Laminar flame speed of a methane-hydrogen-air mixture

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1 Introduction

Laminar flame speed is the speed at which an un-stretched laminar flame will propagate through a quiescent mixture of unburned reactants. Laminar flame speed is given the symbol sL. Laminar flame speed is a property of the mixture (fuel structure, stoichiometry) and thermodynamic conditions upon mixture ignition. The following report contains computer calculations based on Python (Cantera) which count the changes of laminar flame speed base on a function of equivalence ratio and comparison of those results with the experimental data. The computer calculation are based on three different fuels (represented by methane and hydrogen): pure methane, mixture of methan-hydrogen (50/50) and pure hydrogen. Equivalence ratio determines the percentage content of air in the mixture.

2 Mathematic model

$$S_L = S_{L,\mathrm{ref}}\left(\frac{T_u}{T_{u,\mathrm{ref}}}\right)^{\gamma}\left(\frac{P}{P_{\mathrm{ref}}}\right)^{\beta}(1 - 2.1Y_{\mathrm{dil}}) \quad (6.33)$$

for $T_u \geq 350$ K. $T_{u,\mathrm{ref}} = 298$ K, and $P_{\mathrm{ref}} = 1$ atm.

$$S_{L,\mathrm{ref}} = B_M + B_2(\Phi - \Phi_M)^2$$

$$\gamma = 2.18 - 0.8(\Phi - 1)$$

$$\beta = -0.16 + 0.22(\Phi - 1)$$

Figure 1: Mathematical model of the laminar flame from source [2]

There is a big variety of different experimental formulas. The one shown above is valid for various substance after using a proper coefficients.

3 Results

Program returns diagrams of laminar flame speed in three different fuel mixtures of methane-hydrogen in function of equivalence ratio and other data like temperature, pressure in CSV format.

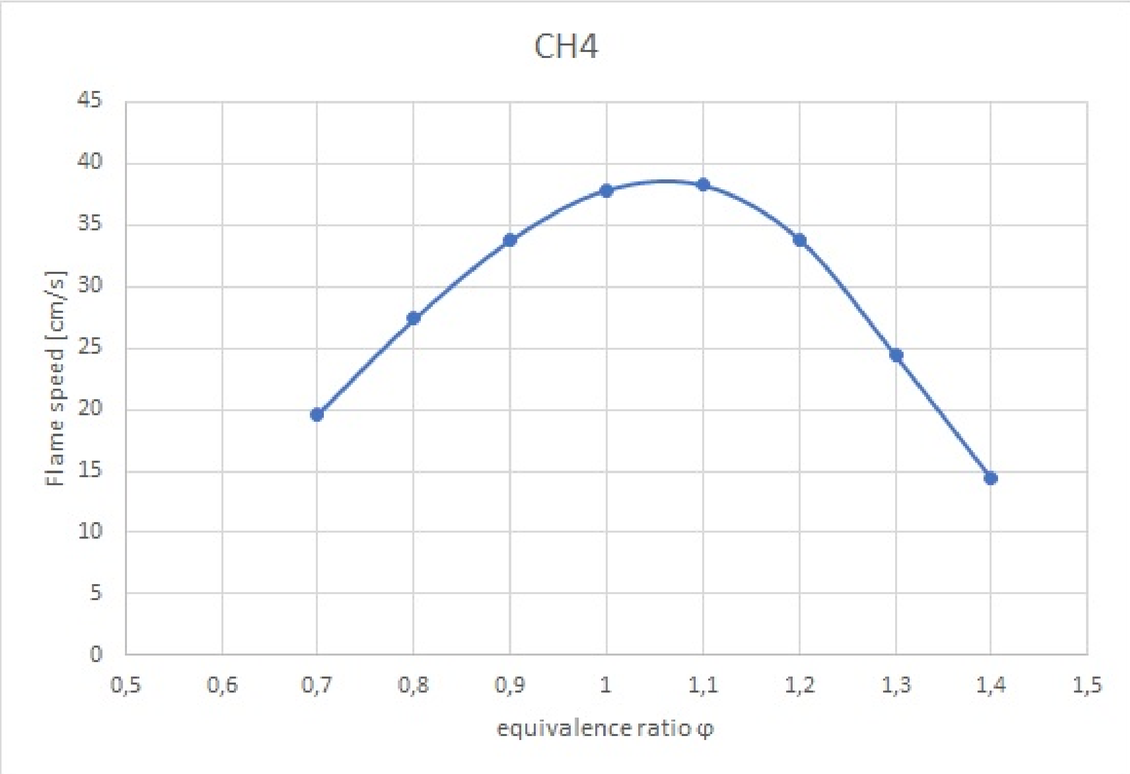

Figure 2: Flame speed of pure methane.

