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Control of a round jet by modification of the initial conditions at nozzle exit

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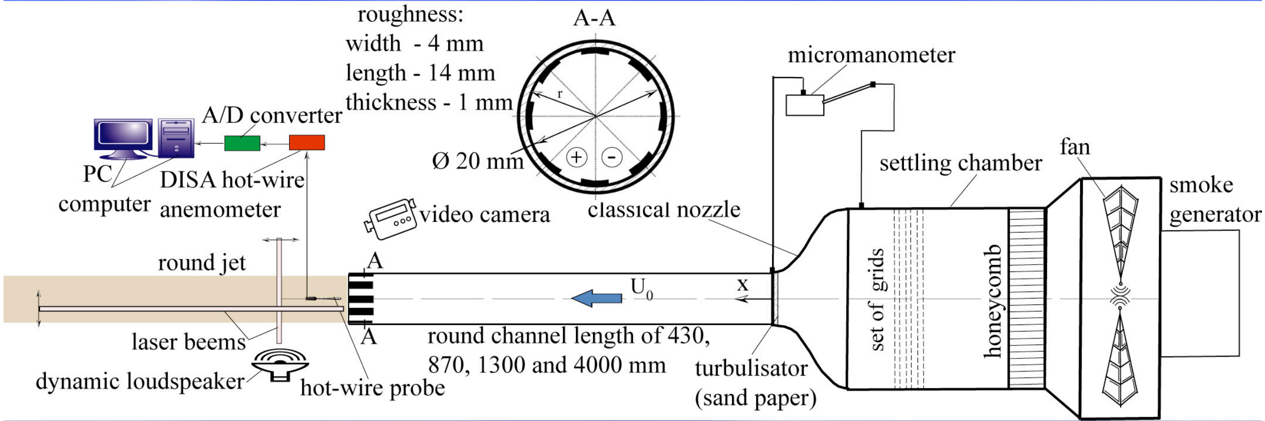

Sketch of the plane jet installation and measuring system

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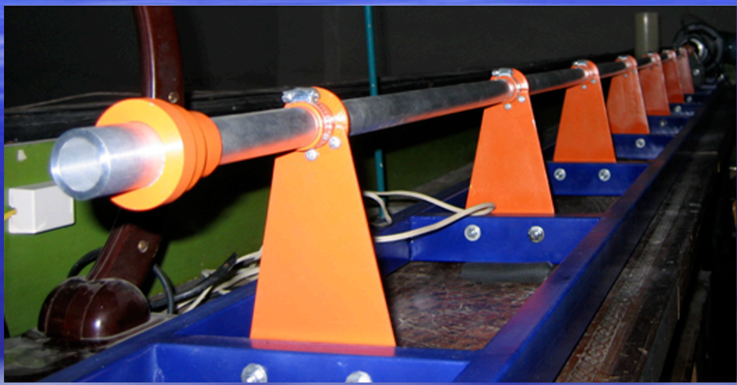

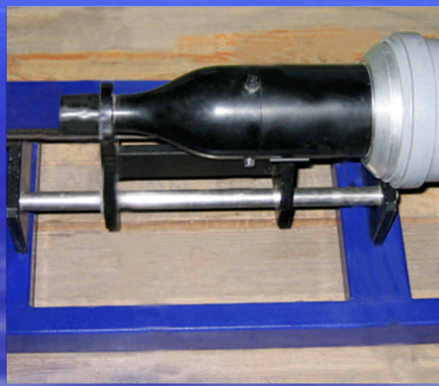

Experimental set-up with a long round channel (see left) and classical nozzle (see right)

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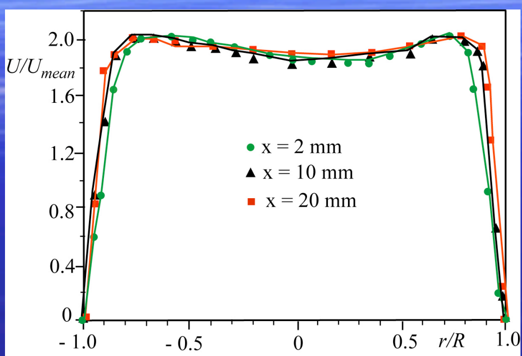
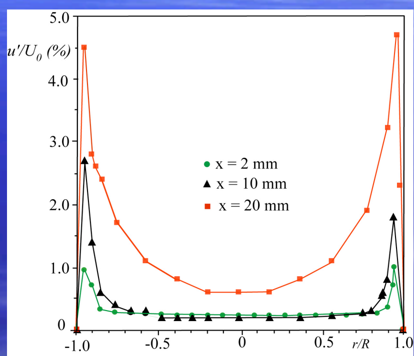
Short classical nozzle

