

NUMERICAL SIMULATION AND EXPERIMENTAL STUDY OF LASER IGNITION OF OXYGEN–HYDROGEN MIXTURE IN A MODEL COMBUSTION CHAMBER

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Abstract: The article considers results of a study on determining optimal areas for laser ignition of an oxygen–hydrogen fuel mixture in a model combustion chamber by focusing laser radiation to initiate an optical breakdown spark in a selected zone. The results of numerical simulation of the nonstationary process of mixing the gaseous components — oxygen and hydrogen — are presented with the determination of the parameters of the resulting mixture in the volume of the model combustion chamber carried out in the LOGOS-Prepost software package. Three zones that are most preferable for laser ignition in the chamber are selected among the zones in which focusing of radiation is possible during laser ignition. These zones are located in the regions of flow recirculation exhibiting fuel mixture compositions close to stoichiometric and low flow velocities. Preferential use of the zones for laser ignition selected by the results of the numerical simulation was confirmed by test fires.

Keywords: numerical simulation; combustion chamber; oxygen; hydrogen; laser ignition; optical breakdown

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Figure Captions

Figure 1 Model combustion chamber: 1 — mixing head; 2 — laser ignition module; 3 — unit for side mounting of ignition module on the combustion chamber; 4 — combustion chamber; 5 — nozzle; 6 — seat for axial mounting of ignition module; 7 — plug; and points Nos. 1–3 refer to the possible ignition zones. Dimensions are in millimeters

Figure 2 Mixing head of the model combustion chamber: 1 — three oxidizer supply holes; and 2 — 24 fuel supply holes

Figure 3 Calculation grid model

Figure 4 Predicted distributions of fuel mass fraction at different times: (a) 0.01 s; (b) 0.5; and (c) 1 s

Figure 5 Predicted vector field of flow velocities at different times: (a) 0.01 s; (b) 0.5; and (c) 1 s

Figure 6 Predicted time histories of the oxidizer-to-fuel ratio (a) and flow velocity (b) in ignition zones: 1–3 — points 1 to 3

Figure 7 Measured time histories of the operation parameters of the combustion chamber during the test fire with fuel feed advance: 1 — combustion chamber pressure; 2 — fuel consumption; 3 — oxidizer consumption; 4 — laser photosensor; and 5 — combustion chamber photosensor

Table Captions

Table 1 Parameters of the model combustion chamber

Table 2 Parameters of the ignition laser

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