Supersonic Jet and Control Jet Interaction visualized with Ultra-High-Speed Camera UltraSpeedStar

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The mixing efficiency in a supersonic jet strongly influences the dynamical behavior of many industrial devices like propulsive jets or ejectors. Active mixing enhancement systems are employed to control the turbulent flow structures. Active systems are often preferred against passive systems since they can be adapted to changing operation conditions (e.g. during take-off of an aircraft).

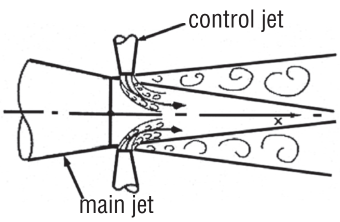

Figure 1
Operating principle of control jet and main jet interaction.

In a supersonic wind tunnel facility of the University of Poitiers in France the mixing mechanisms induced by an active pneumatic control jet are investigated. Visualization techniques are employed in order to understand the interaction between the main supersonic jet and a control jet. Strong instabilities of the control jet have been evidenced and the impact of the turbulent quantities was analyzed. It was shown that a strong modification of Reynolds stress is present at small distances from the interaction.[1]

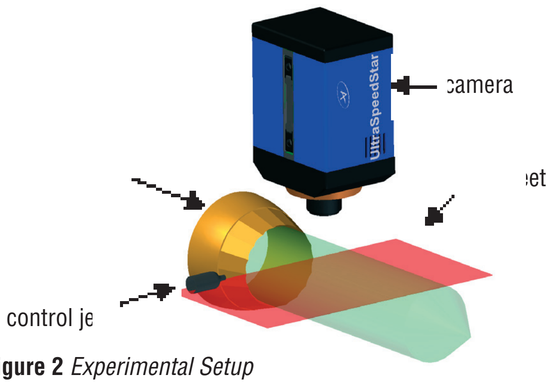

Figure 2 *Experimental Setup*

Ultra-high-speed visualizations running at 100 kHz frame rate have been performed in the near field of the interaction to understand the effects of nozzle geometry. The setup consists of a Mach 1.37 free jet. The control jet is placed D/10 downstream perpendicular to the main flow.

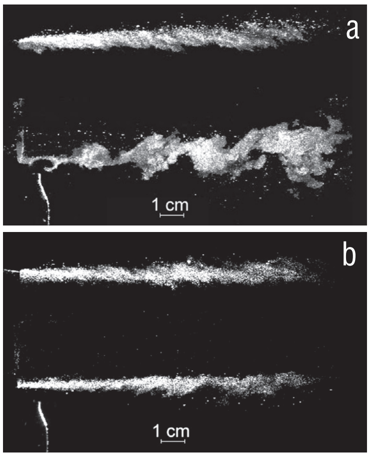

Figure 3
Snapshots of the seeded mixing layer. The control jet is located on the right of the jet exit, a) active, b)

In the shown investigations LEA researchers used the *UltraSpeedStar* camera system from LaVision with 16 frames at a maximum frame rate of 1 MHz. The system integrates a pulsed DPSS laser from Spectra-Physics running up to 100kHz. The laser light was formed to a light sheet illuminating the mixing zone close to the nozzle exit. SiO_2 particles added to the control flow reflect the light in so-called Mie-scattering. The camera detects this light and thus images the mixing of the control flow into the main flow.

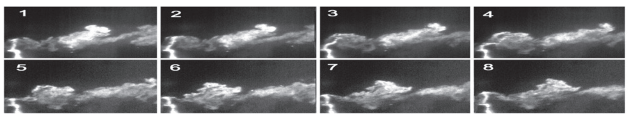

Figure 4 *Right half of the main jet with control jet interaction in a sequence of 8 frames taken with UltraSpeedStar at interframe times*

Due to the ultra-high-speed recordings a flapping behavior of the control jet was found. It was illustrated that the control jet oscillations are periodic at a flapping frequency close to 13 kHz. Only ultra-high-speed recordings with interframe times as short as 10µs can present the true picture of dynamical properties of such supersonic flows.

