Research of limit thermal tension in capillary and porous materials of the thermal power installations

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Research of limit thermal tension in capillary and porous materials of the thermal power installations: *Research of thermal tension of the badly heat pipe capillary and porous coverings which have low porosity (quartz) is conducted. The mechanism of processes of coverings' thermodestruction is considered by tension of the stretching, compression and shift. There is only limit tension of compression at small values of time of giving of a thermal stream and only since the moment near 0,5 s in area $0{,}4.10^{-2}$ m tension of compression passes into stretching tension.*

Key words: *Cyclone; Compression; Strength on stretching; Elasticity module.*

INTRODUCTION

Application of the capillary and porous coverings in heatpower installations restrains to the insufficient knowledge of the mechanism of their destruction in case of approach of the limit thermal condition of the steam-generating surface [1, 9].

It is interesting to consider analogy of processes of destruction (melting) of the metal steam-generating surface of heating in case of approach of boiling's crisis [4, 9] and crisis of very strong rocks, such as quartz, granite and teschenite which were executed in the form of the capillary and porous coverings [1, 3]. It is necessary to expect a number of regularities in behavior of integrated characteristics of the heat exchange inasmuch as it is possible to apply the equation of non-stationary heat conductivity to the both elastic firm media [2, 3].

Studying of the mechanism of process of the porous coverings' destruction at the impact on them a high-temperature supersonic fiery stream was studied in works [1, 3, 9].

EXPOSITION

At the thermomechanical cyclonic way cyclic nature of change of the covering's blanket temperature remains and development of the thermal tension caused by a gradient of the temperature and coverings' destruction happen at lower temperature than a case of direct-flow fire influence. The destroyed surface heats up previously a high-temperature torch that significantly weakens structure, reduces durability and fortress of coverings owing to structure's distinction, anisotropy of thermal, physicomechanical and other properties of the minerals which make them. Heating of the granite and ferruterous quartzite to 800 0C leads to the reduction of their coefficients of fortress for 4-5 times.

Rocks from which badly heat pipe coverings are made as multicomponent heterogeneous systems which represent difficult educations. Properties of the rocks depend on conditions of the education and on those physical and chemical processes and the phenomena which took place in them during existence to the large extent.

Various temperature effects promoting emergence or development of deformations, the relaxations of tension causing change of a phase condition of breeds can be shown under the influence of heat in rocks depending on their natural state (porosity, humidity, structure, texture) and mineralogical structure. Thermal expansion and polymorphic transformations on which ways of thermal destruction of breeds are based first of all belong to these effects.

At the coverings' thermal destruction the area of the surface which is irradiated with a torch should be allocated. After a while this part of the surface heats up to temperature and temperature remains in other parts of breed. there is a temperature gradient in breed under an irradiated surface in consequence of which the breed extends unevenly. Surrounding not heated layers render resistance to this expansion. As a result the both thermal tension in heated part and in the surrounding not heated massif are created. This tension can reach destroying values.

If we accept that growth rate temperature on an irradiated high-temperature stream of the surface is proportional to the difference of final and current temperature, so the temperature of the heated covering changes by the law

$$T = T_0 e^{kt} + T_S\left(1 - e^{-kt}\right), \tag{1}$$

where: k - coefficient; t - time.

If the covering extended without counteraction (freely)

$$l_{fre} = \alpha L\left(T - T_0\right), \tag{2}$$

So no tension would appear in it. Let the destroyed environment be similar to a core.

The greatest temperature (thermal) tension from compression will arise if the ends of a core are fixed

$$\sigma_{\max} = -E\frac{l_{fre}}{L} = -\alpha E\left(T - T_0\right). \tag{3}$$

Actually, the core receives lengthening smaller than l_{fre}

$$l = l_{fre} - l_{com} = \alpha L, \tag{4}$$

where l_{com} - compression received on a core of surrounding breeds as a result of impact

$$l_{com} = -\frac{1}{E}\sigma_T L. \tag{5}$$

From here thermal tension from the compression

$$\sigma_{Ther} = -E\left[\alpha\left(T - T_0\right) - \frac{l}{L}\right]. \tag{6}$$

It is considered that arising tension always squeezing when the surface heating and durability on compression is more for 10 times than durability on stretching and shift, that destruction is caused by the last tension which are really formed in breed. However, the role of compression's tension of it should be ascertained.

