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Radiation and temperature of aluminum flame

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Background

General context:

- The severity of the restriction on pollutant emissions pushes car manufacturers towards a sophistication of the power train, and even the total electrification of the vehicles, questioning the way of storing the onboard energy and the conversion mode of the primary energy.

ANR project:

Several research teams are studying metal combustion as an energetic vector for transportation:

- Description of the aluminum flame
- Product of the magnesium flame
- Reduction of the metal oxide thanks to the solar energy
- Feasibility of integration into a vehicle

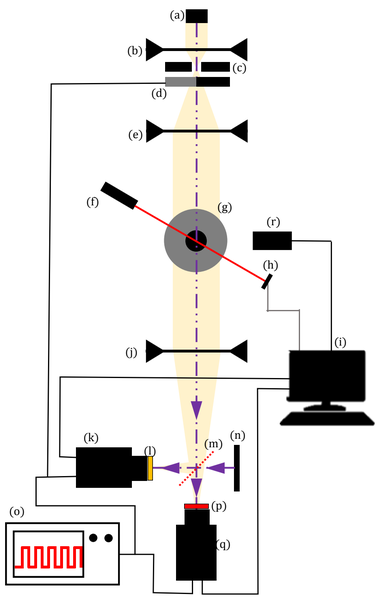
Objectives

- Calculate the **temperature** of the condensed phase
- Evaluate a part of the **radiated power** in order to do an energy balance

Future works

- Describe a non-pressurized and a pressurized confined flame
- Observe the flame front closely

Experimental set-up



Experimental Optical Setup:
(a) Backlight
(b-e-j) Lens
(c)Pinhole
(d) Chopper
(f) Laser
(g) Burner
(h) Photodiode
(i) Acquisition system
(n) Black surface
(m)
(p) 905nm filter
(l) 700nm filer
(k-q) Cameras
(o) Signal generator
(r) Fluxmeter

The experimental set-up allows to measure the radiated power, the power density and to acquire pictures. A spectrometer is also installed but not presented in this poster

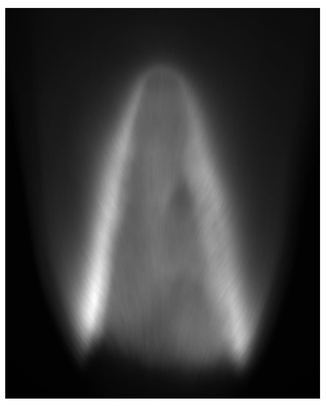
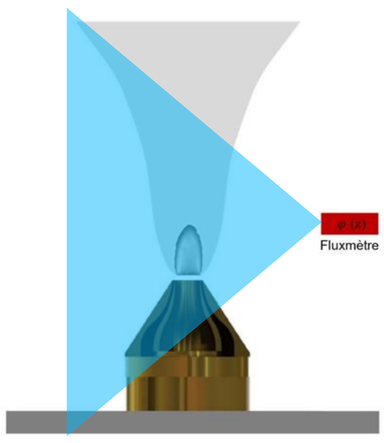


Image of a flame through the 700nm filter

Flame specificity :

- Bunsen burner
- Al/air mixture
- Power: 10kW
- Presence of a 500W-pilot flame to ignite and stabilize the flame



Solid angle visualization of the fluxmeter

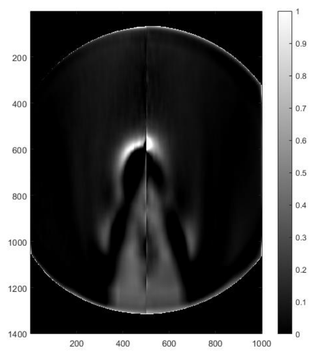
Pyrometry technique

Work in progress (cameras are used)

The flame is considered as axisymmetric and the scattering is neglected.

The experimental set-up provides four images ; two pairs of images at 905 nm and 705 nm with and without backlight.

Each pair of images is used to evaluate the absorption at each point.

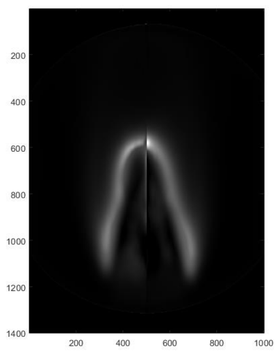


Local Absorption at 905nm

Then with an onion-peeling-like deconvolution, it is possible to find out the local emissions considering the absorption.

The temperature is calculated thanks to the ratio of two Planck's law.

For the moment, too much noise is observed. The use of 4 images instead of 2 heightens this noise. This leads to an under evaluation of the absorption, especially near the flame front.



Local emission at 905nm

Legros, G., Wang, Q., Bonnety, J., Kashif, M., Morin, C., Consalvi, J.-L., Liu, F., 2015. Simultaneous soot temperature and volume fraction measurements in axis-symmetric flames by a two-dimensional modulated absorption/emission technique. Combustion and Flame 162, 2705–2719. https://doi.org/10.1016/j.combustflame.2015.04.006

Results Emissions

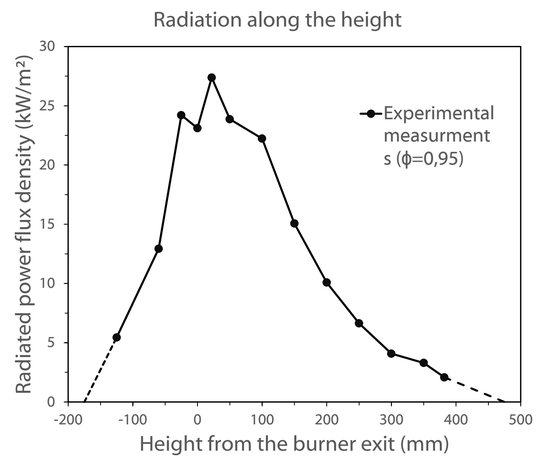
Work in progress (fluxmeter are used)

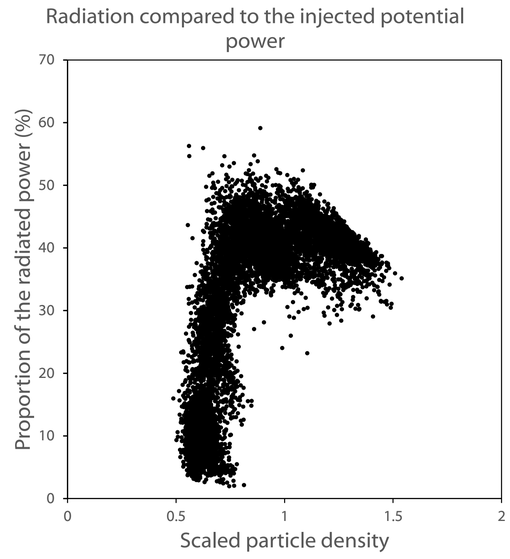
The plume radiation is negligible compared to the radiation emitted by the flame.

By observing several powder densities, the radiative power seems to be constant at around 40% for an equivalence ratio between 0.8 and 1.5.

This behavior can be explained by the fact that the unburnt particles react with the ambient air and create a double flame (a premixed flame and a diffusion flame).

Under the equivalence ratio of 0.8 the drop in power highlights the stability issues and the extinction of the flame.





Workshop on MECRE, 31st October and 1st November 2022