COMBUSTION SCIENCE AND TECHNOLOGY
2018, VOL. 190, NO. 1, 186–188
https://doi.org/10.1080/00102202.2017.1379513

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SHORT COMMUNICATION

Comment on "Experimental Studies of Magnetic Effect on Methane Laminar Combustion Characteristics"

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ARTICLE HISTORY 9 January 2017; accepted 11 September 2017

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The article by Wu et al. (2016), published recently, reports interesting results on the influence of magnetic fields on various characteristics of laminar diffusion flames of methane on a co-annular burner. The experimental results reported show that, with the increasing magnetic field, the flame dimensionless length decreases while the dimensionless width and flame temperatures increase. Further, thermal NO_x production in the flame was reduced substantially as a result of the influence of the gradient magnetic field.

While there is no doubt about the influence of magnetic field on several measurands, some of the experimental data on the reference flame, i.e., methane flame in the absence of the gradient magnetic field, do not make sense. It is well established that in laminar diffusion flames, the flame height is proportional to the fuel flow rate, as documented, theoretically and experimentally, by Roper (1977) and Roper et al. (1977) among others. Roper's flame height expression for a laminar diffusion flame on co-flow circular burner is given as (Roper et al. 1977):

$$L_{\mathrm{f}} = 1300 \frac{Q_f (T_\infty / T_{\mathrm{F}})}{\ln(1 + 1/S)}$$

where Q_f is the volume flow rate of the fuel; T_∞ and T_{F} are air and fuel temperatures, respectively; and S is the stoichiometric air-fuel mole ratio, where quantities are evaluated in SI base units (m, K, m^3/s). For the methane flow rate of 2.5 L/h, Figure 3 in Wu et al. (2016) displays a flame height of about 64 mm for the case of no magnetic field. With the same flow rate of 2.5 L/h, which is about 6.94×10^{-7} m^3/s, and equivalent fuel and air temperatures, Roper's correlation (Roper et al., 1977) yields a flame height of about 9 mm. In our previous experiments with methane diffusion flames with slightly higher fuel flow rates of 3 L/h, measured flame heights were about 10 mm (see, e.g., Charest et al. 2014; Daca and Gülder, 2017) agreeing with Roper's equations. Further, in the methane diffusion flame experiments of McEnally and Pfefferle (1998), the methane flow rate was 240 cm^3/min (14.4 L/h) and their flame height was measured at about 50 mm. To get a methane flame height of 64 mm, as claimed by Wu et al. (2016), the fuel flow rate should be about 17–18 L/h; the stated 2.5 L/h methane flow rate would not yield a flame with a 64-mm length.

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Another surprising aspect of the results is the temperature profiles presented in the article of Wu et al. (2016). The centerline temperature measurements with fine thermocouples reported in the article show very large discrepancies when compared to the published measurements in the literature. The general centerline temperature profile trends depicted in Figure 5 of the Wu et al. (2016) article are not in agreement, even qualitatively, with temperature profiles measured or simulated in similar diffusion flames (see, e.g., Charest et al. 2011; McEnally and Pfefferle, 1998; Smooke et al., 1999; Sun et al., 2017). The centerline temperature data, shown in Figure 5a in the Wu et al. (2016) article in the absence of magnetic field, are replotted in Figure 1 along with the centerline methane flame temperature data from McEnally and Pfefferle (1998). It is difficult to justify the apparent discrepancy in temperature profiles from the two different laboratories. The centerline temperature starting at about 1400 K at the burner exit in the Wu et al. (2016) data and decreasing with axial height is not physically possible in laminar diffusion flames under stated conditions.

When the metering of the fuel flow rate and measurement of the flame temperatures for the reference flame condition are problematic, it would be challenging to assess the validity of the conclusions reached in the article. It is difficult to figure out the reasons for the noted discrepancies; it is hoped, however, that this comment will be useful to the potential users of results presented, and may provide some guidance to the authors of the subject article by Wu et al. (2016) in checking their experimental records.

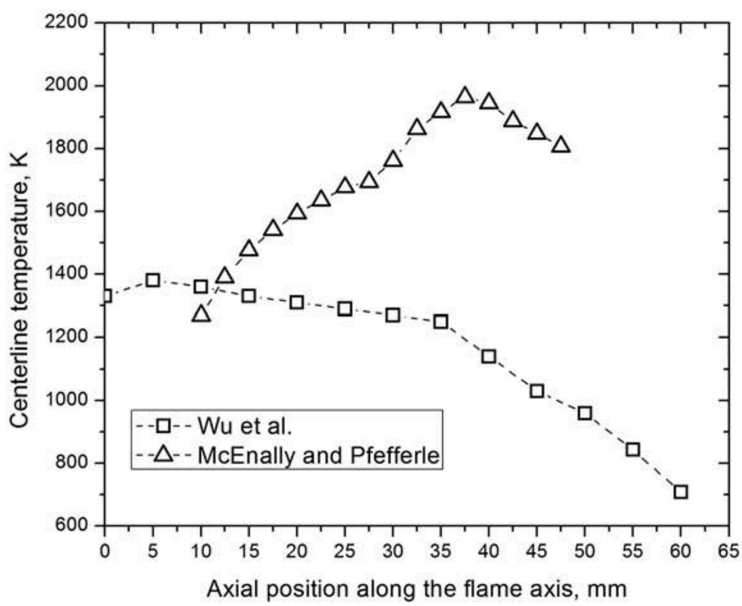

Figure 1. Comparison of the centerline temperatures in methane diffusion flames reported by Wu et al. (2016) to measurements of McEnally and Pfefferle (1998). Data points were extracted by a graph digitization software (ScanIt v.2.03.0) from the plots in the respective articles.

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