FFT ANALYSIS OF PLANAR DISTRIBUTIONS OF OSCILLATIONS IN A THERMAL PLASMA JET

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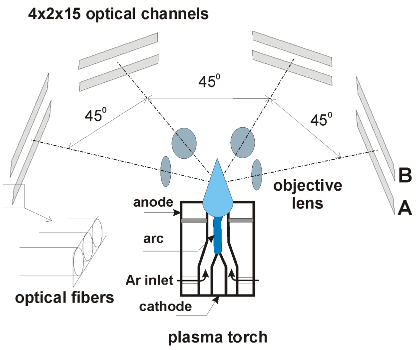
ABSTRACT

Plasma jet optical radiation was recorded by the arrays of optical fibres. The jet was observed from 4 directions in two parallel planes perpendicular to the jet axis. The record lengths and time resolution were sufficient for the application of the FFT yielding a detailed view of the oscillation phenomena in the plasma flow. The tomographical reconstruction of planar distributions of the jet radiation intensity from interpolated data was carried out via the inverse Radon transform. Significant oscillations were identified and their planar distributions examined by means of the Fourier transform. We show differences between oscillations of electric and hydrodynamic origins. Different spatial distribution, stability and energy dynamics is shown. Possible case of close and mutually influencing frequencies is also described.

EXPERIMENTAL ARRANGEMENT

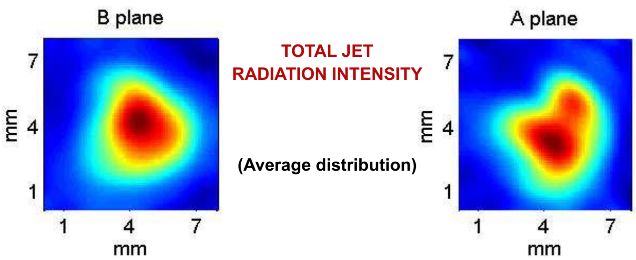


D.C. fed Ar plasma torch, arc current 150 A, flow rate of argon 30 slm (standard litres/min.), maximal arc length 44 mm, nozzle diameter 8 mm.

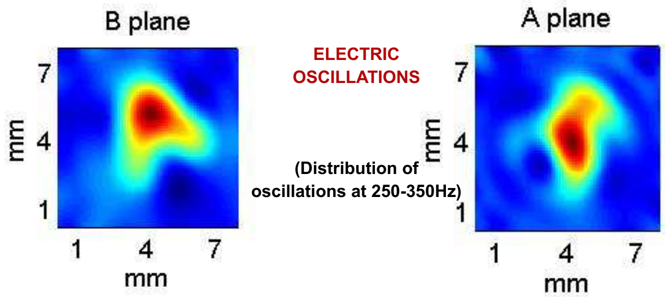
METHOD OF EVALUATION

The plasma jet radiation was projected through 4 objective lens on face areas of linear arrays of optical fibers with diameters 1 mm. The arrays consisted of 15 elements each and they were arranged at 2 levels above the nozzle. The arrays at one level (**plane B**) captured the radiation **2 mm** above the nozzle orifice and the arrays at the second level (**plane A**) detected radiation **6 mm** above it. The arrays detected the plasma jet radiation from 4 directions separated by angle intervals 45°. The electronic part of the measuring equipment consisting of photodiodes, amplifiers, multiplexers, A/D converter and computer provided the records with the sample rate 468 kHz/channel and record lengths 1 Msample/channel. For the data evaluation we have used the method of trigonometric and polynomial interpolations extending the number of the input profiles for the inverse Radon transform.With these methods we could reconstruct either the distribution of plasma jet radiation intensity or distribution of specific oscillations in each of the planes.

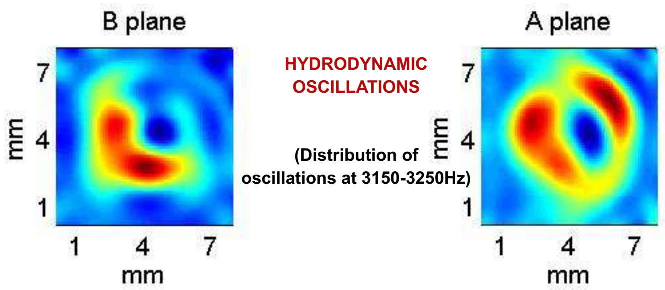
RESULTS



The reconstruction of the average total jet radiation intensity in both planes shows cylindrical geometry and distributions similar to gaussian ones. The distribution is more uniform in the plane B, which is closer to the nozzle. In the plane A we can see some displacement of the intensity maximum and a more irregular shape.

