Table 1 Fuel and radiation data from Naegeli et al.[2]

Fuel No.	%H	%PA	Radiation, kW/m^2
1	13.5	1.39	160
3	13.5	9.75	170
4	12.5	1.48	185
5	12.5	10.96	205
7	12.5	20.52	225
8	11.5	1.57	220
9	11.5	11.72	240
10	11.5	21.28	255
11	11.5	31.21	260

Table 2 Predicted radiation fluxes for three fuels

Fuel	%H	%PA	Parameter 1 (linear) predicted flux	Parameter 2 (nonlinear)
A	11.5	0.5	220	205
B	11.5	11.7	240	240
C	11.5	50.0	305	265

and the nonlinear fitting parameters, for operating conditions matching those pertaining to the data in Table 1. Table 2 and Figs. 1 and 2 show that though the two fitting parameters predict nearly the same radiation fluxes for values of polycyclic aromaticity between 1.5% and 30%, they differ in their radiation flux predictions for fuels of very low or very high aromaticity. For both extremes, the nonlinear fitting parameter predicts radiation fluxes which are significantly lower than the radiation fluxes predicted by the linear fitting parameter.

To date, radiation flux data for petroleum-derived fuels of either very low or very high polycyclic aromatic content are virtually nonexistent in the literature. Clark[1] reported that JP-10, with a polycyclic aromaticity of only 0.04%, produced radiation fluxes which were considerably below the fluxes predicted by the linear fitting parameter but were in agreement with the nonlinear parameter predictions. Further evidence that gas turbine combustion radiation fluxes show a nonlinear dependence on polycyclic aromaticity may allow greater flexibility in the property specifications for combustor fuels. For example, instead of limiting fuel hydrogen to a minimum of 12% and polycyclic aromaticity to a maximum of 3%, a future fuel specification might recognize that a fuel with a hydrogen content of 11.5% and a polycyclic aromatic content of 0.5% can be burned without increasing the combustor radiation level.

It is important to state that this Note does not advocate either of the two correlating parameters for flame radiation; it simply points out that both parameters are equally excellent for predicting radiation fluxes. Furthermore, the mathematical complexity of the two parameters is identical, in that each parameter involves a single optimized constant. In other words, the fact that the nonlinear parameter yields correlation coefficients which are as good as those for the linear parameter is not due to a larger number of fitting constants in the nonlinear parameter.

A second remark is that this Note does not recommend the complete removal of aromatics from jet fuels as a means of reducing flame radiation fluxes. Some aromatics are necessary to prevent elastomer shrinkage in fuel systems; thus, it is unrealistic to speculate that future fuels will not contain aromatics. However, the possibility that future fuels might be refined to low levels of both hydrogen and aromaticity is a subject of continuing debate.[4] A significant reduction in flame radiation brought about by lowering the polycyclic aromaticity below 1% may be the incentive needed by fuel refiners to find low-cost methods for producing such fuels.

Conclusion

Radiation flux data from a recent paper by Naegeli et al.[2] have been shown to be excellently correlated with two distinct fitting parameters which involve fuel hydrogen and fuel aromaticity. One of the parameters is linearly dependent on polycyclic aromaticity while the second parameter has a nonlinear dependence. More radiation flux data from fuels whose polycyclic aromaticity is either very low or very high are needed to determine which fitting parameter is more correct.

References

[1] Clark, J. A., "Fuel Property Effects on Radiation Intensities in a Gas Turbine Combustor," *AIAA Journal,* Vol. 20, Feb., 1982, pp. 274-281.

[2] Naegeli, D. W., Dodge, L. G., and Moses, C. A., "Sooting Tendency of Polycyclic Aromatics in a Research Combustor," *Journal of Energy,* Vol. 7, No. 2, March-April 1982, pp. 168-175.

[3] Naegeli, D. W. and Moses, C. A., "Effect of Fuel Molecular Structure on Soot Formation in Gas Turbine Engines," ASME Paper 80-GT-62, 1980.

[4] NASA Lewis Jet Aircraft Fuels Symposium, Cleveland, Ohio, Nov. 1983.

Errata: "A Low Mach Number Euler Formulation and Application to Time-Iterative LBI Schemes"

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DURING the preparation of the manuscript, the term $\rho^{-1} U \nabla \cdot \rho U$ was inadvertently omitted from the left-hand side of Eqs. (4) and (9) and should be included in these equations. This term was correctly included in the analysis and calculations reported in the paper.

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