Experimental and numerical study of lean flame blow-out during methane-hydrogen mixture combustion with a different hydrogen addition

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In the last decade, a method for increasing the stability of "ultra-lean" (heater air excess factor $\alpha > 2.3$) low-emission combustion based on the use of alternative fuels or on the use of initiating additives to conventional fuels has been actively studying in Russia.

Research of combustion processes and pollutant emissions in the combustion products of hydrocarbon fuels, carried out abroad and in Russia, show an improvement in combustion characteristics when using hydrogen as a fuel, and as an additive to hydrocarbon conventional fuels. Even a relatively small addition of hydrogen, which has a high burning velocity, makes it possible, on the one hand, to reduce the emission of a number of pollutants, and, on the other hand, by operating on “lean” mixtures, to ensure the efficiency and stability of the fuel combustion process.

At the same time, as is known, when using hydrogen additives in fuel, a number of problems arise, namely:

- increased heat load on the elements of the combustor of the engine;
- high probability of flashback upstream, which can lead to partial or complete destruction of the flame tube head;
- high probability of occurrence of high-amplitude pressure pulsations, which can lead to the destruction of the combustion chamber elements;
- change in the combustion chamber stable operation range along the border of lean blow-out, considering the change in the laminar flame propagation velocity.

Therefore, when developing new combustion devices, it is necessary to determine the combustion chamber stable operation range, namely, lean blow-out and the probability of flashback upstream. At the stage of combustion devices development it is advisable to use verified calculation methods in a three-dimensional formulation, using the methods of computational fluid dynamics and combustion to solve these problems.

Thus, the objective of the study in this paper is the development and verification of a methodology for determining the limits of stable combustion in the methane-hydrogen mixture combustion.

As a result of research performed, computational and experimental research were carried out to determine the lean blow-out and flashback upstream on a model combustion chamber in combustion of a methane-hydrogen mixture with a hydrogen fraction of 0..60% by volume.