
Measurement and prediction of unstable mode frequencies in coaxial gas-assisted atomization

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Résumé

Coaxial gas atomization, which is a key phenomenon in many processes such as propellant mixing in rocket engines, displays a variety of regimes depending on the dominant mechanism, be it surface tension, shear stresses or even confinement effects.

Our approach to study the unstable mechanisms at play has two prongs; one consists in computing the dispersion relation of the primary instabilities in an ideal coaxial flow configuration from linear stability analysis using a shooting method. The other part relies on high-speed imaging of an air-water spray to measure the frequency of the large scale flapping motion commonly observed in coaxial jets.

In parallel, we also characterize the flow conditions using hot wire anemometry and Particle Image Velocimetry in an attempt to better constrain the input parameters of the stability analysis. This characterization shows the differences between the stability analysis model and real flow conditions, helping us understand the range of validity of our analysis and the parameters which pilot the instabilities.

By comparing the results of high speed imaging and stability analysis, we show that both results coincide well, possibly indicating that primary instabilities do develop into the large scale flapping downstream and identify which mechanism is at play. Furthermore, the mixing layer thickness in the gas flow shows to be the key parameter selecting the dominant frequency, enticing us to further study geometrical variations of our nozzle, as well as other working fluids such as liquid nitrogen.

An experimental setup is currently being assembled at Institut Néel, with the aim of imaging a liquid-gas nitrogen spray at low temperatures. The setup will control both fluids temperature, ensuring minimal phase change, replicating the conditions of the air-water jet. Thanks to the low surface tension of liquid nitrogen, we hope to reach higher Weber number regimes to verify our atomization models against.

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