MATHEMATICAL MODELING OF THE COMBUSTION WAVE IN THE SHS

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Currently, uranium dioxide is used as fuel for nuclear reactors. This compound has a low coefficient of thermal conductivity, which negatively affects its strength.

One of the ways to solve this problem is the use of dispersive nuclear fuel. Typically, dispersion fuels are manufactured using traditional powder metallurgy methods, but they have several disadvantages. These deficiencies deprived of the SHS method.

In the process of SHS, there are complex dependencies of phase formation on the temperature of the reaction, therefore, in order to predict the properties of the synthesized materials, it is necessary to build a mathematical model of the course of SHS.

Since SHS processes are associated with heat conduction, then the heat conduction equation can be used to describe the system.

The burning wave will propagate from the top of the sample to its bottom. It is seen from the experiments that the propagation of the combustion wave occurs at almost constant speed, therefore, to simplify the function of thermal sources, we take the velocity of its propagation constant. We also assume that chemical reactions occur instantaneously, this gives us the right to talk about the heat source as a point source of heat moving at a constant speed.

Let us assume that SHS occurs in vacuum, therefore heat transfer from the sample borders is possible only with the help of radiation, and the lower end of the sample is thermally insulated. Assume that the sample is uniformly heated at the initial time.

The heat equation with boundary and initial conditions will take the form:

$$\frac{\partial u}{\partial t}-\alpha^2\cdot\frac{\partial^2 u}{\partial z^2}=\frac{\delta(z)}{c};\ \lambda\cdot\left.\frac{\partial u}{\partial z}\right|_{z=H/2}=\varepsilon\cdot\sigma_B\cdot\left(u^4-u_c^4\right);\ \lambda\cdot\left.\frac{\partial u}{\partial z}\right|_{z=-H/2}=0;$$

$$\left.u\right|_{t=0}=u_0;\ \delta(z)=\begin{cases}Q, & z=H/2-v\cdot t;\\ 0, & z\neq H/2-v\cdot t;\end{cases} z\in\left[-H/2;H/2\right],$$

where λ is the coefficient of thermal conductivity;

u_c is the ambient temperature;

ε is the degree of blackness of the body;

σ_B – Stefan-Boltzmann constant;

$u = u(z,t)$ – function of temperature;

u_0 – initial body temperature;

α – thermal diffusivity;

H – height of the sample;

v – velocity of propagation of the combustion wave;

Q – heat source.