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Sound control of the turbulent axisymmetric air jet suitable for application

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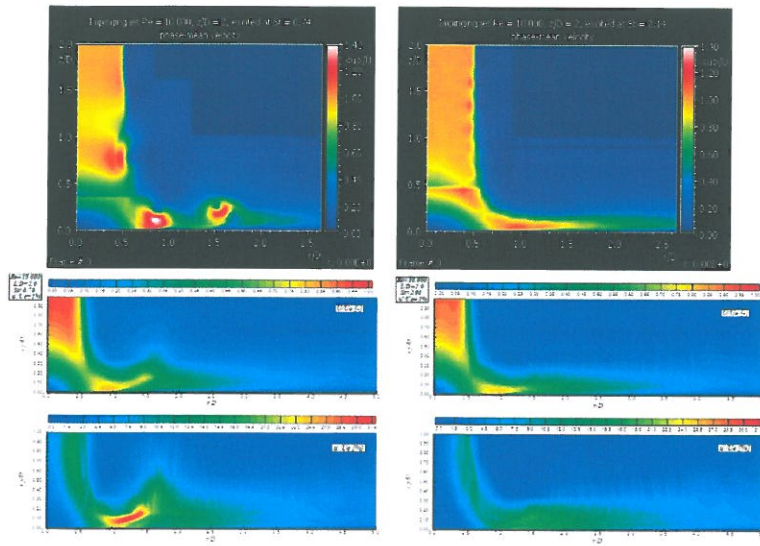
The subject of this paper is the submerged, round, unconfined turbulent axisymmetric jet, which issues from nozzles with different geometries and impinges to the flat heated plate positioned normally to the jet axis. The aim of experimental investigations, mathematical modeling and numerical simulations is to widely investigate properties and the vortex structures of modified and unmodified jet, that are assumed to have great importance in the heat transfer process. It is found that the vortex roll-up can be controlled by adding small amplitude modulation of the nozzle exit velocity using external source of low-amplitude oscillations or self-sustained oscillations generated in the operation of the specially designed whistler nozzles.

The experimental setup for the flow-field measurements in free and impinging jet configurations consists of a bell-shaped converging nozzle, a settling chamber, a system for the flow perturbation, an impingement plate located perpendicular to jet axis, an air supply system and a control and data acquisition system. The measuring system consists of a hot-wire probe, operated in a constant-temperature mode, controlled by DANTEC Streamline anemometer. The probe was mounted on a 2D traversing device. The perturbation level was defined as the normalized velocity r.m.s. u'/U_e in the middle of the nozzle exit. The level was in the range $u'/U_e=1-3\%$.

Air jet normalized velocity profiles and normalized velocity r.m.s. profiles at the free jet centerline for a fixed Reynolds number, $Re=10000$, different excitation Strouhal number, $St_D=0.3-2.12$, and excitation amplitude in the range $u'/U_e=1-3\%$, are shown on the Figure 1.

*Figure 1. Normalized velocity and velocity r.m.s. profiles along the jet centerline;
– flow and excitation conditions: $Re=10000$; $St_D=0.3-2.12$; $u'/U_e=1-3\%$*

From presented figures can be clearly distinguished four ranges of Strouhal number where jet behavior can be considered as very similar. First excitation Strouhal number range is around naturally most amplified mod of excitation (called “preferred mode”), $St_D \approx 0.3$. Second belongs to the frequency range around double most amplified mod value, $St_D \approx 0.6-0.7$, denoted in the literature as a stable vortex pairing mode. Third excitation Strouhal number range are values around $St_D \approx 1.0$ and fourth is above $St_D \approx 1.8$. All excitation modes have their own characteristics that can be explored more deeply.



Very uniform zone of turbulence intensity, which has been verified for all investigated axial distances between the nozzle lip and impinging surface, can be considered as very predictable characteristic controlled by sound modifications with Strouhal number $StD \geq 2.0$.