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Effect of hydrogen addition to methane-air jet flame based on Sandia flame D

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The present study investigates the effect of hydrogen addition to methane-air jet flame based on Sandia flame D[1]. For this purpose, RANS simulations with a global four-step[2] mechanism were first compared with other simple (1-step[3], 2-step[4]) and detailed mechanisms (DRM-19[5], GRI-Mech 3.0[6]) using the standard $k - \varepsilon$ model. The accuracy of the simulations was further verified based on the LES wall-adapting local eddy-viscosity (WALE) model. The turbulence-chemistry interaction was described by the eddy dissipation concept (EDC) model, and the radiation heat transfer was considered using the P1-assumption. All simulations were carried out with OpenFOAM. Both numerical simulations, RANS and LES, were compared with available experimental data. The results show a good agreement between measurements and simulations, RANS and LES, for the selected flame using a global four-step mechanism. The simulations with 1-step and 2-step mechanisms will lead to an advancement of the hot region and additional increment of the velocity of the jet flame. In contrast, the simulations with detailed mechanisms perform relatively accurately but are more computationally expensive. After that, the analysis of the influence of different mixture $H_2 - CH_4$ proportions were carried out using the WALE model and the global four-step mechanism. The addition of hydrogen leads to the advancement of the maximum temperature position, with a higher peak temperature, and a subsequent faster decay in temperature in the case of constant air mixture proportion. Additionally, local acceleration occurred in the flame reaction zone, where the velocity was slower behind that. It implies that the addition of hydrogen to methane-air fuel promotes the earlier formation and faster dissipation of the jet flame.

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