SHADOW AND BACKGROUND ORIENTED SCHLIEREN INVESTIGATION OF SHOCK WAVES IN GAS-DISCHARGE MEDIUM

J. JIN[1], I.V. MURSENKOVA[1,c], N. N. SYSOEV[1] and I.A. ZNAMENSKAYA[1]

[1]Department of Physics, Lomonosov Moscow State University, Moscow, 119991, Russia

[c]Corresponding author: Tel.: +74959394428; Fax: +74959328820; Email: murs_i@physics.msu.ru

KEYWORDS:

Main subjects: shock waves, pulse gas discharge, flow visualization
Fluid: flow with shocks, relaxing plasma of gas discharge
Visualization method(s): shadow method, background oriented schlieren
Other keywords: nanosecond volume discharge, plasma sheet, image processing

ABSTRACT: Non-stationary flow arising in gas discharge chamber after surface discharge and combined volume discharge of nanosecond duration in air was investigated by means of background oriented schlieren (BOS) and shadow technique. Gas discharges have attracted great interest in recent years because they may be used to solve various problems of plasma aerodynamics [1]. The experiments were performed at the shock tube mounted with a special discharge chamber described in [2]. Two side walls of the discharge chamber are the quartz glasses for the possibility of optical investigations of the discharge area. Sliding surface discharges (plasma sheets) and volume discharge of length 10 cm were initiated in discharge chamber at pressure 6-13 kPa (air densities ~ 0.08-0.17 kg/m^3). The value of pulsed voltage was 25 kV. The current reached its maximum (~1 kA) during 30 ns. Pulse discharge time was about 200 ns that much less than gasdynamic time in shock tube. As a result, a set of semi-cylindrical shock waves around the surface discharge channels was initiated [2]. Shock waves moved from two plasma sheets towards each other in the discharge section.

The flow visualization system includes shadow method and background oriented schlieren. Two methods record the flow images at the same moment of time. The source of light for both methods was pulse Nd:YAG laser (wavelength 532 nm, pulse duration 6 ns). The BOS displacement field was determined by direct cross-correlation algorithm. Poisson equation for density was solved numerically [3].

Quantitative and qualitative results showed that the shape of shock waves and their intensities were different in the case of surface discharge in air and surface discharge combined with volume discharge. Shock waves velocity also was not quite the same. The reason for these differences was that in the case of initiation of the volume discharge shock waves from plasma sheets moved through the relaxing medium of volume discharge. In particular, the initial temperature in the medium of volume discharge was higher than temperature in the test chamber in case of surface discharge in air. The results obtained by the BOS and shadow technique indicated that the gas discharge plasma affected the shock waves movement. The use of two visualization methods gave complete information on the experiments.

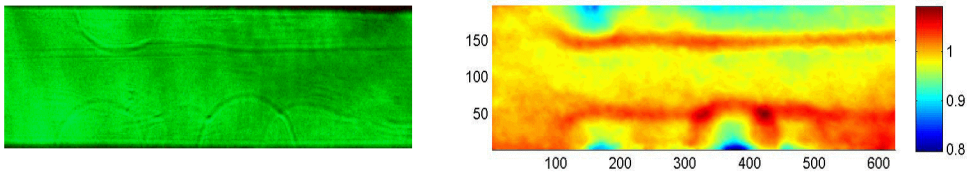

Fig. 1 Images of shock waves 13 μs after the volume discharge: shadow image (left) and BOS density field (right). Scale of shadow image was adjusted to fix the BOS results.

References

1. Moreau E. *Airflow control by non-thermal plasma actuators.* J. Phys. D: Appl. Phys. 2007, **40** (3), p. 605

2. Znamenskaya I.A. et al. *Experimental investigation of shock-wave processes in the pulsed ionization of the surface of a shock-tube channel.* J. Eng. Phys. 2010, **84** (1), p. 33

3. Jin J. et al. *Shadow and BOS Analysis of Shock Interaction with Zone of Pulse Volume Discharge. Proc. of PSFVIP-8*, Moscow, Russia, 2011