SPHERICAL DIFFUSION FLAME OF ETHYLENE IN THE SPACEFLIGHT EXPERIMENT “ADAMANT”

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Abstract: The joint spaceflight experiment Flame Design (Adamant) of NASA and Roscosmos is one of six experiments currently conducted at the International Space Station as part of the ACME (Advanced Combustion via Microgravity Experiments) project. The objective of the experiment is to study the fundamental mechanisms of control of soot formation in a spherical diffusion flame (SDF) formed around a porous sphere and the radiative extinction of the SDF under microgravity conditions. The objects of research are “direct” and “inverse” SDFs of gaseous ethylene in an oxygen atmosphere with additives of inert gases (nitrogen and carbon dioxide) at room temperature and subatmospheric and atmospheric pressures. The “direct” flame is a flame formed in an oxidizing atmosphere when fuel is supplied through the porous sphere. The “inverse” flame is a flame formed in a fuel atmosphere when an oxidizing agent is fed through the porous sphere. The experimental data are used to test one-dimensional, two-dimensional, and three-dimensional physical and mathematical models of the phenomenon, including reduced and detailed kinetic mechanisms of ethylene oxidation and combustion, soot formation, transport properties in a multicomponent gas mixture, as well as convective and conductive heat transfer and heat transfer by radiation. It is expected that the project will provide new knowledge about the physics and chemistry of diffusion flames which will help in solving the problems of combustion control and reduction of harmful combustion emissions. The article presents some current experimental and theoretical results of the project.

Keywords: spaceflight experiment; microgravity; spherical diffusion flame; ethylene; numerical simulation

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Figure Captions

Figure 1 A porous sphere with a thermocouple and a gas supply tube (*a*); nonsooting diffusion flame (*b*); and sooting diffusion flame (*c*)

Figure 2 Determination of the flame radius in the experiment (by the average size of the luminous zone) (*a*) and in the calculation (by the distance to the gas temperature maximum) (*b*)

Figure 3 Computational domain (Inlet; Buffer channel; Porous sphere; Outer space; Outer wall)

Figure 4 Spatial distributions of temperature and mass fractions of ethylene, oxygen, acetylene, and soot 20 s after ignition; flame #10

Figure 5 Spatial distributions of the soot mass fraction 10 (*1*), 20 (*2*), and 30 s (*3*) after ignition

Figure 6 Comparison of predicted (curves) and measured (signs) time histories of flame radius: (*a*) flame #2; (*b*) #8; (*c*) #10; and (*d*) flame #5

Figure 7 Comparison of predicted (curves) and measured (signs) time histories of porous sphere temperature: (*a*) flame #2; (*b*) #8; (*c*) #10; and (*d*) flame #5

Figure 8 Predicted time histories of the maximum gas temperature (*a*) and cumulated soot mass fraction (*b*): *1* — flame #2; *2* — #8; *3* — #10; and *4* — flame #5

Table Caption

Experimental conditions for selected spherical diffusion flames

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