VELOCIMETRY AND ACCELEROMETRY IN HIGHLY LUMINOUS PLASMA JET

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Introduction

Thermal plasma spraying technology is used in a number of technical applications where particles are injected into the plasma flow. Measurements of the injected particles velocities and accelerations in the plasma jet are important for plasma spraying technology, mainly for improvement of particle feeding. We have developed a fast variant of the particle tracking velocimetry and accelerometry (PTVA) able to measure particle velocities and accelerations in the hot core of thermal plasma jets as well as in particle injection zone, yielding all three tracking coordinates for up to four tracking particle positions.

Experimental and Capturing Devices

The experimental device was an experimental cascaded DC plasma torch. Corundum particles sizes 60 – 80 μm was injected into the plasma jet by particle feed nozzle. The injected particles in the plasma jet are illuminated by strong light pulse of duration 100 μs. The light pulse is generated by an approximately 200 J capacitive discharge in xenon flash lamp and concentrated into measurement volume by an optical collimator. Particles positions are captured during the light pulse by two perpendicular multi-exposition CCD cameras, equipped with shared rotating mirror. The fast rotating mirror placed between objective lens and CCD chips of the cameras causes image shift over the sensitive area of the chips. Auxiliary electronic circuits allow triggering of the flash lamp and the cameras in the arbitrary position of the rotating mirror. By this technique we yield sequence of images, in this case four expositions separated by time 20 μs. For experimental arrangement of the capturing device see Fig. 1.

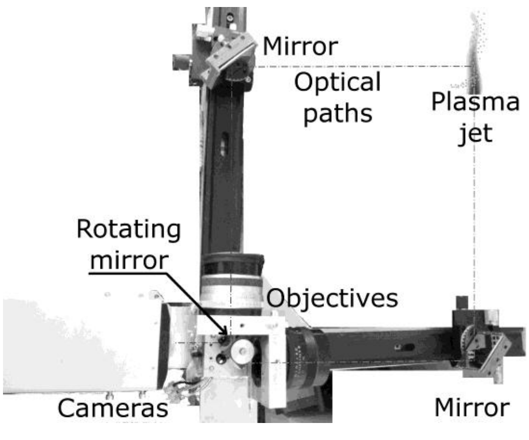

Fig. 1. Experimental arrangement.

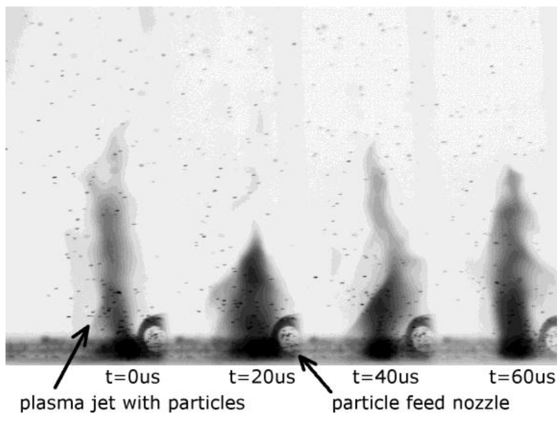

Fig.2. Example of captured image.

Evaluation method of the images

Acquired images is evaluated by applying a gradient filter. Particles—being the bright spots on the fuzzy picture of the plasma jet—become recognizable. The four times exposed image, for example see Fig. 2, is cut into sequence of four images. After that the code finds centres of the particles and identifies the same particles in other expositions. The finding of the particles centres is done in several steps. At first, the image is converted into 1-bit black and white image and particles are identified as compact objects. Particles centres are then found in the original 12-bit image as the geometrical centre of gravity in the compact object. In this way, we can get sub-pixel resolution of the particles coordinates, which is important for acceleration measurement. Identification of the same particle in next exposition is based on correlation analysis. The particles are moving on almost straight trajectories, the correlation coefficients of two velocity vectors constructed from three succeeding particle positions therefore 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. The found velocity and acceleration vectors are then identified in 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. In this way we are able to determine all three coordinates of the vectors origin. For examples see Figs. 3 and 4.

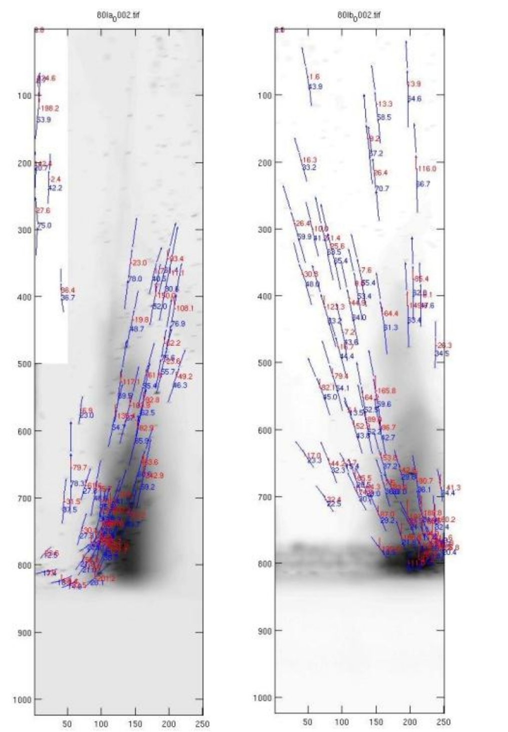

Fig. 3. Two perpendicular images with found velocity and acceleration vectors.

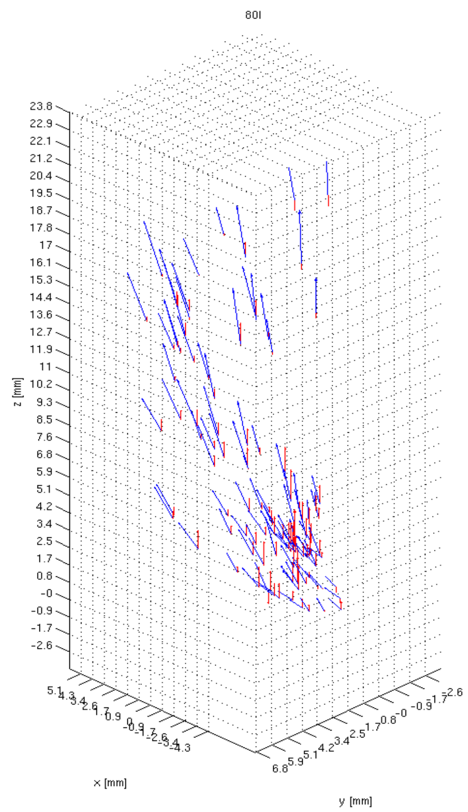

Fig. 4. Velocity and acceleration vectors projected into measurement volume.

Acknowledgement

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