Plasma vortex reactor for production of heat energy and hydrogen

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The problem of creating efficient energy sources, including alternative ones, has become increasingly noticeable. One of the most promising technologies is the use of plasma vortex reactor (PVR), which can be both heat and hydrogen generator. The efficiency of hydrogen and heat production obviously increases in the vortex flows, which carried their downstream. At the same time, the structure of the flow is strongly influenced by a number of factors: the organization of the input and output of the mixture components, the shape and arrangement of the discharge electrodes, swirl number, the mass flow of components. Here, a numerical simulation of the structure of the gasdynamic and thermal fields formed in a 3D unsteady viscous turbulent vortex flow of pure argon in a PVR duct under experimental conditions is carried out for different configurations of electrodes system and source localization. The spatial distributions of the source power, duct geometry and electrodes configuration were chosen phenomenologically.

The no-slip velocity and fixed temperature conditions were imposed along the tube and electrode surfaces. At the duct inlet and outlet, fixed mass flux conditions were used. At the outlet, we imposed the boundary conditions with the static pressure equal to the atmosphere pressure. To closing of the Navier-Stockes system the Spalart-Allmaras model with option of curvature correction was used. Pressure-velocity coupling schemes were tested and gave equal results. For spatial discretization of density, momentum, energy and turbulent quantities, a second-order upwind scheme is applied. The program package solves governing equations using the finite volumes method. The computational grids consisted of about 4·106 hexahedral cells. Three different types of electrodes are considered in the simulation: a thick electrode, a thin electrode, and a pipe-like electrode.

Largely, the structure of the flow is determined by the paraxial counterflow zone, typical for strongly swirled flows [1,2]. Between the electrodes, a stagnation zone is formed. Eventually, it leads to the zone overheating. At the combination of thick anode and pipe-like cathode the pressure gradient along the symmetry axis draws out the hot gas from the interelectrode area. The counterflow zone weakens, but overheating is also quite significant, which lead to rising of radiative loss through the side walls. Optimum is the combination of a thin anode and a hollow cathode located at the output of the PVR. In this case, heat is effectively carried away upstream, so that the overheating zone is not formed. A qualitative agreement between the simulation and the experimental data for pure argon has been obtained.

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