Two layers or a cores in a covering should be allocated (one adjoins to another from below).

While heating in the bottom layer there will be stretching tension σ_{stret}

$$l_1 = \alpha_1\left(T_1 - T_0\right)L = \frac{1}{E_1}\sigma_1 L, \tag{7}$$

$$l_2 = \alpha_2\left(T_2 - T_0\right)L - \frac{1}{E_2}\left(\sigma_2 - \sigma_{stret}\right), \tag{8}$$

but $l_1 \approx l_2; \sigma_S = \sigma_{stret}$;

$$\frac{\sigma_{stret}}{E} = \Delta\left\{\alpha\left(T - T_0\right) - \left(\frac{\sigma_T}{E}\right)\right\}, \tag{9}$$

Or even more exactly

$$\frac{\sigma_{strer}}{E} = l_X\left[\alpha + \left(T - T_0\right)\frac{d\alpha}{dT} - \frac{d}{dT}\left(\frac{\sigma_{ther}}{E}\right)\right]\frac{dT}{dx}, \tag{10}$$

where: E - elasticity module; α - coefficient of linear expansion; l_X - factor, dimensional lengths and on the module equal to unit; L - length of the studied element.

It is visible from the given ratio that the stretching tension grows with growth of the gradient of temperature in case of the coefficient of linear expansion grows with a temperature $\left(\dfrac{d\alpha}{dT} > 0\right)$.

Research of a limit condition of the capillary and porous coverings executed from the badly heat pipes low-porous mineral environment (rock, such as quartz), is presented in figure 1 [2, 3]. The solution of the problem of the thermoelasticity was considered when the equation of non-stationary heat conductivity was solved under boundary conditions of the second sort.

Decisions are submitted in a look of distribution diagram tension σ_i on covering thickness ($Z-h$) at various thermal streams q_i and time of their giving. Thermal streams surfaces q_1, q_2, q_3 causing melting of the covering (q_1) and also the creating limit tension of compression q_2 and stretching q_3 are considered.

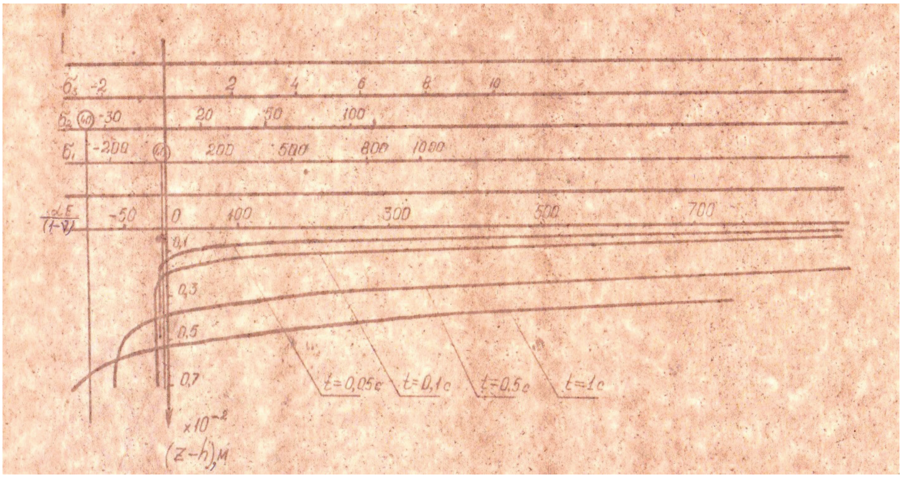

Fig.1. Distribution diagrams of the tension on covering thickness from a plate at various thermal streams and time of their action