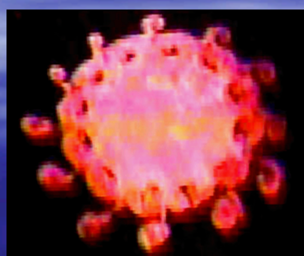


The impact (steep shear layer) mean velocity profiles



Fluctuation velocity profiles

Streamwise smoke visualization pattern



Spanwise smoke visualization pattern

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Smoke visualization of the round jet evolution downstream at the different distances from a nozzle exit

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Smoke visualization of the round jet evolution depending on growth of the jet velocity at a constant distance from the nozzle exit

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Smoke visualization of the natural streaky structures

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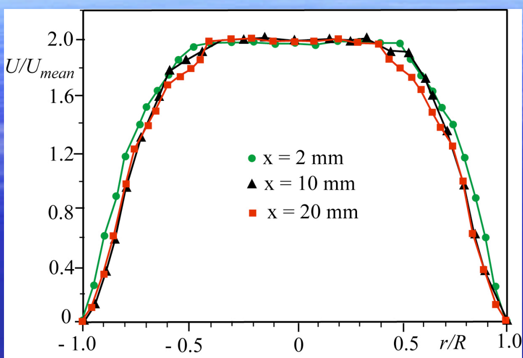
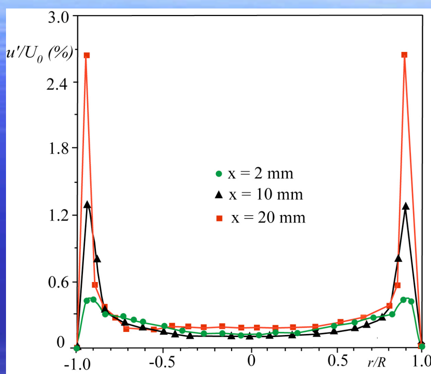
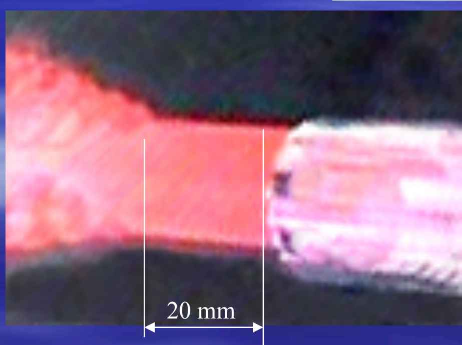




The impact mean velocity profile gradually approach to parabolic profile because of lengthening of the classical nozzle channel up to 430 mm



area of the purely laminar jet

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Smoke visualization video of the round jet evolution at the lengthening of the classical nozzle channel to 430 mm

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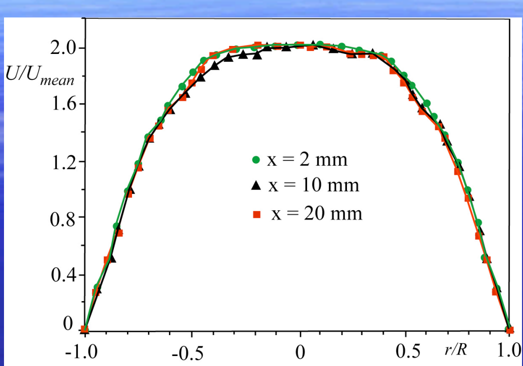
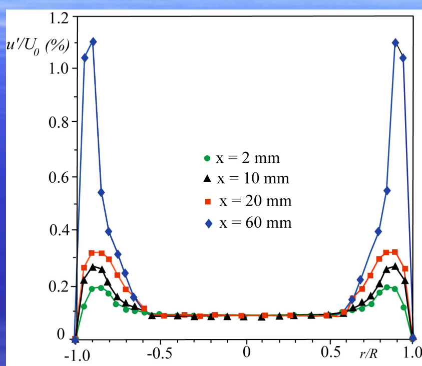
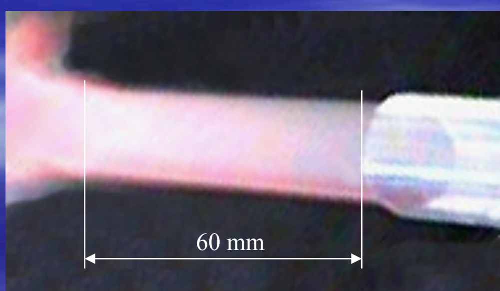




The impact mean velocity profile continue gradually approach to parabolic profile because of lengthening of the classical nozzle channel up to 870 mm



area of the purely laminar jet

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Smoke visualization video of the round jet evolution at the lengthening of the classical nozzle channel to 870 mm