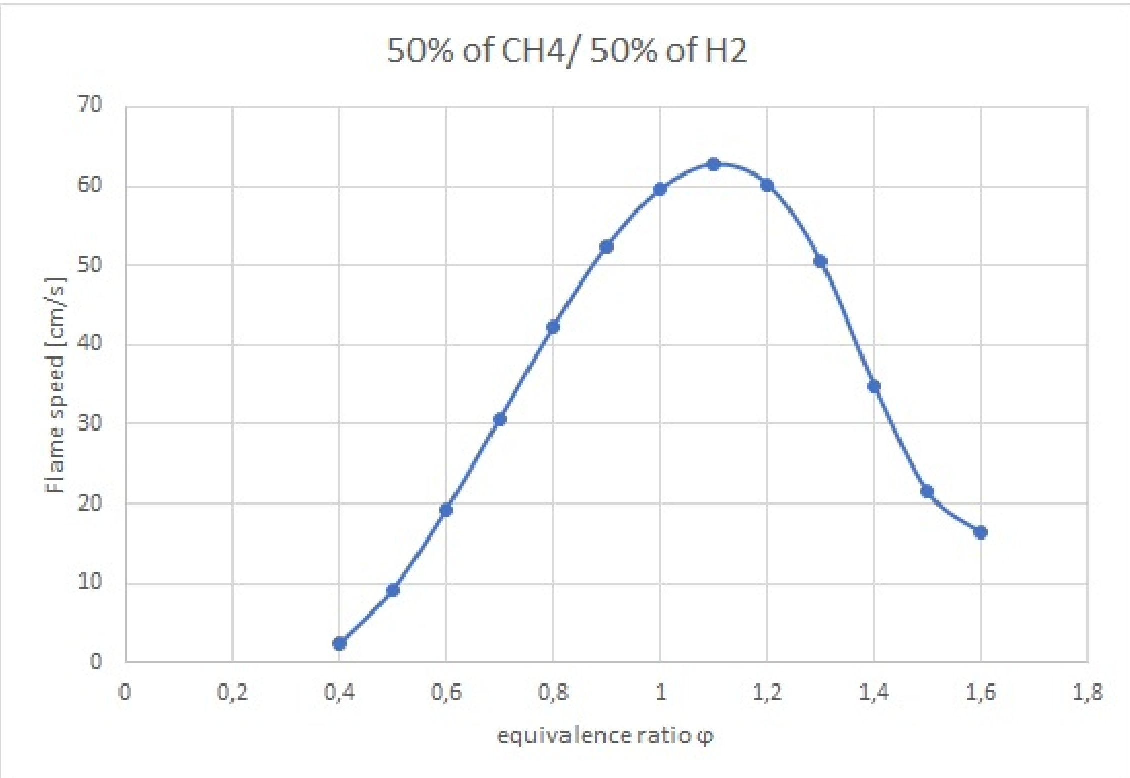

Figure 3: Flame speed of mixture methane-hydrogen with half content of each.