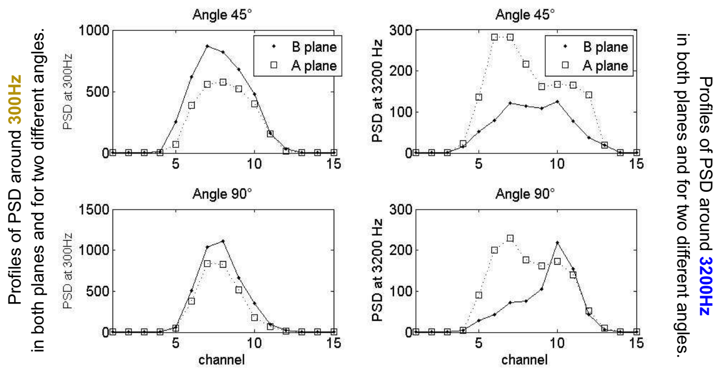


The oscillations at electric frequency (300Hz) are present mainly at the jet axis and their distribution is similar to that of the total jet radiation intensity. These oscillations originate from the small ripple in supply current. Comparison of spatial distribution of these oscillations between plane A and plane B shows that radial and angular positions of these oscillations in the plasma flow are relatively stable.



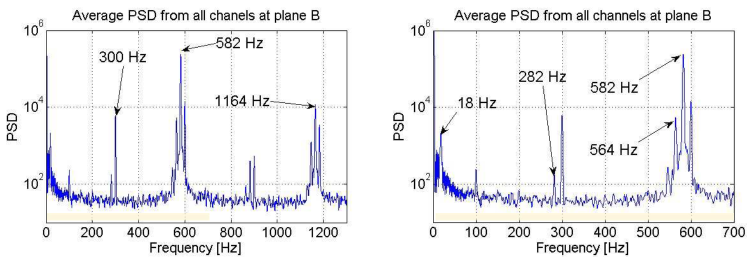
The structures characteristic for higher frequencies, which are hydrodynamic in origin, manifest themselves in the boundary layer. This is the area of mixing with external air and more turbulent flow. Comparison of spatial distribution of these oscillations between plane A and plane B shows that these oscillations change their position in much more vivid way.

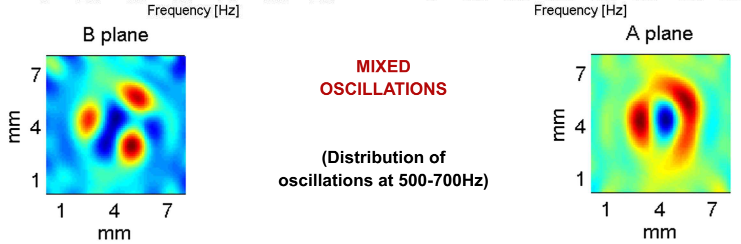
OSCILLATIONS INTENSITY PROFILES IN BOTH PLANES



Energy concentrated in the electric oscillations decrease with the distance from the plasma torch nozzle. On the other hand, energy concetrated in hydrodynamic oscillations gain more energy "on the way up" and some of them are even generated in the boundary layer.

OSCILLATIONS INTERACTION AND ENERGY TRANSFER





Interesting phenomena occur in the frequency interval, where the harmonic of the main electric frequency and subharmonic of the hydrodynamic frequency are very close to each other. We presume, that the strong electric frequency (600 Hz) supported from inside parts of the plasma torch "energizes" one of the subharmonics (582 Hz) of the hydrodynamic frequency (1164 Hz).

CONCLUSION

A new way of plasma jet optical radiation measurements performed simultaneously from different angles allowed us tomographical reconstruction of spatial distributions of different oscillation structures. Low-frequency oscillations, which are electric in origin, manifest themselves in the jet core and show a relatively stable behaviour. High-frequency oscillations are created and manifest themselves in the boundary areas and possess vivid dynamics. The results have also shown an interesting example of possible interaction and energy transfer between different oscillation types.

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