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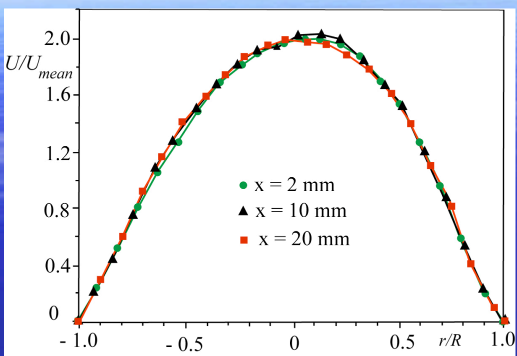
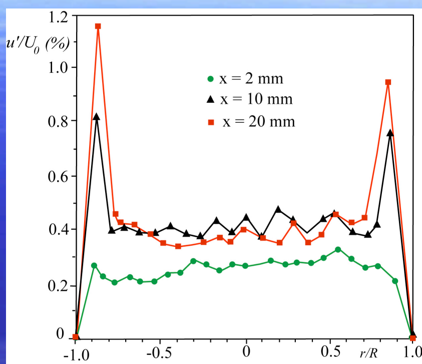
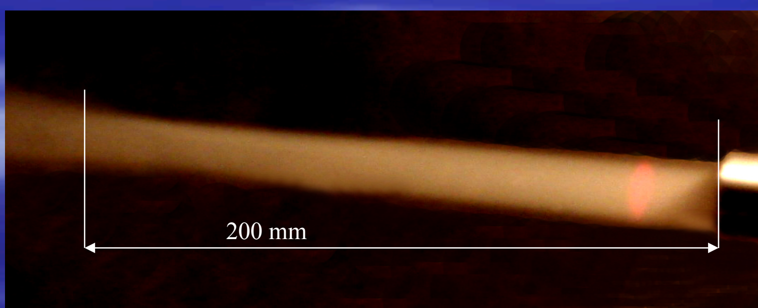




Acoustic effect of different intensity and frequency on region of purely parabolic laminar jet has not been found.

The impact mean velocity profile to become parabolic profile because of lengthening of the classical nozzle channel up to 4000 mm



area of the purely laminar jet

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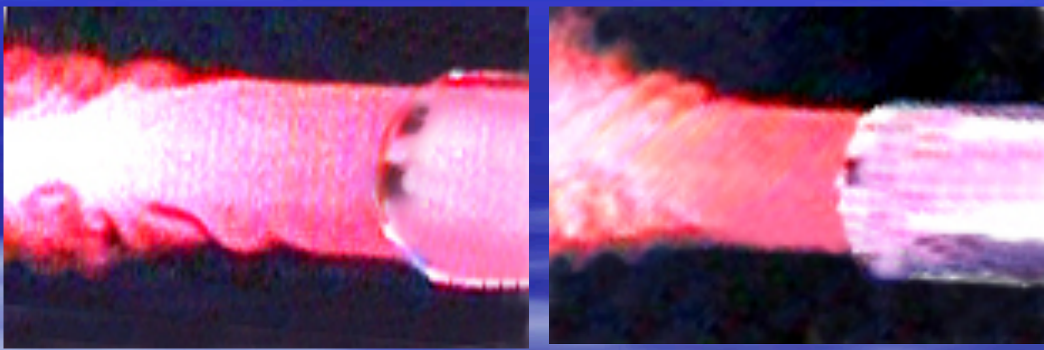
Acoustic effect on the classical round jet

An effect of acoustic forcing on the ring vortices developing in the classical laminar jet has been found. It is shown, that their scale depends on the frequency of acoustic oscillations.



Smoke visualization of the classical jet under the effect of acoustic excitation at 110 Hz (left) and 250 Hz (right), flow velocity at the jet axis U0 is equal to 5 m/s (Re =U0 × d / ν = 6667).

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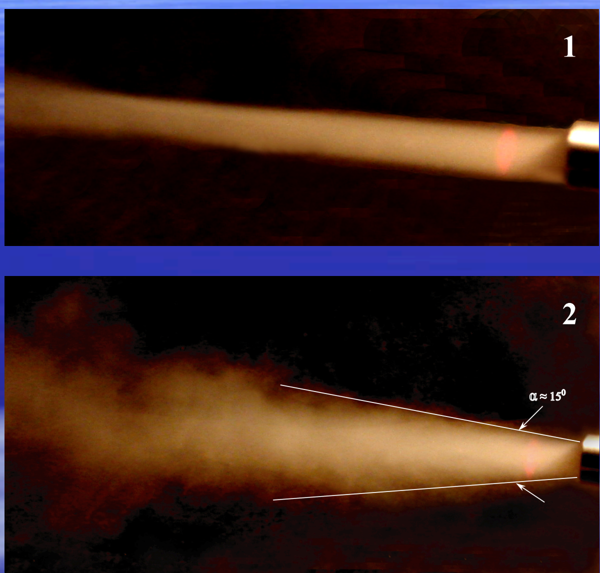

