

Burning Without Carbon: The Progress, Challenges, And Future Of Hydrogen And Ammonia Combustion

P.J. Coelho

Mechanical Engineering Department
Instituto Superior Técnico, Universidade de Lisboa
Av. Rovisco Pais, 1049-001 Lisboa, Portugal

Abstract

Hydrogen and ammonia play an important role in the current shift to the combustion of cleaner fuels, mainly driven by the need to reduce carbon dioxide emissions and thereby mitigate global warming and climate change. However, burning these fuels presents significant challenges. Hydrogen has a high flame speed and diffusivity but increases the risks of auto-ignition and flashback in premixed flames and can enhance combustion instabilities and NO_x formation. In contrast, ammonia has low reactivity and a low flame speed, is difficult to ignite and stabilize, and can potentially emit significant amounts of NO_x and unburned ammonia. This lecture will review the progress achieved in understanding and controlling hydrogen and ammonia combustion, from fundamental combustion science to advanced technologies for practical combustion systems. Particular attention will be given to hydrogen–ammonia mixtures and to combustion strategies aimed at simultaneously achieving high efficiency, stable operation and low emissions. The roles of fuel composition, equivalence ratio, mixing, flame stabilization and staged combustion will be discussed. The lecture will conclude by discussing whether hydrogen and ammonia can provide not simply carbon-free combustion, but genuinely clean, efficient and reliable combustion, and by identifying the key scientific and technological challenges that will shape the future development of these fuels.