

Experimental investigation of supercritical injection

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Abstract

Over a certain value of temperature and pressure, known as the critical point, pure fluids enter the supercritical domain where the separation between the liquid and the gas states becomes much less apparent. The clear discontinuity observed when crossing the saturation curve is then replaced by a continuous evolution from liquid-like to gas-like states. Such a behavior can be found in combustion applications such as rocket engines or gas turbines (including turbojets) [1] and their improvements require a better understanding and control of the mixture of fuel and oxidizer. As very few experimental data on the behavior of injection and mixing under supercritical conditions are available in the literature, the modeling of the flame under such conditions lacks data and the validation of the simulations becomes very limited [2].

The objective of this work is to fill this gap by providing experimental quantitative data on a jet of ethane in a high-pressure chamber, filled with nitrogen at rest from atmospheric up to 6 MPa [2]. For example, Fig. 1 shows a jet of ethane (300 K) into nitrogen (333 K) at 4.5 MPa, i.e. below the critical point of ethane, 4.87 MPa. Various injection regimes are studied by shadowgraphy imaging varying the temperature, the pressure as well as the fuel mass flow rate. Then, through adequate post-processing, the spreading angle of the jet is computed, and its evolution analyzed. Finally, a thorough study of the velocity evolution for a supercritical jet is achieved for a broad range of inlet conditions (50 cases) using the Image Correlation Velocimetry (ICV) technique [3].

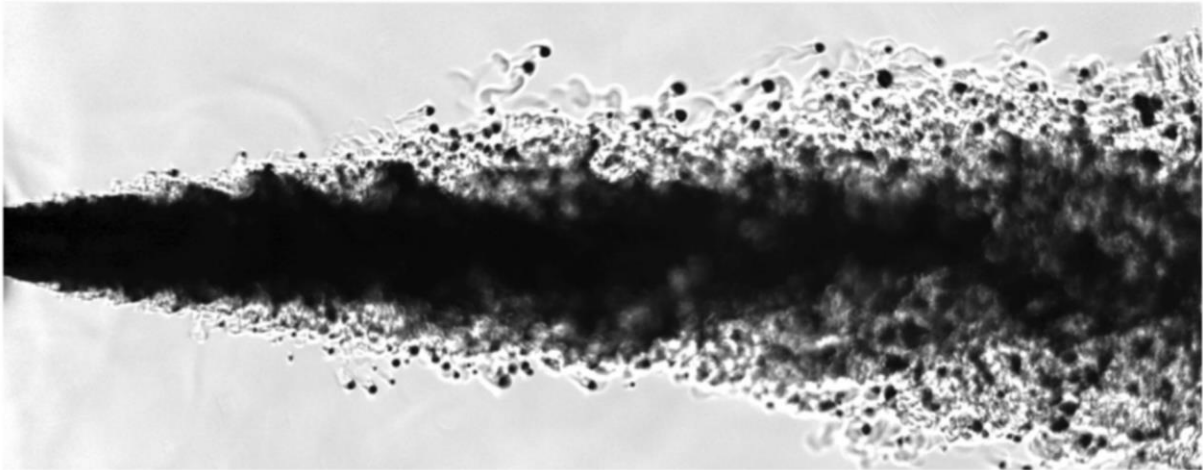


Fig. 1: Jet of ethane (dark), injected from left to right, into nitrogen (white) below the critical point of ethane. Pressure is set to 4.5 MPa.

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