Percolation model of combustion

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We consider how combustion processes in inhomogeneous media gain inhomogeneity because of exponential dependencies in equations. Amplification of local fluctuations takes place during the starting stage of combustion cycle in ICE after fuel injection.

In ideal conditions reaction rate depends on molecular concentration and some factor k as $-da_1/dt = -da_2/dt = ka_1a_2$. Here k depends on temperature as $k = k_0 \exp(-ER^{-1}T^{-1})$ and apparently this coefficient has a remarkable variation range. Let consider typical activation energy E be equal to $40 kal \cdot mol^{-1}$ and the universal gas constant R be equal to $1.99 \cdot 10^{-3} kcal \cdot mol^{-1} \cdot K^{-1}$. Then here we observe $k(500K^o) = 10^{-17.4}$ and $k(1000K^o) = 10^{-8.7}$. So if temperature T increases 2 times the coefficient $k(T)$ will increase billion times! [1]

Molecular concentrations a_1, a_2, T and other magnitudes are statistically distributed in real life. Also T has feedback coupling with local energy output. Therefore, values form random fields in a combustion gap. Stochastical behavior leads to dramatic intensification of combustion processes in some rare but meaningful areas. And one can investigate intermittent random fields using statistical moments using follow rule: if M_k increases as k increases this will point out irrelevancy of averaging approaches. For instance, a fuel spray notably clear demonstrates intermittent properties because it definitely encapsulates pure fuel droplets and areas of irregularly saturated vapor. There exists a set of small areas giving a boost to local burning process. These areas configure clusters with very irregular structure and could be described by fractal dimension D. So in some cases inflaming frontier should pass a very long path in between different areas with very different properties.

Computer simulation shows that flame propagation time from one point to another one depends on the shortest path length between two points. We show that this length significantly increases at the percolation threshold. So lengths of paths could explain an ignition timeout and its statistical properties. Also in some cases path does not exist between two points. This means that some areas are inaccessible by the flame. So completeness of combustion is attributable to a balance of accessible and inaccessible areas in a percolation system. We performed 3D computer simulation and theoretical researches in order to find out other properties and features of clusters and surfaces important for combustion theory.

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