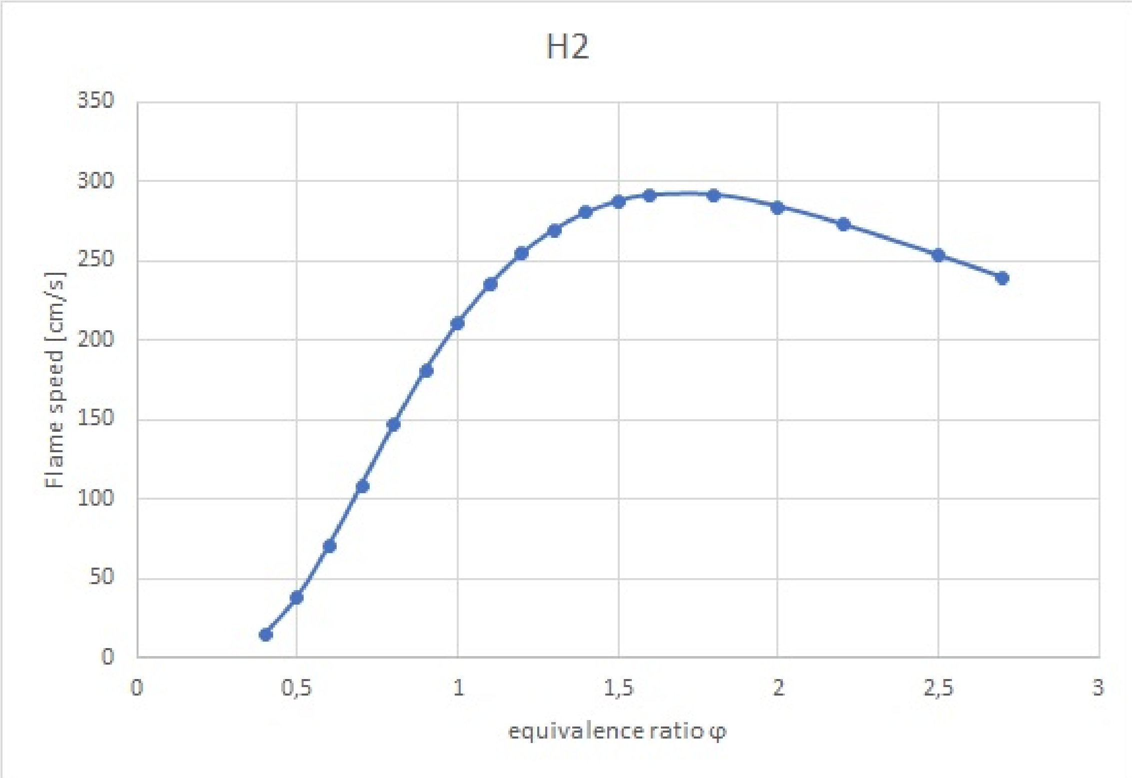

Figure 4: Flame speed of pure hydrogen.

