UNSTABLE BEHAVIOR OF SUBSONIC ROUND AND PLANE JETS IN A TRANSVERSE ACOUSTIC FIELD

V.V. Kozlov[1,2], G.R. Grek[1] , G.V. Kozlov[1] & Yu.A. Litvinenko[1]
[1]*Siberian Branch of Russian Academy of Sciences Khristianovich Institute of Theoretical and Applied Mechanics*,
[2]*Novosibirsk State University, Novosibirsk, 630090 Russia*

Summary Results of experimental studies of the mechanism of evolution of plane and round macro – and micro - jet flows at low Reynolds numbers in a transverse acoustic field are discussed. New data on the jet development mechanism are obtained through hot-wire measurements and smoke visualization of the jet flow with the use of stroboscopic laser illumination of the jet at frequencies of the acoustic influence on the latter. A lot of the new phenomena in development of the micro - jets in a transverse acoustic field are found.

RESULTS OF EXPERIMENTS

Round macro - jet

Results of the experimental studies of a subsonic round macro - jet mechanism evolution are presented in [1]. The round macro - jet with top - hat mean velocity profile at a nozzle exit is subjected by Kelvin-Helmholtz instability. On the other hand, it is demonstrated that a parabolic mean velocity profile at nozzle exit renders cardinal influence on the jet structure and characteristics of its evolution. It is found, that the round jet with parabolic mean velocity profile at nozzle exit has purely laminar region of flow of the big length and without presence of the ring vortices [1]. It is shown that acoustic irrespective of its frequency and intensity does not render influence on region of purely laminar jet with parabolic mean velocity profile at nozzle exit. As a whole, for the first time it is shown the opportunity to control by characteristics of the round jet development by means of the initial conditions changes at the nozzle exit.

Round micro - jet

Based on the knowledge about round macro - jet development [1], we started studying the features of development of a round micro - jet with both parabolic and top - hat mean velocity profiles at the nozzle exit in the presence of a transverse acoustic field. The experiments showed that the round micro - jet has a significant length of the laminar flow region in the absence of the acoustic field (see figure 1). There is an assumption that the micro - jet always has a parabolic mean velocity profile at the nozzle exit because the gradientless jet core practically disappears. Studies of the micro - jets evolution at nozzle diameters of 200, 400, 500, and 1600 μm are showed features of the mechanism of micro - jet development under action of a transverse acoustic field.

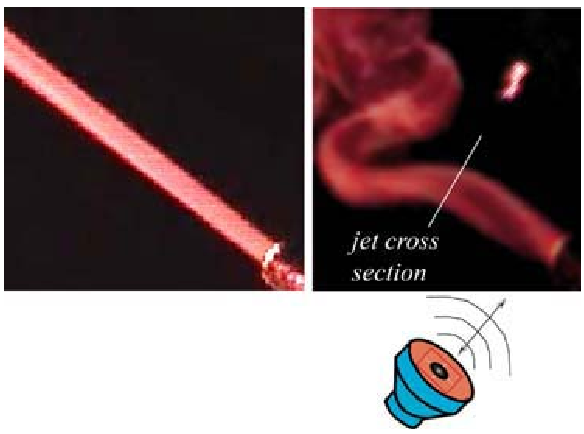

Figure 1: Smoke visualization of the effect of a transverse acoustic field on the round micro - jet: without the acoustic field (at the left) and with the acoustic field (at the right) f = 40 Hz (sound intensity of 90 dB).

This primarily refers to detection of the phenomenon of round micro - jet flattening (see figure 1) under the action of a transverse acoustic field (intensity up to 90 dB). The jet becomes plane and it starts sinusoidal oscillation, that is typical for sinusoidal instability of the plane jets [2]. The process of splitting of a unified jet into two jets under the action of the transverse acoustic field is revealed in figure 2. Thus, the round micro - jet under action of a transverse acoustic field is subjected by flattening, acquires features of the plane jet evolution and splits into its two jets.

Plane macro - jet

Results of the experimental studies of a subsonic plane macro - jet mechanism evolution are presented in [2]. It is found, that the plane macro - jets with top - hat and parabolic mean velocity profile at a nozzle exit is subjected by sinusoidal instability. It is shown, that the plane jet with top-hat mean velocity profile at the nozzle exit has three type of instability: instability of two shear layers and instability of a jet as single whole far downstream. On the other hand, the parabolic plane jet is subjected only to instability of a jet as single whole.

