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Kinetic and Material Property Effects on Fingering Instability in Counterflow Smoldering Combustion

Ekeoma Rowland Ijioma[1,2]

[1] *Meiji Institute for Advanced Study of Mathematical Sciences, Japan,*
[2] *Graduate School of Advanced Study of Mathematical Sciences, Meiji University.*
erijioma@meiji.ac.jp

Based on a one-temperature combustion model (see Eqs. (1)–(3)) derived through periodic homogenization, we investigate numerically the consequence of kinetic and material property effects on the structure of counterflow smoldering combustion waves. The combustion waves are unstable and resemble finger patterns which describe the overlapping of burned (in dark shade) part of a material with the unburned (in light shade) part. In [1], it is known experimentally that the instability results from diffusion instability of oxygen deficiency. In this presentation, we extend the investigation detailed in [2] by focusing on the tip-splitting regime of the fingering instability, in which we show the dependence of the finger width on the ability of the front to release heat. We also see that in a relatively low blowing rate, the porosity of the system can be controlled in order to suppress the tip-splitting of the fingers.

$$\frac{\partial T}{\partial t} - \nabla^2 T + \phi \Lambda Pe \cdot \nabla T = ANCe^{N(1-1/T)}, \tag{1}$$

$$\phi \frac{\partial C}{\partial t} - \frac{1}{Le}\nabla^2 C + \phi Pe \cdot \nabla C = -ANCe^{N(1-1/T)}, \tag{2}$$

$$\frac{\partial R}{\partial t} = H_R ANCe^{N(1-1/T)}. \tag{3}$$

Eqs. (1)–(3) is in non-dimensionalized form. The main variables and parameters in the system are described as follows: T is the temperature of the gas-solid reactant, C is the oxygen concentration, R is the concentration of the consumed material (in most cases referred to as the conversion depth). Pe is the Péclet number that measures the strength of advection relative to molecular diffusion, and Le is the Lewis number which gives the ratio of heat transport to mass transport. A is the pre-exponential kinetic factor in the reaction term, and ϕ is the porosity of the system which is a measure of the pore volume fraction in the porous material.

References

[1] O. Zik and E. Moses *Fingering instability in combustion: an extended view*, Phys. Rev. E: Stat. Nonlin. Soft Matt. Phys. *60* pp. 518-531 (1999).

[2] E. R. Ijioma, A. Muntean and T. Ogawa, *Pattern formation in reverse smouldering combustion: a homogenisation approach*, Combust. Theory Model **17**, 2, pp. 185-223 (2013).