VALIDATION OF THE ATEC-HE SOFTWARE IN TERMS OF MODELING FIRE-JET AND FIREBALL

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According to the "Concept for the Development of Hydrogen Energy in the Russian Federation", one of the priority tasks for the development of hydrogen energy is the creation of low-carbon hydrogen production technologies. Taking into account the high flammability and fire and explosion hazard of hydrogen, an important aspect is to ensure safety at hydrogen energy facilities. In order to minimize the risks of emergency situations, adequately assess the severity of their consequences, optimize technological processes and conduct a deterministic analysis of the safety of hydrogen energy facilities, special software is being developed, in particular, ATEC-HE, developed on the ATEC platform [1] and intended for conservative modeling of emergency scenarios describing emissions of fire and explosion hazardous substances and their consequences at hydrogen energy facilities.

In 2018, a procedure for mandatory certification of software tools implementing computational models of processes affecting the safety of nuclear facilities was introduced [2]. Therefore, to solve problems related to the quantitative assessment of the risk of developing emergency situations, only those approaches should be used that have successfully passed the validation procedure, which consists of comparing the parameters of real experiments with the results of their mathematical modeling.

In order to confirm the possibility of using the ATEC-HE, such calculation modules as "fire-jet" and "fireball" were validated. The models were validated using experimental data published in open sources.

The engineering model "fireball" allows to estimate the areas of damage by thermal radiation from a large-scale flame, realized during combustion of a cloud of flammable gas. The model allows to calculate the diameter of the fireball, its lifetime, as well as the value of the average surface intensity, depending on the mass of the hazardous substance participating in the combustion process.

The validation of the engineering model of the fireball was carried out using experimental values of the fireball diameter and its lifetime [3].

A comparison of the calculated and experimental data showed that the average relative error in the diameter of the fireball was 13%, and its lifetime was – 14%.

The mathematical model of a fire-jet describes the thermal effect of a burning gas jet without taking into account buoyancy. The implemented model allows one to determine the visible length of the flame and calculate the mass flow rate and the time of complete outflow for an outlet of a given diameter, as well as to evaluate the fields of potential risk of thermal injury as a result of exposure to a burning jet during a given period of time.

The fire-jet model was validated based on experimental values of the visible flame length and mass flow rate for three different orifice diameters: 52.5, 20.9 and 5.08 mm. Comparison of the modeling results with the experimental data showed that the average relative deviation of the visible flame length for the orifice diameter of 52.5 mm was 3.5%, and of the mass flow rate 0.7%, for the orifice diameter of 20.9 mm 2.6% and 1% respectively [4]. For the experiments conducted with the orifice diameter of 5,08 mm, the average relative deviation of the visible flame length was 9.5%, and of the mass flow rate 18.8% [5].

The satisfactory agreement of the calculation results with the data of the corresponding experiments was shown. Based on the results of the work, verification matrices were compiled for the described models, which will be expanded with data, obtained using the VNIITF experimental base. The verification matrices will be used in the verification report of the ATEC-HE for passing the procedure of its certification.

References

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