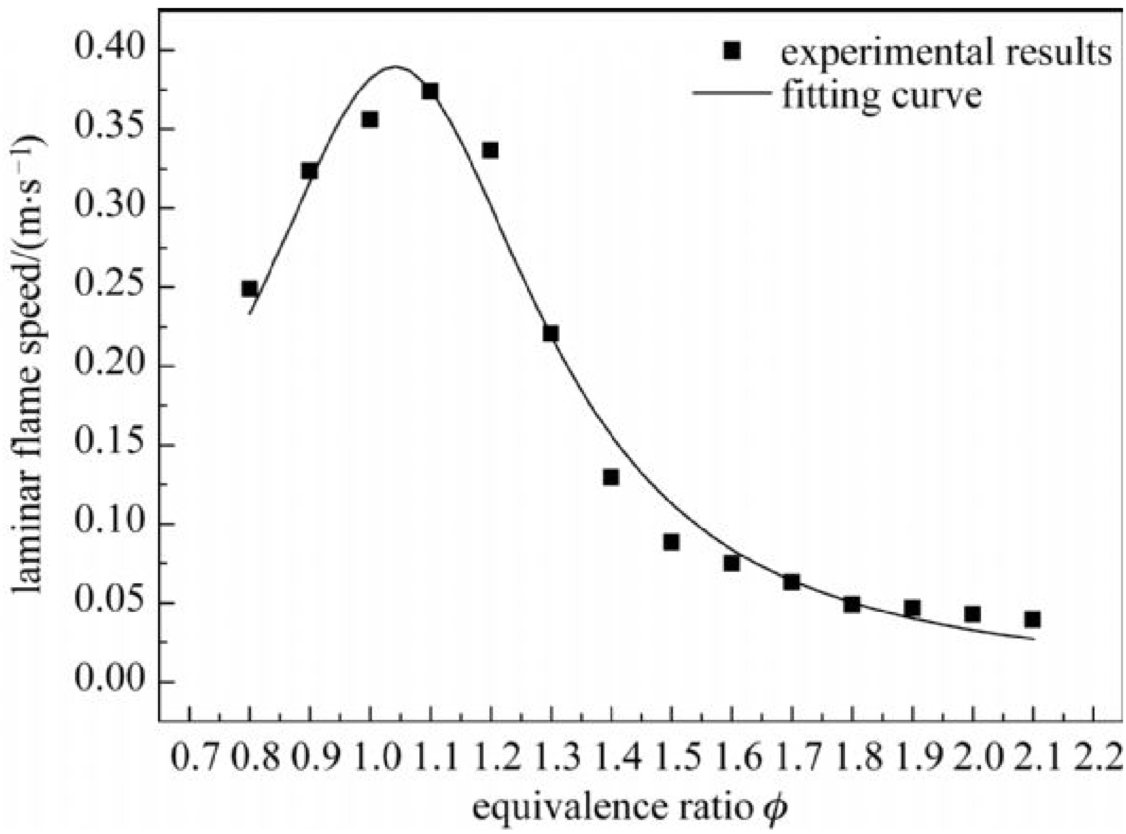

Figure 5: Experimental flame speed of pure methane

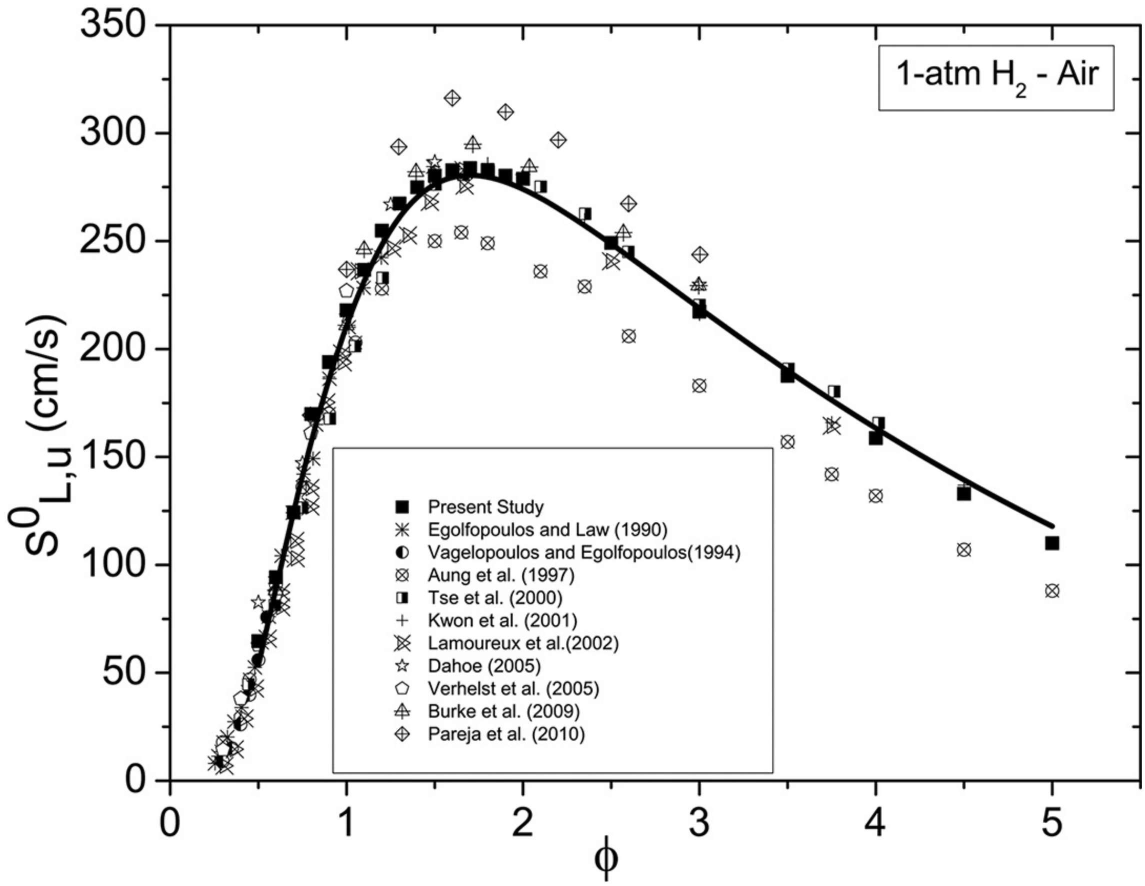

Figure 6: Experimental flame speed of pure hydrogen.

4 Conclusions

Results from calculations for different fuels are very similar to experimental results. Differences can be caused by non-ideal representation of the mixture and assumptions of mathematical model. Diagrams perfectly present the influence of the amount of air in mixture for each fuel. Each fuel specifications are the reason for differences beetwen both flame speed and characteristic equivalence ratio for specific combustion speed.

5 References

$http://en.wikipedia.org/wiki/laminarflamespeed$[1]

$http://arrow.utias.utoronto.ca/ogulder/ClassNotes6.pdf$[2]