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# DURABILITY AND STRENGTH CAPACITY OF ASBESTOS-CEMENT TUBES

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**Key words and phrases**: asbestos-cement; durability; wear-out; kinetic unit; durability; voltage; strength capacity; heat-resistance; activation energy.

**Abstract:** The problem of work capacity increasing for asbestos-cement tubes and its forecasting is viewed on the basis of thermal-fluctural approach to the mechanism of rigid bodies destroying. The received experimental datum open a perspective of work capacity forecasting for asbestos-cement tubes under different loads in a vast temperature interval and in a different operation period.

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Asbestos-cement tubes are widely used for sewage wastes and sewage diversion. Operating reliability and durability of tubes depends on asbestos-cement structure. The characteristic properties of asbestos-cement are connected with micro-dispersal reinforcement of cement stone by asbestos fibre; its unisotopism conditioned by asbestos fibre location, and its considerable porosity. In the operation process tubes are exposed to different power, temperature and chemical influences. Tubes destruction is caused either by erosive wear or by cracks formation in a tube's wall. The operation time of downpour and sewage tubes is in most cases considerably shorter than the standard. Therefore there is a necessity to analyse the regularity of asbestos-cement destruction under a continuous load with the given constant voltage and temperature and besides to analyse the influence of different factors on tube's material wear-out.

To determine asbestos cement durability the experimentally verified kinetic thermal-fluctural mechanism of rigid body destroying was used [1]. The kinetic concept takes account of atomic thermal motion as a mechanical destruction process determinant besides the force exerted on a body.

Consequently the destruction does not result from the accidental and the most proper conditions but results from the irreversible changes. These changes accumulate starting from the moment when any load is applied and they cause the body to fall into pieces.

Durability tests with lateral flexure were run on 120×10×5 mm specimen beams. 6-8 specimen were tested with the fixed parameters (voltage and temperature). Dependence of time before the destruction on voltage is shown on Fig. 1. As it is shown here the dependencies are linear and form a family of directs converging at one point. To indicate the analytical dependence uniting the time before the destruction (durability), voltage and temperature the dependencies are changed into the coordinates $\lg \tau - 10^3/T$ (Fig. 2).

According to Fig. 2 the dependencies in these coordinates make a family of converging directs.

