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Opinion

To Pressure Gradient Minimization Principle (PGMP) in Combustion of Porous Media. Fibrillar Model Application

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Opinion

There is the well-known Quasiisobaric Approximation (QA) [1] widely used both in combustion theory and, in particular, at numerical calculations [2], of multi-component gas flows during heterogeneous combustion. Nevertheless, arguments underlying the above said QA are not always obvious and have not yet been directly formulated [1]. Therefore, each time of the QA usage one have to check carefully whether all the conditions of QA approximation are met and whether there are no parameters beyond the scope of QA. I'm going to discuss here the relation between PGMP and QA in much more details than it has been done in [1]. In my opinion, PGMP as a research tool may have just two alternative options: i) be completely and everywhere (in/on a reacting sample, etc.) equivalent to QA, and ii) be equivalent to QA only partially and quite locally depending on the kinetics under consideration, liquid phases generated by reactions and their dynamic behavior in porous combusted products (if any), IC, BC, etc. For example, option i) may be illustrated by the simplest reversible single stage combustion reactions of type: $C + O_2 \leftrightarrow A + CO + C_{O2}$ (1), where C is cellulose in a form of known tissues (Table 1), A is residual solid ash, and the last 2 terms in eq.1 represent gas of carbon oxides. Vice versa, irreversible single stage combustion synthesis of TiC [3-6] has illustrated option ii): $Ti + C \rightarrow TiC$ considered earlier [6] (see eq.1, Table 1). Paper [3] represents an example of the PGMP first application. From the point of wave physics, PGMP means that small pressure disturbances propagate at a velocity of sound that exceeds the all other speeds recorded during combustion and related to the above mentioned waves, such as: the combustion front speed (us) the and the speed of inflow and outflow gases u_g (see relation (1), Table 1). Due to the fast moving acoustic perturbations, pressure gradients created locally at hot points and areas of high temperature heterogeneous reactions hot points and areas of exothermic reactions tend to decrease pressure in them as well as the pressure gradients on the points and areas boundaries because of the samples and boundaries interior open porosity (the simplest case considered). Otherwise, with no open pores in the interior and on boundaries, pressure gradients are supported for a long time on the points and areas filled by liquid phases and the additional analysis of moving phases should be done.

Let's consider viscose, cotton and a capacitor paper as sample of combustible medium. Viscose is an artificial fiber made of natural cellulose (wood, including hardwood), similar in properties to cotton. Let's consider peculiarities of the above mentioned PGMP and QA in the case of these fibers combustion, as well as the difference between SHS and combustion of tissues. In contrast to QA, a nonzero (but minimizing the action, or least action principle, LAP, [5]) pressure gradients may be formed in areas of SHS samples filled by melting intermediate SHS products/ As the result, one has to conclude that the points and areas of melted phases stagnate! the points and areas of melted phases stand support locally nonzero pressure gradients on themselves all the time of combustion

In accordance to fiber density [4]: $\rho = \rho_f(1 - \mu) + \mu\rho_p \le \rho_f$, i.e., i.e., the following estimate holds during combustion under fibrillation model: $.\rho/\rho_f < 1$, (1) where μ is a fiber porosity, ρ_f is fibrills density. Thus, fiber density ρ is always lower than the density of the solid fibrills from which it is woven.

Table 1: Combustion and sound velocity of natural tissues.

№, Combustion Velocity us [m/s] (Conditions)	Tissue	Sound Velocity[m/s]
1	deciduous viscose	182
2	viscose from spruce	125.4
3;0.005-0.01(in rolls)	Capacitor paper	200
40. 006-0.008 (humidity<10%)	Cardicel supercord (needles) (Sweden)	175
0.008-0.02	Cotton(untreated and pure)	from 24 up to 60

In agreement with the mass flux conservation: $u_g = u_s \cdot \rho_s/\rho_g \le 1[m/s]$ [2] and gas flow velocity is always less than or equal to the speed of sound (see Table 1 and estimates [1,2]).

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