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Well-resolved LES of flashback in a turbulent premixed hydrogen jet flame

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We investigate the boundary layer flashback process of a turbulent jet-stabilized flame operating with pure hydrogen using well-resolved LES. First, we compare our simulations against experimental data for mean flow velocities in non-reacting and reacting conditions. Next, we examine the characteristics of the steady hydrogen flames in terms of thermo-diffusive instabilities. As reported in numerous DNS studies, high laminar burning velocities and increased heat release rates are found to govern the flame.

Similar to the experiments carried out at TU Delft [1], flashback occurs in regions of low velocity at a distinct distance from the wall. We carefully repeat the flashback ramps and observe a robust flashback mechanism, which is provoked by quasi-coherent flow structures, namely low velocity streaks, in the boundary layer of the mixing tube, which are capable of transporting slow-flowing, preheated and H2-enriched fluid in the direction of the core flow. This mechanism refers to an ejection event and acts as the triggering event for flame flashback.

Additionally, we perform parametric studies to study the effect of the flashback mechanism for various wall temperatures and Lewis numbers.

[1] L. A. Altenburg, S. A. Klein, M. J. Tummers, Under review: Flame-induced pressure gradients in turbulent premixed natural gas-air and hydrogen-air jet flames, Combust. Flame. (2024)