Hydrogen-enriched natural gas (HENG) in the home: The effects of hydrogen addition on the stability, performance and running cost of domestic appliances

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Abstract

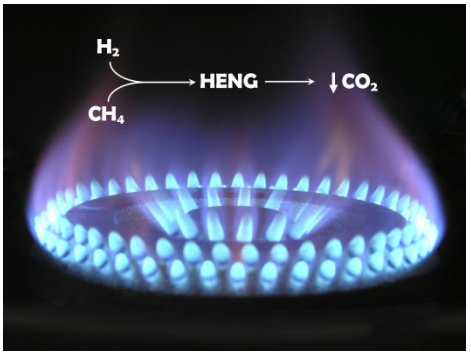
With levels of atmospheric carbon dioxide exceeding 400 ppm for the first time, it is becoming increasingly vital to implement a low-carbon strategy in all avenues of daily life. To this end, there has been significant recent interest in the domestic use of hydrogen-enriched natural gas, or "HENG", in place of the conventional natural gas currently used in businesses and homes. Due to the disparate properties of hydrogen and natural gas, however, it is not possible to incorporate too high a percentage of hydrogen into the supply without a major overhaul of existing end-use appliances; for this reason, our study explores the maximum proportion of hydrogen in HENG which may be achieved within the present-day infrastructure.

A meta-analysis of existing combustion models has been conducted to determine the maximum theoretical percentage of hydrogen in HENG that is compatible with typical contemporary natural gas appliances. The stability of a burner is tested experimentally using varying HENG composition and air-to-fuel ratio, in addition to changing the diameter of the burner ports.

A theoretical maximum of approximately 35 mol% was predicted for the proportion of hydrogen in HENG; above this value, flash-back was expected to occur during extinction of the flame. Flame stability was demonstrated experimentally for hydrogen percentages approaching this predicted limit, even in the case of atypically large port diameters of more than 2 mm.

Having verified the limits of HENG composition to ensure safe, effective and reliable appliance operation, the possibility of a real-world adoption of HENG in place of natural gas has been demonstrated. The benefits of such a changeover are expected to be significant; supplying houses with HENG fuel containing 30 mol% hydrogen, for instance, would decrease household carbon dioxide emissions by an estimated 11-18 %.

Image



Recent Publications

1. Jones DR, Al-Masry WA, Dunnill CW (2018) Hydrogen-enriched natural gas as a domestic fuel: An analysis based on flash-back and blow-off limits for domestic natural gas appliances within the UK. Sustainable Energy & Fuels, *submitted.*
2. De Vries H, Mokhov AV, Levinsky HB (2017) The impact of natural gas/hydrogen mixtures on the performance of end-use equipment: Interchangeability analysis for domestic appliances. Applied Energy 208:1007-1019.
3. Dodds PE, McDowall W (2013) The future of the UK gas network. Energy Policy 60:305-316.
4. Linan A, Vera M, Sanchez AL (2015) Ignition, liftoff, and extinction of gaseous diffusion flames. Annual Review of Fluid Mechanics 47:293-314.
5. Kalantari A, McDonell V (2017) Boundary layer flashback of non-swirling premixed flames: Mechanisms, fundamental research, and recent advances. Progress in Energy and Combustion Science 61:249-292.
6. Okafor EC, Hayakawa A, Nagano Y, Kitagawa T (2014) Effects of hydrogen concentration on premixed laminar flames of hydrogen-methane-air. International Journal of Hydrogen Energy 39:2409-2417.



Biography

Daniel Raymond Jones carries out research into the production and end-use of hydrogen, with a present focus on the combustion dynamics of hydrogen-enriched natural gas mixtures and their implications regarding real-world burner appliances. His other research concerns the synthesis of hydrogen through photocatalytic water-splitting within an aqueous nanocomposite suspension, in addition to the use of nano-sized composites to photocatalyse the degradation of dye pollutants in water. Other expertise include the phenomenological modeling of gas reactions, and he has previously developed a technique for the estimation of the activation energies of gas reactions at a semiconductor surface based on the electrical response as a function of temperature and gas concentration.

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