Sub Topic: Ammonia

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Enabling ultra-lean combustion of ammonia-hydrogen in porous media burners

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Abstract

To mitigate climate change caused by the anthropogenic release of carbon dioxide and methane in the atmosphere, many industries must transition to carbon-free renewable energy sources within the next decades. One of the possible fuels considered for this task is ammonia. It is a carbon-free fuel that can be synthesized from green hydrogen and whose combustion does not emit any greenhouse gases [1–3]. Several challenges must however be addressed before this fuel can be widely deployed in practical systems: ammonia-air flames have a significantly slower flame speed, higher ignition temperature and larger flame thickness than conventional hydrocarbon flames. Ammonia combustion can also generate significant amounts of pollutants such as nitric oxides and unburnt ammonia. Porous media have been used to address similar combustion challenges and allow the stabilization of very lean flames for applications such as gas turbines, jet engines and radiant heaters for industrial processes [4–7]. In this work, we extend previous studies [8, 9] and examine the stabilization of ammonia-hydrogen-air flame in a porous media burner, with a particular focus on lean mixtures. Flames are stabilized at the interface between two open-cell ceramic foam with different pore size [10]. Heat is recirculated by conduction and radiation in the ceramic matrix, thereby preheating the fuel and enhancing the flame consumption rate. We demonstrate experimentally that an adequately designed porous media burner can stabilize flames over a wide range of operating conditions: (1) from pure ammonia to a 40% hydrogen volume fraction; (2) very lean ($\phi = 0.5$) to rich ($\phi = 1.4$); and (3) with a turn-down ratio greater than 15:1. Power densities in excess of $90\,\mathrm{MW\,m^{-3}}$ can also be achieved. Finally we report the NO_x and unburnt ammonia emissions of this porous media burner and find that operation in the ultra-lean regime can lead to a good compromise between low NO_x and low unburnt ammonia emissions.

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