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SOME ASPECTS OF PYROLYTIC COMPRESSION OF CARBON COMPOSITES IN CONDITIONS RADIALLY MOVING ZONE OF PYROLYSIS

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The some features of compression process carbon composites by a pyrolytic carbon from a gas phase in the conditions of radially moving zone of pyrolysis are researched. The processes of transporting for gaseous hydrocarbons in the porous structure of material, their decomposition and formations of pyrolytic carbon on the heated surfaces of pores are considered.

Keywords: carbon composites, compression, pyrolytic carbon, method radially moving zone of pyrolysis, modeling

In technology of production of composite on the basis of carbon one of mainframe redistributions is packing of porous structure of carbonized carbonplastic by a pyrolytic carbon, precipitable from a gas medium [1,2].

The decline of level for porosity of carbon composites will be realized by the methods of gas-cycle compression, id est. packing of porous structure hard carbon material (by a pyrolytic carbon) from a gas phase with the use of thermal and chemical methods. To the number such methods there are applied the method of pyrolytic compression in isothermal conditions and method of radially moving zone of pyrolysis [3,4].

In the process of by a pyrolytic compression method radially moving zone of pyrolysis the change of thermophysical descriptions of carbon composites is related with the decline of their porosity, that, in turn, results to the increase of values for coefficients of heat conductivity, and, consequently, and gradient of temperature on the thickness of these materials. As a result, there is an acceleration of diffusion for natural gas in the volume of composite and increase of speed of its decomposition as far as moving away from the open surface of material, and, consequently and conditions for the increase of density of carbon composites from the side of the closed surface which directly contacts with the sources of temperature.

The model of carbon composite as a plate with thick δ, which is characterized by cylindrical pores with the effective radius r_{ef} and porosity $\prod$ is examined Mentional pores are located perpendicularly to the surface of composite, and also have a smooth and power homogeneous surface. Thus the surface of composite with a co-ordinate $\ell = 0$ is heated to the temperature T_{ext}, and its surface with a co-ordinate $\ell = \delta$ is washed natural gas with the temperature T_g.

Then distribution of temperature on the thickness of model medium it is possible to describe one-dimensional differential equation of non-stationary heat conductivity of kind

$$\tilde{n}\cdot\rho\ \frac{\partial T}{\partial\tau}=\frac{\partial}{\partial\ell}\left(\lambda\frac{\partial T}{\partial\ell}\right)\ . \qquad (1)$$

with regional conditions

$$T(0,\ell)=T_0\ ;\quad T\,\Big|_{\ell=0}=T_{ins}\qquad \lambda\frac{\partial T}{\partial x}\Big|_{\ell=\delta}=\alpha\cdot(T_{ext}-T_g) \qquad (2)$$

where c, ρ – a heat capacity, kJoule/(kg·К), and current mass density, kg/m^3; carbon composite respectively; T – a temperature, K; ℓ, τ – current linear, m, and temporal co-ordinates, with, respectively; λ – a coefficient of heat conductivity of carbon composite, W/(m·К); T_{ext}, T_{ins} – a temperature of external and inside surface of composite, K, respectively; α – a coefficient of heat transfer from natural gas to the external surface of composite, W/(m^2·К); T_g – a temperature of natural gas, K; T_0 – a temperature of carbon composite, К.

Task about diffusion of natural gas in the pore of compo taking into account his decomposition on her surfaces and formations of pyrolytic carbon it is possible to present the system of equations:

$$\frac{1}{D}\cdot\frac{\partial C}{\partial\tau}=\frac{\partial^2 C}{\partial\ell^2}+\theta\ \frac{\partial C}{\partial\ell}-\frac{2k}{r_{ef}\cdot D}\ \exp\left[\left(-\frac{\AA}{R\cdot T_{ext}}\right)\cdot\exp(\varphi\cdot\ell)-\theta\cdot\ell\right]\cdot C=0\ ; \qquad (5)$$

$$\tilde{N}(\ell,0)=\tilde{N}_S\ ;\quad \tilde{N}(\tau)\,\big|_{\ell=\delta}=\tilde{N}_S\quad -D\,\frac{\partial C}{\partial\ell}=\beta_m\cdot(C_S-\tilde{N}_0)\ , \qquad (6)$$

where D – a coefficient of diffusion for natural gas, m^2/s, $D=D_{ext}\cdot\ T/T_{ext}$; D_{ext} – a coefficient of diffusion natural gas, m^2/s, at the temperature T_{ext}; C, C_S – a concentration natural gas in a pore and on the surface of carbon composite, kg/m^3, respectively; E – energy of activating of formation of pyrolytic carbon, kJoule/kg; R – universal gas constant, кДж/(moth·К); $\varphi=\delta^{-1}\cdot\ln\ T_{ins}/T_{est}$; $\theta=1{,}5\beta_m$; C_0 – a concentration of natural gas in a reactor, kg/m^3; β_m – a coefficient of speed for mass transfer of natural gas, m/s.

The change of density on the thickness of composite is described by equation:

$$-\vartheta\,\frac{d\rho}{d\ell}=S_i\cdot k\cdot C \qquad (11)$$

with a border condition

$$\rho\,\big|_{\ell=\delta}=\rho_0\ , \qquad (12)$$

where ϑ – speed of height of pyrolytic carbon, m/s; S_i – a specific reactionary surface of composite pores, m^2/kg.

The specific reactionary surface of pores can be defined from correlation:

$$S_i=\frac{2(\rho_{act}-\rho)}{r_{ef}\ \cdot\rho_{act}\cdot\rho}\ , \qquad (13)$$

where ρ_{act} – an actual density of material carbonplastic.

Putting correlation (13) in equation (11), we get

$$-\vartheta \frac{d\rho}{d\ell} = \frac{2(\rho_{ä} - \rho)}{r_{ýô} \cdot \rho_{ä} \cdot \rho} \cdot k \cdot C \ . \qquad (14)$$

System of equations (6), (14) and regional conditions (2)-(4), (8)-(10) and (12) describe the processes of distribution of temperature on the thickness of the made more compact carbon compo taking into account diffusion of natural gas in his porous structure and decomposition on the walls of pores of pyrolytic carbon which stipulates the increase of density of this material. The decision of the foregoing system of the constrained differential equations is realized by numeral methods.

It is set that at the pyrocarbon compression of carbon compo by a method radially moving zone of pyrolysis in the central zone of material his density less than, than near both surfaces, and allocation of density of composite on its thickness correspond to the conclusions of work [3]. The results of experiments on the study of process of compression of carbon composite in the medium of natural gas for foregoing conditions confirmed their sufficient convergence with results, got with the use of the worked out model.

Conclusions. The fitness of the offered model of forming of density of carbon composite is set from a gas phase for the quantitative estimation of dallocation of density on the thickness of material at his pyrolytic compression in the conditions of method radially moving zone of pyrolysis.

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