[1] "Experimental Study of a supersonic jet-mixing layer interaction", E. Collin et al., erwan.collin@lea.univ-poitiers.fr, LEA, University of Poitiers, submitted to Physics of Fluids

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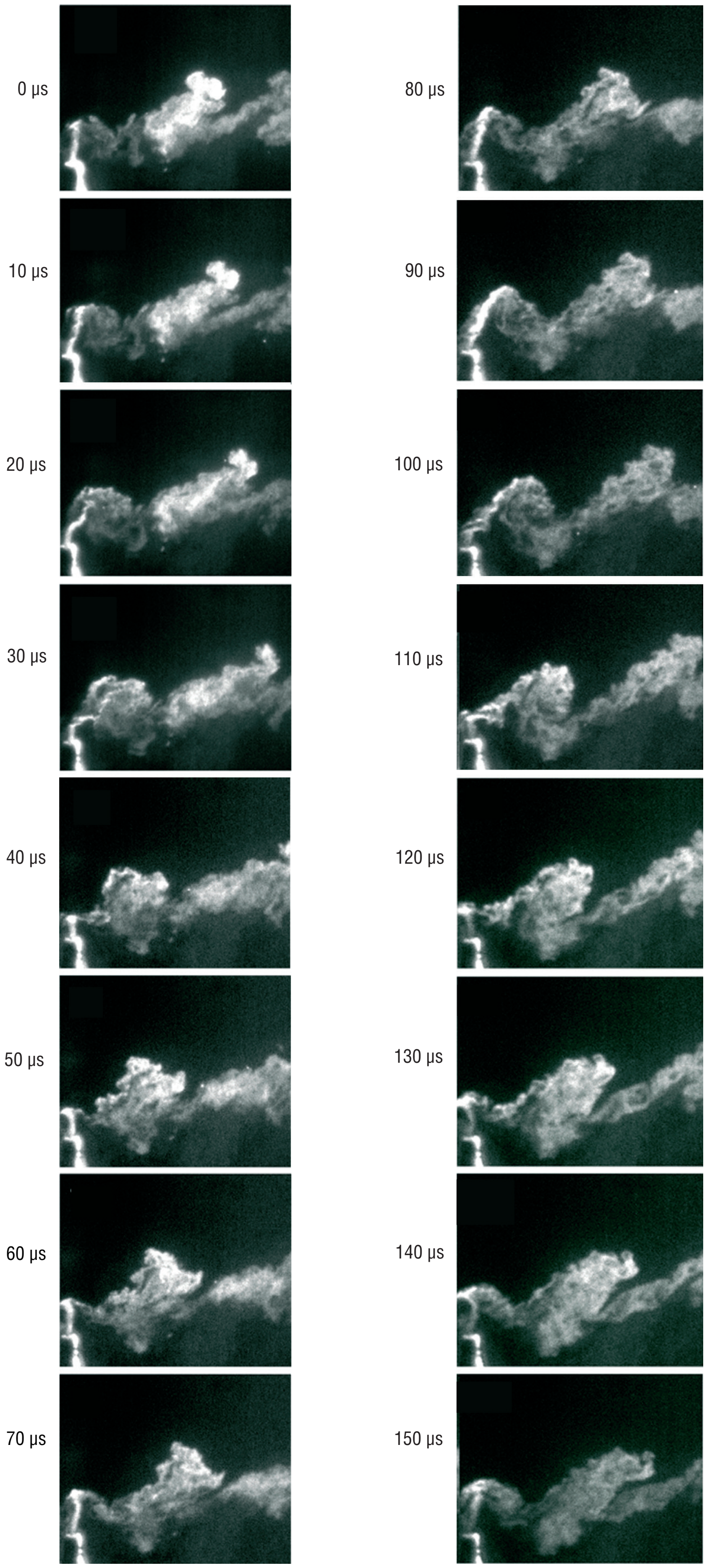

Figure 5

Right half of the main jet with control jet interaction in a sequence of 16 frames taken with UltraSpeedStar at interframe times of 10 µs.

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