

Laminar Burning Velocity of NH₃/NO/N₂ mixtures: an experimental and numerical study

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Ammonia (NH₃) is not only a hydrogen carrier but also promising carbon-free fuel. The understanding of its combustion kinetic is crucial, especially its interaction with key nitrogen chemistry species such as nitric oxide (NO). To improve the understanding of NH₃/NO interaction on all levels, experimental measurements were carried on NH₃/NO/N₂ mixtures to determine fundamental combustion parameters such as the laminar burning velocity and Markstein length. The experiments were conducted in a spherical combustion vessel under normal pressure and temperature for different equivalence ratio and oxidizer mixtures (%NO ranging from 40 to 70 in N₂). Experiments showcased a shifting behaviour of maximum laminar burning velocity from rich to lean mixtures with increasing %NO in the oxidizer mixture. Furthermore, the Markstein length becomes less dependent upon equivalence ratio with NO addition. After appraisal of a dozen recent mechanisms from literature, Han et al. (2021) was chosen as one best accurate kinetic model for NH₃/NO/N₂ combustion to provide kinetics analysis. The numerical simulations were conducted using the open software CANTERA to evaluate additional fundamental parameters such as the Lewis number, which details the transport mechanism of species in the flame front and the Zel'Dovich number which corresponds to the dimensionless overall activation energy. In addition, appraisal of the reaction mechanisms revealed an unusual behaviour with respect to temperature and heat release rate profiles. A 2-step variation was for first time observed. Based on the kinetics analysis, it was found that the 1st increase of temperature corresponds to the location in the flame front where major reactions lead to heat release and the 2nd one to an excess of NO undergoing conversion to N and N₂ in a reverse thermal-NO mechanism, releasing energy at a much slower rate than during the temperature increase. This reduces NO emissions even at lean conditions.

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