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Stable detonative combustion of hydrogen in a supersonic flow coming in a convergent - divergent nozzle

The possibility of stationary detonation combustion of hydrogen-air mixture coming into an axisymmetric convergent-divergent nozzle with a high supersonic velocity is investigated. A necessary condition for the stabilization is the formation of supersonic flow in the convergent section of the nozzle Therefore first, this work experimentally and numerically solves the problem of the starting of a convergent - divergent nozzle in a supersonic flow. It is shown that the supersonic start-up can be realized both by throwing a nozzle into the formed supersonic stream, and when the nozzle is accelerated to a given velocity. A peculiarity of the flow formed is the emergence of an oblique shock wave in the convergent section of the nozzle and the Mach disk because of this wave interaction with the axis of symmetry. In calculations with combustion, air at the inlet to the nozzle is replaced by a hydrogen-air mixture of a given concentration. The main difficulty in the problem of stabilization of detonative combustion is associated with the spontaneous ignition of hydrogen behind the Mach disk and the propagation of detonation upstream. Additional problems arise when initiating detonative combustion of hydrogen under conditions of a rarefied atmosphere: the ignition does not guarantee the formation of a stationary detonation in the nozzle. Investigations are fulfilled on the base of Euler gas dynamics equations with detailed kinetics of combustion. Calculations are made use modified Godunov'method. It is shown the possibility of stabilizing the detonative combustion of hydrogen-air mixtures coming into the axisymmetric nozzle at the Mach number from 7 to 9 at heights up to 16 km.

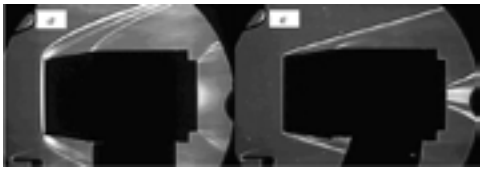

Figure1: *Nozzle startup experiment: a - unsuccessful startup if the nozzle is installed before the start of blow down, b - a successful starting if the nozzle is thrown into the airflow at Mach number of 6.*

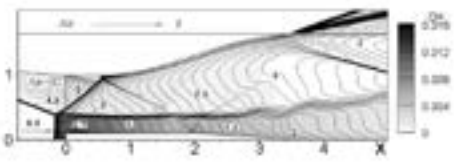

Figure 2: *Lines of a constant Mach number against the background of the OH concentration at stable detonative combustion of the hydrogen-air mixture 0.19H2 + 0.21O2 + 0.79N2 at the altitude of 14 km.*

Biography

Yuri V Tunik graduated from a usual school in the small town of Moscow region and entered the Mechanical Mathematics Department of Moscow State University by name M V Lomonosov (MSU). In 1970, he received higher education and continued to study at the graduate school of the same faculty. In 1976, he defended his thesis on gas-dynamic lasers and in 2002, the thesis "Dynamics of combustion in two-phase media containing methane" to acquire scientific degree of the Doctor of Physical and Mathematical Sciences. Since 1974, he has been working as a Researcher in the Research Institute of Mechanics of MSU. Currently he is a leading Researcher.

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