Numerical and experimental study of NOx formation during hydrogen combustion in a model combustion chamber with a cluster microflame burner device

Sergey S. Matveev, Dmitry Idrisov, Nikita Gurakov, Alina Litarova, Roman Ivanov

Samara National Research University, 34, Moskovskoye shosse, Samara, Russia, 443086
matveev@ssau.ru

At present, atmospheric pollution by nitrogen oxides NOx, which are formed in the combustion chambers of gas turbine engines and power plants, is a serious environmental problem. In addition, reducing greenhouse gas emissions (or carbon footprint) to combat global climate change has become a relevant issue in recent years. And while ultra-lean premixed combustion technologies are used to address the issue of reducing nitrogen oxide emissions, fuels with lower carbon content must be used to reduce the carbon footprint. An alternative fuel that does not contain C atoms is hydrogen. The use of hydrogen as a fuel in traditional combustion chambers with burner devices providing combustion in a swirling flow is impossible due to the high probability of flame flashback upstream, as well as the occurrence of gas auto oscillations in the combustion chamber. This is due to the fact that the combustion process of hydrogen is different from that of methane due to the large difference in physical and chemical properties (calorific value, rate of chemical reactions, etc.).

Research shows that with a high hydrogen content in the fuel, a transition to a fundamentally different design of the burner device is necessary (BD). An example of such a device is the so-called cluster microflame burner. The cluster microflame BD concept is based on the integration of two key technologies: low NOx combustion and flame flashback-resistant combustion. Low NOx emissions are ensured by intensive mixing of fuel and air using a coaxial jet system. Each coaxial jet consists of a central fuel jet surrounded by an annular air stream. Immediately after the coaxial jet exits the perforated plate orifice, a high level of turbulence is generated in the jet due to abrupt expansion and interaction with adjacent jets. In this way, rapid mixing of fuel and air is ensured, which creates conditions for organizing a combustion process with low NOx content by reducing the volume of high-temperature zones.

The aim of this work is to conduct experimental studies of hydrogen combustion in a model combustion chamber with a cluster microflame BD developed at Samara University to estimate the level of nitrogen oxides emission, as well as to develop a methodology for numerical modelling of hydrogen combustion and validation of the developed mathematical model.

Acknowledgment

The study was supported by the Russian Science Foundation, projects no. 22-79-10205, (https://rscf.ru/project/22-79-10205/).