Stratified hydrogen-air mixtures

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The study of fast combustion processes in stratified hydrogen-air mixtures is of fundamental importance for enhancing the level of industrial safety. Due to its low density, a hydrogen leak in a confined space can lead to gas stratification and the formation of a combustible mixture layer, creating a risk of fast combustion. The specific risks associated with its extremely wide flammability limits and minimal ignition energy make the development of specialized methods for preventing and suppressing fast combustion in stratified systems critically important.

The paper presents two-dimensional numerical modeling of fast combustion propagating through a layer of reactants, a layer of combustible mixture with an inhibitor additive, or a layer of combustible mixture with a diluent additive. Both a detailed kinetic mechanism and a reduced kinetic mechanism were used to simulate the combustion kinetics of hydrogen in air with an inhibitor additive. A series of cases with different concentrations of diluent and inhibitor additives were studied, which allows for evaluating the effectiveness of various passive and active measures to improve explosion safety at facilities associated with hydrogen use. The development of the mathematical models and numerical simulations were performed using the facilities of National Research Centre "Kurchatov Institute" Federal Science Centre "Scientific Research Institute for System Analysis of the Russian Academy of Sciences" on the topic No. FNEF-2024-0002 "Mathematical modeling of multi-scale dynamic processes and virtual environment systems".