Nanosecond surface sliding discharge in a supersonic air flow with an oblique shock wave: experiment and numerical simulation [[1]](#footnote-1)\*)

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The results of an experimental and numerical research of a supersonic airflow with an oblique shock wave in the discharge chamber of a shock tube at nanosecond surface sliding discharge initiation are presented. The work demonstrates the importance of the study of the pulsed discharge action mechanism on inhomogeneous supersonic flow in the plasma aerodynamics [1, 2]. An oblique shock wave was generated in a supersonic airflow around a small obstacle on the lower wall of the discharge chamber channel at flow Mach numbers of 1.16–1.70. Numerical simulations of the gas-dynamic flow in the channel are performed by a pulsed energy input near the upper wall. The energy input region in the simulations was set in accordance with the experimental results on the geometry of the discharge channel. The flow in the channel was modeled by the solution of unsteady two-dimensional Navier–Stokes equations for a turbulent flow of a viscous compressible gas[3].

In the experiments, a surface sliding discharge of ~ 300 nanoseconds duration was initiated on the upper wall of the discharge chamber at a pulse voltage of 25 kV. The area of ​​discharge 100×30 mm2 in a homogeneous air [1, 4]. In an inhomogeneous supersonic airflow, the discharge current is concentrated in a single channel in the region of interaction of the inclined shock wave with the boundary layer. The concentration of electrons in a channel exceeds 1015 cm-3 at a discharge current of ~ 1 kA [4]. A shock wave propagates from the discharge channel affecting on the shock-wave flow structure in the channel.

The spatial structure of the flow with an oblique shock wave is studied by the direct shadowgraphy method. High-speed shadowgraphy of the flow field was carried out with a frequency of up to 525000 frames per second. The discharge current and the discharge radiation were recorded simultaneously. Digital processing of sequences of obtained shadowgraph images showed that a localized discharge channel generates a semi-cylindrical shock wave. The shock wave dynamics depends on the flow parameters and the discharge parameters. Numerical simulation taking into account the experimental dynamics of the shock front, showed that thermal energy ~ 0.20 J is released in the discharge channel under the experimental conditions. The shock wave effect on the flow can be used to flow control.

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References

1. Mursenkova I.V., Znamenskaya I.A. and Lutsky A.E. Influence of shock waves from plasma actuators on transonic and supersonic airflow. J. Phys. D: Appl. Phys., 2018. Vol. 51, No 5. 105201
2. Starikovskiy A.Yu., and Aleksandrov N.L. Gasdynamic Flow control by ultrafast local heating in a strongly nonequilibrium pulsed plasma. Plasma Physics Reports. 2021. Vol. 47. P. 148–209
3. G. Glushko, I. Ivanov, I. Kryukov. Computational method for turbulent supersonic flows. Math. Models Comput. Simul., 2010. Vol. 2. No 4. P. 407-422
4. Mursenkova I.V., Ulanov P.Yu., Kuznetsov A.Yu., Liao Yu. Plasma parameters of a nanosecond surface sliding discharge in a supersonic airflow. <http://www.fpl.gpi.ru/Zvenigorod/XLVIII/Te.html>
1. \*) [abstracts of this report in Russian](http://www.fpl.gpi.ru/Zvenigorod/XLIX/Pt/ru/GQ-Mursenkova.docx) [↑](#footnote-ref-1)