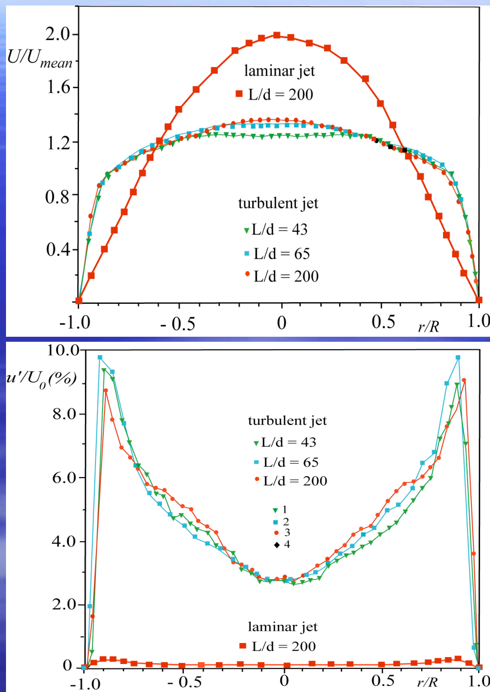

Smoke visualization of the laminar **(1)** and turbulent **(2)** jets; mean (top-right) and fluctuation (bottom-right) velocity profiles for the laminar **(1)** and turbulent **(2)** jets near the nozzle exit, flow velocity at the jet axis U0 is equal to 5 m/s (Re =U0 × d / ν = 6667).

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CONCLUSIONS:

● Experimental data on control of a round jet varying the initial conditions, that is, the distributions of mean and fluctuation velocity components close to the nozzle exit, are presented.

● Both laminar and turbulent regimes of the jet are considered involving results of smoke visualization of the flow patterns performed at one and the same Reynolds number.

● Variation of the initial conditions near the exit of the round jet nozzle may have a pronounced effect upon the jet structure and its evolution characteristics. In particular, transformation of the mean velocity distribution at the nozzle from the classical one with a flat section in the jet core to a parabolic profile, results in an extended puraly laminar flow region and suppression of the ring vortices.

● In the case of parabolic mean flow distribution, the puraly laminar jet is observed up to 200 mm downstream of the nozzle at the exit diameter of 20 mm. Also, such variation of the initial conditions reduces the intensity of velocity fluctuations from about $u'/U0$ = 1 % in the shear layer and 0.4 % in the jet core to 0.3 % in the entire cross section of the jet, where $U0$ is the mean velocity at the jet axis.

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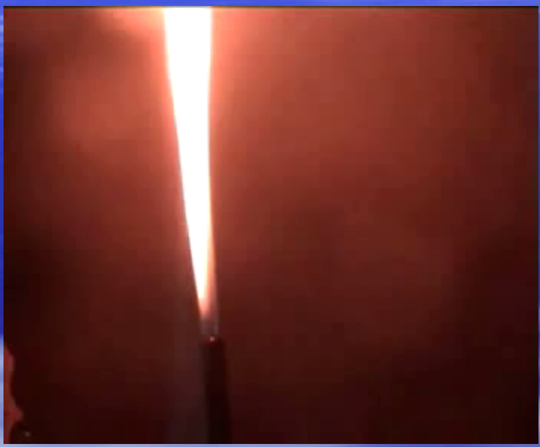
● An effect of acoustic forcing on the ring vortices developing in the laminar jet has been revealed. It is shown, that their scale depends on the frequency of acoustic oscillations. On the other hand, acoustic effect of different intensities and frequencies on region of purely parabolic laminar jet has not been found.

● Then, using surface roughness spaced close the classical nozzle exit, the turbulent jet has been modeled. Comparing the laminar and turbulent jets, both at $Re = U0 \times d / \nu = 6667$, it is shown that the laminar one is converged downstream while the turbulent jet spreads at an angle of about fifteen degrees. Velocity fluctuations in the turbulent jet are more than fifteen times higher than those in the laminar flow regime.

● As a whole, the results we obtained for the first time show a possibility to control the flow structure in a round jet through modification of the initial conditions at the nozzle, i.e. the transformation of the mean velocity distribution from the classical one to its parabolic profile.

Results of these studies can be useful to understanding of the combustion processes of microjets



Examples of the combustion modelling of the laminar (left) and turbulent (right) round jet in case of the parabolic mean velocity profile at nozzle exit for laminar flow

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I thank you for your attention