DOI: 10.34854/ICPAF.51.2024.1.1.154

SIMULATION OF THE INFLUENCE OF SPARK DISCHARGES ON THE EFFICIENCY OF MIXING AIR FLOW WITH SUBSONIC AND SUPERSONIC SECONDARY JET *)

Volkov L., Firsov A.

JIHT RAS, Moscow, Russia, volkov.ls@phystech.edu

This work elucidated the effect of plasma formations on a special type of gas flow, which is formed when a secondary transverse gas jet is injected into a supersonic air flow from an orifice on a flat wall. This flow takes place, for example, in some types of aircraft engines when fuel is injected into supersonic combustion chambers. In recent decades, various methods have been proposed and studied to intensify the mixing of gases in a given flow, which is necessary to increase the efficiency of engines [1].

Spark discharges are considered by some researchers [2] as a source of disturbances that can stimulate the development of instability in the shear layer at the boundary of the transverse jet, and promote the mixing of gases. The mechanism of the effect of discharge on the flow is mainly due to pulsed heating, which leads to the formation of a shock wave and an expanding thermal cavity. In [3], the choice of the optimal pulse heating frequency was justified.

The aim of this work was to compare the integral criterion of mixing efficiency [3] for the following injection methods and pulsed heating parameters:

a) injection: through a cylinder-shaped injector or through a supersonic Laval nozzle,

b) discharge location: on the edge of the injector orifice or in the injector channel,

c) heat release energy: from 5 to 25 mJ per pulse.

To solve the problem, numerical modeling was performed in the software package FlowVision. By solving the unsteady Reynolds-averaged Navier-Stokes equations (URANS), the evolution of the flow characteristics was obtained. The KEFV turbulence model was used [4]. The electric discharge was modeled using a volumetric local heat source, which was specified as an additional term in the URANS. CO_2 was used as the secondary jet gas simulating the fuel. Databases with information on the density, heat capacity and transport coefficients of equilibrium plasma in air and CO_2 at high temperatures (up to 50,000 K) were taken from [5, 6]. The selected flow parameters make it possible to reproduce the modeled phenomenon in a full-scale experiment using equipment available at the JIHT RAS: Mach number in the air flow – 2; jet-to-crossflow momentum ratio ~1, injector orifice diameter – 3 mm, air temperature – 170 K, pressure – 22 kPa.

Local flow characteristics were obtained and an integral criterion for mixing efficiency was calculated. It has been shown that in some cases, due to the effect of electric discharges on the flow, the value of the integral criterion of mixing efficiency can increase by more than 15%.

The study was supported by the Russian Science Foundation grant No. 21-79-10408.

References

[1]. Q. Liu et al (2020) *Progress in Aerospace Sciences* **119** 100636
[2]. W. Hongyu et al (2023) *Physics of Fluids* **35(9)** 96101
[3]. L.S. Volkov and A.A. Firsov (2023) *Computer Research and Modeling* **15(4)** 845-860
[4]. S.V. Zhluktov and A.A. Aksenov (2015) *Computer Research and Modeling* **7(6)** 1221-1239
[5]. C. Catalfamo et al (2009) *European Phys. J. D.* **54(3)** 613–621
[6]. M. Capitelli et al (2013) Fundamental Aspects of Plasma Chemical Physics. Springer New York **74** 273–347

*) abstracts of this report in Russian