

1C08: A NEW TYPE OF STEADY AND STABLE, LAMINAR, PREMIXED FLAME IN ULTRA-LEAN, HYDROGEN-AIR COMBUSTION.

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Comment by Hai Wang, University of Southern California, USA

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Concerning water destruction in flames, the reaction responsible for this phenomenon must be $\text{H}_2\text{O} + \text{H} \rightarrow \text{H}_2 + \text{OH}$. For this reaction to occur, the H atom must be in super-equilibrium. What is the driving force for this super-equilibrium?

Reply by Joseph Grcar

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The query is mistaken because the reaction path analysis in the paper identifies the water destruction as coming from a different reaction, namely $\text{O} + \text{H}_2\text{O} \leftrightarrow 2 \text{OH}$. The paper does not include a reaction path analysis for the exchange of oxygen atoms among the various species, so what accounts for the super-equilibrium of O atoms is unclear at this time. By the way, the reaction mentioned in the query, $\text{OH} + \text{H}_2 \leftrightarrow \text{H} + \text{H}_2\text{O}$, is identified in the paper as the major reaction that consumes the fuel and creates the final product.

The query certainly indicates there are some interesting issues to examine here. I would be happy to collaborate in further examining the simulation results to resolve these questions.

Comment by Suresh Aggarwal, University of Illinois at Chicago, USA

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Your paper is very interesting and of value to combustion community. It also has important implications for using hydrogen to enhance the lean flammability limits of hydrocarbon fuels. Perhaps you can refer to this aspect in the paper. We have recently published [1] showing that the lean flammability limit of propagating stretched methane flames is significantly enhanced by the addition of hydrogen.

Reference:

[1] A.M. Briones, S.K. Aggarwal, V.R. Katta, *Combust Flame* 153 (2008) 367–383.

Reply by Joseph Grcar

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I am aware that hydrogen can be used as an additive to enhance the burning of hydrocarbon fuels at their lean limit. In fact, I mention this application [1] and for further information cite R.W. Shefer et al. [2]. My paper dealt exclusively with premixed hydrogen flames, and the paper by Briones et al. discusses non-premixed methane-air

triple flames with hydrogen addition. Addressed by neither of our papers is the premixed hydrocarbon case with hydrogen addition. Markstein, in his 1964 book, comments that the addition hydrogen makes any lean flame thermo-diffusively unstable. It would be interesting to see whether those flames exhibit the very large cellular structures that I found. I would be happy to discuss the possibility of collaborating with the commenter on examining this question.

References:

- [1] Joseph F. Grcar, John B. Bell, Marcus S. Day, Paper 2B13, *Proc. Combust. Inst.* 32 (2008) in print.
- [2] R.W. Shefer, et al., *Int. J. Hydrogen Energy* 28 (2003) 1131–1141.