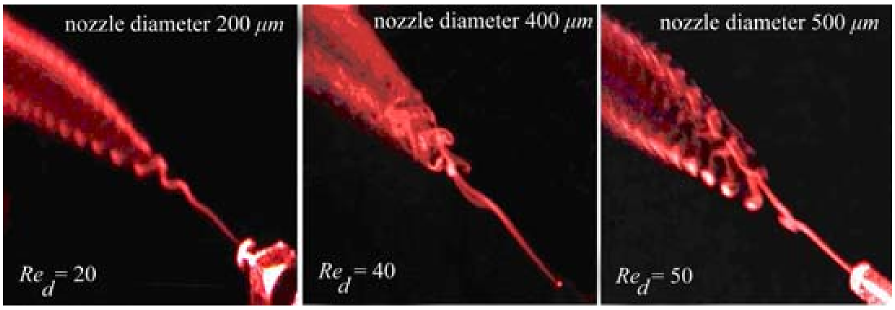

Figure 2: Smoke visualization of the micro - jet development in the transverse acoustic field with the frequency f = 200 *Hz* at various diameters of the nozzle outlet orifice (d = 200, 400, and 500 μm).

Plane micro - jet

In the case of the transverse acoustic field influence on the plane micro - jet, formation the sinusoidal vortex street is accompanied by the processes of bifurcation and twisting of the plane micro - jet at its edges in the direction of the variable flow velocity vector generated by the acoustic field (see figure 3). It is clearly seen in figure 3, that acoustic forcing at 90 *dB* makes the jet plane swirl in the opposite directions in each period of acoustic forcing due to tip effects.

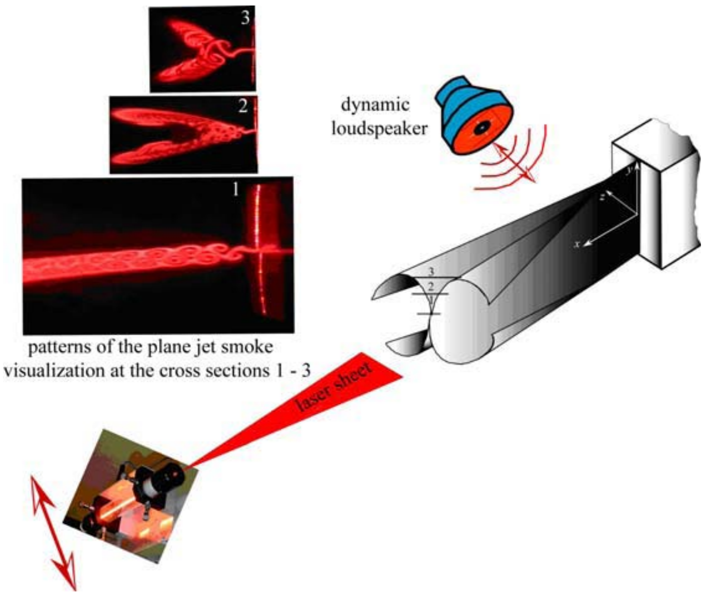

Figure 3: Scheme of the plane micro - jet development (h = 200 μm) under the transverse acoustic field action (f = 150 *Hz*, 90 *dB*) and the smoke visualization patterns of the jet in the plane xz for various positions in the direction of the axis y.

CONCLUSIONS

As a whole, these investigations showed that the mechanism of development of the round and plane macro – jet and micro - jet in the presence of the acoustic field is qualitatively identical. However, proportionality of the acoustic action intensity with the jet energy revealed a number of new phenomena, which were not observed previously in the development of macro - jets. It is necessary to attribute to them as follows: the flattening of the round micro - jet and its further development according to the laws of evolution of the plane jet and the process of bifurcation of both round and plane jets in a wide range of frequencies and intensities of the transverse acoustic field.

The work was supported by the Russian Foundation for Basic Research (№11-01-00292), the Council of the President of the Russian Federation Leading Scientific Schools (NSh-454.2008.1), State contract № 14.740.11.0354.

References

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[2] Kozlov G.V., Grek G.R.., Sorokin A.M., Litvinenko Yu.A.: Influence of initial conditions at the nozzle exit on the structure of a plane jet. *The bulletin of Novosibirsk State University. Series: Physics,* 3(3), 25-37, 2008 (in Russian).