

5A05: MEASUREMENTS OF THREE-DIMENSIONAL MEAN FLAME SURFACE AREA RATIO IN TURBULENT PREMIXED BUNSEN FLAMES.

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Comment by Matthew Dunn, The University of Sydney, Australia

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You have examined a wide range of turbulence and chemistry time scales in your experiments which is an ideal way to study the effects of flame surface area parametrically. The flame surface area data you present is based on the $C = 0.5$ iso-surface. Have you found any dependence on the level of the C iso-surface selected; or for that matter have you found a significant difference between the conditional mean and the unconditional mean flame surface density for the high turbulence intensity flames?

Reply by Yung-Cheng Chen

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I haven't examined the flame surface area ratio, AT/AL , evaluated with a different progress variable value other than 0.5. So it is hard to say exactly how much difference there is if I choose a different C iso-surface. But, I would say the difference is very small. This is indirectly supported by the insensitivity of the mean flame surface density distributions across the flame brush on the progress variable value for the Sydney Bunsen flames, as shown in Fig 23 of [18] cited by the paper. This is the conditional mean. For the unconditional mean, substantial differences may exist if a progress variable value smaller than 0.2 or greater than 0.8 is chosen (Fig 22 of [18]).

Comment by Hemanth Kolla, Cambridge University

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Your presentation on measurements of three-dimensional mean flame surface area ratio in turbulent Bunsen flames was very interesting. These measurements are a reliable way to test Damköhler's hypothesis of $ST/SL = AT/AL$. However, this scaling argument forms only one part of Damköhler's hypothesis which is valid for moderate turbulence intensities (wrinkled or corrugated flamelets regimes). At high turbulence intensities, when say one is in the notional thin reaction zones regime, Damköhler's hypothesis gives the scaling $ST/SL = DT/DL$, where DT is the turbulent diffusivity and DL is the laminar diffusivity [1]. It is hence probably not surprising that the values of AT/AL you measured fall much below the values of ST/SL given by the expressions of Peters or Zimont.

Reference:

[1] Peters, *Journal of Fluid Mechanics* 384, 107–132.

Reply by Yung-Cheng Chen

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It is certainly true what you have described the two different limits of Damköhler's hypothesis and that the relationship of $ST/SL = AT/AL$ is only postulated at the large-scale limit. The point here, however, is not to make serious assessment of this hypothesis but to check how far apart or how close the realistic AT/AL value is from or to the prediction of ST/SL based on the commonly used model equations for the flame conditions investigated in this work. If we put aside the notion of regime diagrams, the comparison is only reasonable at relatively low u'/SL and poor at high u'/SL values (see Fig. 7 in paper). The reason could be two-fold and the answer I think is still open. The first one as you mentioned here is due to the invalidity of $ST/SL = AT/AL$. But it would imply that it is valid only at very low turbulence levels. The other possible explanation as I have mentioned in my presentation is related to the accuracy of ST , in particular, to its definition. My recent experiment [1] shows that if the relationship of $ST/SL = AT/AL$ is anywhere near accuracy, ST has to be the turbulent consumption speed, rather than the turbulent displacement speed.

Reference:

[1] Y.-C. Chen, M. Kim, J. Han, S. Yun, Y. Yoon, *Combust. Flame*, 154(3), (2008) 434–447.

Comment by Andrei Lipatnikov, Chalmers University of Technology, Sweden
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The Zimont expression for the turbulent burning velocity you tested involves a constant $A = 0.5$ on the rhs (Eq. 33 in [1]). Did you use this constant in your calculations?

Reference:

[1] V.L. Zimont, F. Biagioli, *Combustion Theory and Modelling* 6 (2002) 79–101.

Reply by Yung-Cheng Chen
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I have used a constant $A = 1$ in the Zimont expression for the turbulent burning velocity when plotting Fig. 7 in the paper. If as suggested A should be 0.5 instead, the values of ST/SL based on the Zimont model would be reduced by half. This will bring the predicted ST/SL trend much closer to that of the measured AT/AL trend. Hence, it implies that the prediction of AT/AL using Eq. (5) in the paper compares much better with the Zimont model than with the Peters model. This however will not change the other conclusions of this work.