$q_1 = 8{,}8 \cdot 10^7 \dfrac{Watt}{m^2}$; $q_2 = 0{,}12 \cdot 10^7 \dfrac{Watt}{m^2}$; $q_3 = 0{,}08 \cdot 10^7 \dfrac{Watt}{m^2}$ – the limit thermal streams causing melting of a surface, compression and stretching tension, 40 – strength on stretching; $\sigma \times 10^5 \dfrac{N}{m^2}$; $E \times 10^5 \dfrac{N}{m^2}$.

ν - coefficient of the cross compression; q_1, q_2, q_3 - the thermal streams causing melting of a covering, creation of limit tension of the compression and respectively stretching.

CONCLUSION

Having defined temperature distribution in the porous covering (plate), we find the thermal tension of the stretching and the compression arising in some time t at various depth of a covering from its surface ($Z_i - h$) at this value of the thermal stream q_i. The plate from a variable on thickness temperature is in badly tension and total thermal tension consists of the making tension of the compression and stretching.

At the small t there is only compression tension (picture1). Beginning, for example, for quartz, for $t \approx 0{,}5$ s in some areas $\Delta(Z_i - h)$ till $0{,}4 \cdot 10^{-2}$ m tension behind all a short period, and for various intervals of time they are at various depth from the plate surface. The size of coming-off particles of a destroyed covering in the field of transition for each time t will equal $\delta_i = \Delta(Z_i - h)$.

The greatest tension of shift of the coat layers will be observed at the time of tension transition of compression to tension of stretching. Shift tension reaches limit values after breaking points of the compression and before the maximum tension of stretching in time.

Maximum thickness of particles coming off under the influence of compression sm, for quartz makes $\approx 0{,}25 \cdot 10^{-2}$ m. Time of the separation of particles, for example, for teschenite defined by the high-speed filming makes $L5$ s with depending on a brought thermal stream q.

REFERENCES

[1] Polyaev V., Genbatch A N., Genbatch A A. An experimental study of thermal in porous materials by methods of holography and photoclasticity// Experimental thermal and fluid science, avenuie of the Americas, New York, volum5, number 6, November. – 1992. – P. 697-702.
[2] Genbach A.A., Burmistrov A.V. Research of a thermal condition of cylinders of the steam turbines//Industry Kazakhstan, №2(65). – 2011. – P. 91-93.
[3] Polyaev V. M., Genbach A.N., Genbach A.A. A limit condition of a surface at thermal influence//Thermophysics of the high temperatures. – 1991. – T.29, №5. – P.923-934.
[4] Polyaev V., Genbatch A. Control of Heat Transfer in a Porous Cooling System // Second world conference on experimental heat transfer, fluid mechanics and thermodynamics. – 1991. – Dubrovnik, Yugoslavia, 23-28 June. – P. 639-644.
[5] Polyaev V. M., Genbach A.A. Management of the internal characteristics of boiling in porous system//Cryogenic equipment and conditioning: Collection of the works of MSTU. – 1991. – P. 224-237.
[6] Polyaev V. M., Genbach A.A. Management of heat exchange in porous structures//News of the Russian Academy of Sciences. Power and transport. – 1992. T.38, №6. – P. 105-110.
[7] Polyaev V. M., Genbach A.A. heat exchange in the porous system working at joint action of the capillary and gravitational forces//Power system, №7. – 1993. – P. 55-58.
[8] Polyaev V. M., Genbach A.A. Intention of heat exchange of the porous system in a gravitational field//News of the higher education institutions. Power. – 1993. №1-2. – P.91-95.
[9] Polyaev V. M., Genbach A.A. maximum thermal loads in the porous structures//News of the higher education institutions. Aircraft equipment. – 1991. №1. – P.33-37.

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This paper has been reviewed.