The PhD student needs to be in possession on a Master (or equivalent) degree in physics or engineering. Good knowledge in written and spoken English is mandatory, knowledge in French (or the willingness to learn the language) is an asset. The student needs to be highly motivated for experimental work. Experiences in laser based measurement techniques are an advantage, but not necessary. Start from September or October 2022.

How to apply: Please send application documents (cover letter, CV, certificates) to yon@coria.fr and stefano.puggelli@safrangroup.com rapidly (interviews ideally in April).

Literature references

Commodo, M., A. E. Karataş, et al. (2020). "On the effect of pressure on soot nanostructure: A Raman spectroscopy investigation." Combustion and flame 219: 13-19.

Jeon, J. and S. Park (2018). "Effect of injection pressure on soot formation/oxidation characteristics using a two-color photometric method in a compression-ignition engine fueled with biodiesel blend (B20)." Applied Thermal Engineering 131: 284-294.

Song, J., M. Alam, et al. (2006). "Examination of the oxidation behavior of biodiesel soot." Combustion and flame 146(4): 589-604.

Stanmore, B. R., J.-F. Brilhac, et al. (2001). "The oxidation of soot: a review of experiments, mechanisms and models." carbon 39(15): 2247-2268.

Yehliu, K., R. L. Vander Wal, et al. (2012). "Impact of fuel formulation on the nanostructure and reactivity of diesel soot." Combustion and flame 159(12): 3597-3606.

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