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MEASUREMENTS OFPARTICLE VELOCITIES AND ACCELERATIONS IN THERMAL PLASMA JET

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MOTIVATION

Measurements of the injected particles velocities and accelerations in the plasma jet are important for thermal plasma applications, mainly plasma spraying technology. Commonly used methods of optical diagnostics, such as particle image velocimetry or particle tracking velocimetry and accelerometry (PTVA), are complicated due to strong optical emission of the plasma jet. We have developed a fast variant of the PTVA able to measure particle velocities and accelerations in hot core of thermal plasma jet.

EXPERIMENTAL ARRANGEMENT

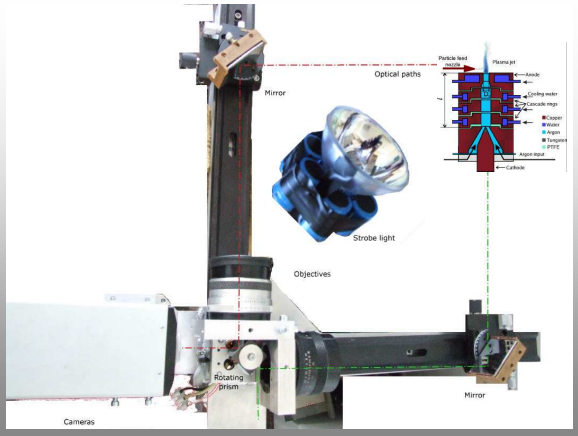
There are a lot of problems associated with a capturing of the dust particles in the plasma jet by a CCD camera. We solve almost all electro-optical problems of the CCD chip by adding a rotating mirror into optical path, yielding the ability of capturing sequences of images in single frame. This also allows us to use inexpensive xenon flash lamps instead of pulse laser for illuminating. We observe the plasma jet by two perpendicular cameras sharing the same rotating prism, thus we are able to determine all three coordinates of particle, and to compute the particle velocity and acceleration from position changes between the four expositions.

EVALUATION PROCEDURE

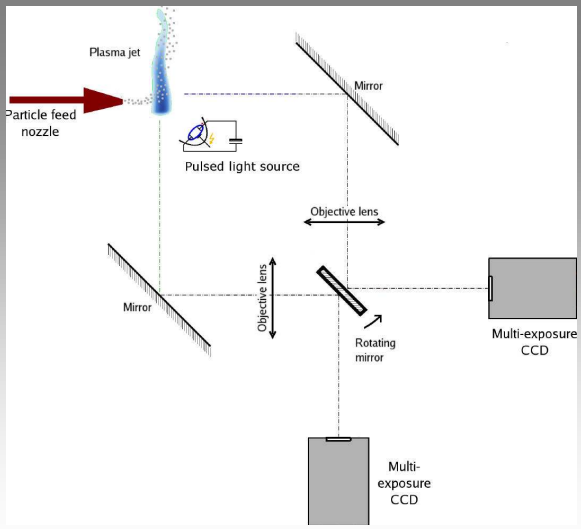
Images acquired are filtered and cut into four separate images. Particles become recognizable and the coordinates of particle center are found. Identification of the same particle in next exposition is based on correlation analysis, the correlation coefficients of two velocity vectors constructed from three succeeding particle positions must be close to 1. Changes in position of the particle between succeeding expositions is proportional to particle velocity. From velocity changes we can get particle acceleration. Velocity and acceleration vectors obtained, are then identified in the perpendicular images. The identification is based on the fact that the vectors origins in perpendicular images must have the same z coordinates in booth images. This way we are able to determine all three coordinates of the vectors origins.

EXPERIMENTAL RESULTS AND CONCLUSION

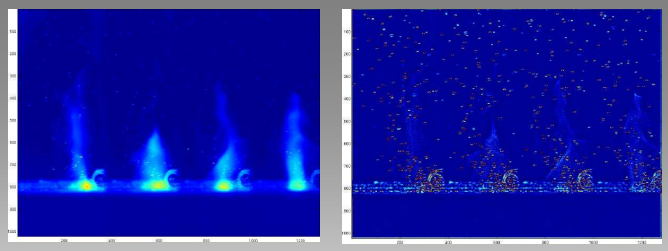
Measured velocities are up to 100 ms^{-1} and accelerations up to $3 \cdot 10^5$ ms^{-2}. Spatial distribution of acceleration is affected by the gas flow rate. The gas flow increase in range 30–80 slm elongates intensive acceleration zone but makes it less uniform. Developed imaging method, combined with software evaluation of images, is able to measure 3-D particle velocities and acceleration in a wide range of plasma torch operating parameters in the hot, highly luminous part of the plasma jet as well as in cold surroundings of the plasma jet.



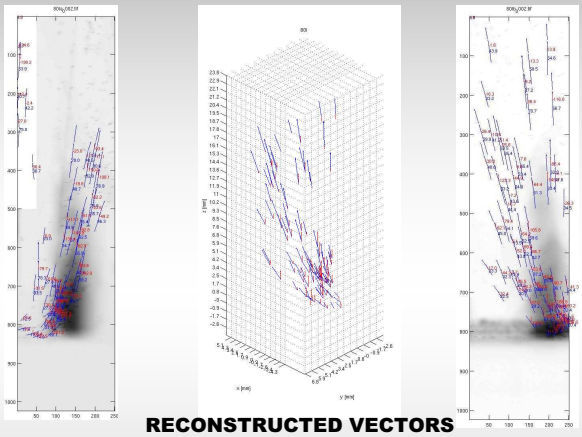
RECORDING DEVICE



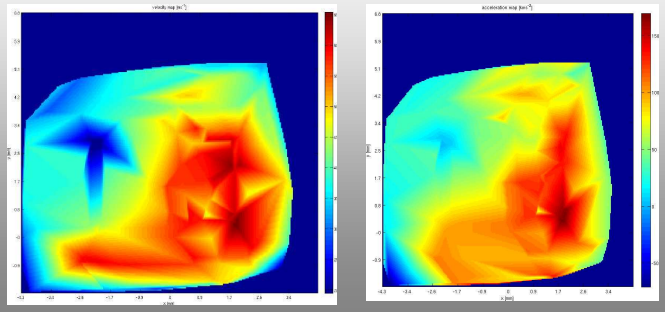
EXPERIMENTAL ARRANGEMENT



ORIGINAL AND FILTERED IMAGE



RECONSTRUCTED VECTORS



VELOCITY AND ACCELERATION MAPS