COMPUTER FLOW VISUALIZATION AND EXPERIMENTAL INVESTIGATION OF COMPACT RING AND DUAL-SLOTTED LINEAR NOZZLES

V.A. LEVIN[1], N.E .AFONINA[1], V.G. GROMOV[1], I.S. MANUYLOVICH[1], G.D. SMEKHOV[1],

A.N. KHMELEVSKY[1], V.V. MARKOV[2]

[1]Institute of mechanics of the Moscow State University, Moscow, 119192, Russia
[2]V.A. Steklov Mathematical Institute RAS, Moscow, 119991, Russia

[c]Corresponding author: Tel.: +74959395307; Fax: +74959390165; Email: Gromov@imec.msu.ru

KEYWORDS: **computer visualization, trust, nozzles, gas central body, measurements**

ABSTRACT: Ring and dual-slotted linear nozzles with the internal cavity on a number of characteristics represent a competition for traditional Laval nozzles as the thrust device of the jet engine. They have noticeably smaller length along thrust vector, possess property of auto adjustability at change of flight height and are considered as perspective for realization a pulsing valve less mode of fuels burning [1].

In the report complex results from numerical and experimental flow research as well as thrust characteristics of a jet engine model thrust device equipped by a ring nozzle with the internal cavity in the form of a spherical segment are presented. For the dual-slotted linear nozzle, corresponding on geometrical parameters considered ring nozzle, numerical visualization of flow shadow picture inside of the cavity is executed. Flow calculations in view of viscosity are performed with use of the numerical solution of non-stationary Navier-Stokes equations for multi component chemically non equilibrium model of the gas medium. The flow in non viscous approach was described due to the original computer system on the basis of Euler's equations, allowing to model two-dimensional non-stationary flows of the multi component inert and reacting gases. Experimental researches are performed in pulse aerodynamic setup [2].

It is shown, that in a stationary mode the flow structure in the considered devices is similar to a flow in nozzles with the central body. The role of the gas central body thus plays the recirculation flow area, which is automatically formed in a nozzle cavity. The gas stream entering in the device through the ring nozzle in a radial direction of a spherical segment, is accelerated till supersonic speed, then turned and expires through the outlet nozzle in the form of a supersonic extending jet, at first in ring form, and then in conic. The jet structure includes areas of rarefaction, compression and shocks in which a turning of a stream from radial to an axial direction take place. The jet angle expansion is defined by the attitude of pressures on an input in the device and in surrounding space. The flow picture in dual-slotted linear nozzle on structure is similar to structure of ring nozzle. However, in case of dual-slotted linear nozzle a surface of the central body under the form appears more pointed at an axis. In both nozzles – ring and linear the primary turn of the stream that inlets from nozzle throat and moves along central body surface, occurs in the attached to a body oblique shock wave. Finally in a dual-slotted linear nozzle the stream is swivels along a thrust vector in an original four-shock configuration, and in a ring nozzle - in intensive hanging shock. A principal cause leading change of details of jet flows, formed by considered nozzles, is the smaller degree of compression of a stream near to an internal cavity axis of symmetry in a dual-slotted linear nozzle in comparison with ring nozzle.

Results of modeling of the non-stationary wave processes accompanying starting and an establishment of flow in experiments with models of similar nozzles devices are presented. Times of nozzle devices starting, formation and existence quasi-stationary regime of the expirations in a receiver are defined. In presented experimental and calculating results it was established that considered ring nozzle developed the thrust approximately twice exceeding corresponding values for sound nozzle.

Work is supported by the RFFI (Project №-11-01-00068a) and RosNauka (N.Sh.-8424.2010.1).

References

1. Levin, V.A. et al. *A new approach to organizing operation cycles in pulsed detonation engines*: in High-Speed Deflagration and Detonation: Fundamentals and Control. Eds. G.D. Roy, S.M. Frolov, R.W. Netzer, and A.A. Borisov. Moscow, ELEX-KM Publisher, 2001, p.223.

2. Levin, V.A. et al. *The dynamics of combustion products flow in a ring nozzle with a half-closed cavity,* Combustion Science and Technology, 2010, **182** (11-12), p.1564.