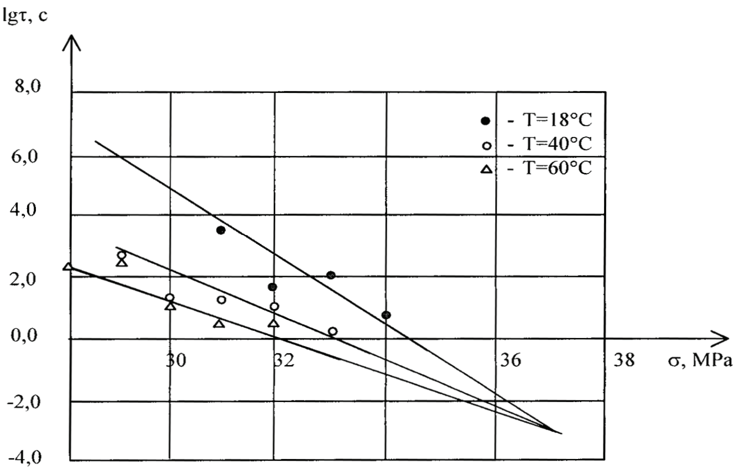


**Fig. 1 The dependence of durability on voltage and temperature of asbestos-cement with the central lateral flexure**

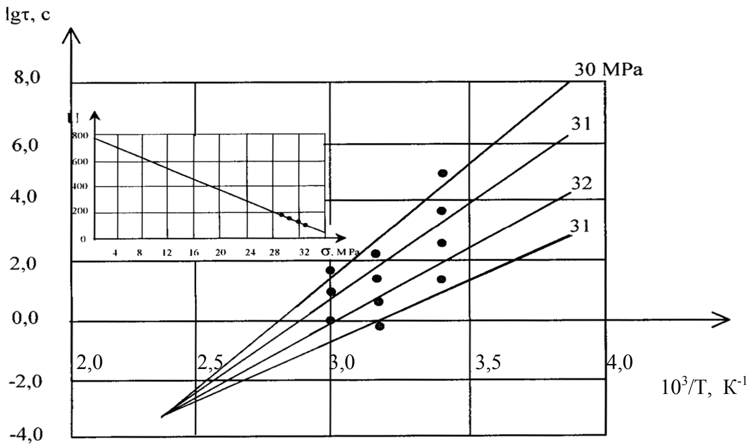


**Fig. 2 The influence of asbestos-cement temperature and voltage on durability (*a*) and on energy of destruction activation (*b*) with the central lateral flexure**

The following equation shows the connection of durability, voltage and temperature:

$$\tau = \tau_m \exp\left\{\frac{(U_0 - \gamma \cdot \sigma)}{R}\left(T^{-1} - T_m^{-1}\right)\right\}, \quad (1)$$

Two main operation parameters can be taken from this equation:

- strength $$\sigma = \frac{1}{\gamma}\left[U_0 - \frac{2,3RT}{1 - T/T_m}\lg\frac{\tau}{\tau_m}\right], \quad (2)$$

- heat-resistance $$T = \left[\frac{1}{T_m} + \frac{2,3R}{U_0 - \gamma\sigma}\lg\frac{\tau}{\tau_m}\right]^{-1}, \quad (3)$$

where $\tau$ – the time before the destruction; $\sigma$ – voltage; $T$ – temperature in K; $\tau_m$, $U_0$, $\gamma$, $T_m$ – physical constants; $\tau_m$ – the constant, showing the fluctuation period of kinetic units; $U_0$ – the maximum energy of destruction activation; $\gamma$ – the structure-mechanical constant; $T_m$ – the limiting temperature of rigid body's existence.

Constant datum were determined by means of graphical analysis from the $\lg \tau - 10^3/T$ dependence. Thus $\tau_m$ and $T_m$ are pole coordinates (converging points) of the dependencies. According to directs slope tangent $\lg \tau - 10^3/T$ –from the formula

$$U = 2,3R \frac{\Delta \lg \tau}{\Delta\left(10^3/T\right)}, \tag{4}$$

values of effective activation energies, $U$, were calculated with the explored voltages. The linear dependence in $U$-$\sigma$ coordinates was constructed (Fig. 2*b*). The maximum activation energy, $U_0$ value was defined with the extrapolation on $\sigma = 0$; the structure-mechanical factor, $\gamma$, was defined according to the direct slope tangent. The values of all the calculated constants are given in the Table 1. The constant values for a corrugated asbestos-cement sheet received earlier in [3] are also given here.

Table 1

**Constant values of asbestos-cement with lateral flexure**

| Product type | $\tau_m$, sec | $U_0$, kDg/mol | $\gamma$, kDg/mol× MPa | $T_m$, K |
|---|---|---|---|---|
| Tube | $10^{-3,5}$ | 780 | 21,9 | 432 |
| Corrugated sheet | $10^{0,2}$ | 323 | 11 | 400 |

As it is shown on the Table 1 the datum of the constants considerably differ for the explored materials. The $\tau_m$ value lowers for the tube asbestos-cement, while $U_0$, $\gamma$ and $T_m$ values raise. This is apparently connected with the size of asbestos-cement fibre and the character of asbestos fibre distribution. The multiplication effect [4] connected with the $U_0$ and $\gamma$ dependence on fibre length occurs in the process asbestos-cement tubes destruction. Both the constants double. The temperature of material decay increases by more than 30° and the period of kinetic units' fluctuation decreases more than thousand times.

The following conclusions can be made according to the received values of constants:

1) asbestos-cement work capacity is conditioned by the parameters of asbestos fibre;

2) material destruction is caused by the fluctuation of large kinetic units;

3) the value of the limiting temperature of body's existence shows the determining role of asbestos fibre in its heat-resistance;

Knowing the values of the physical constants expressed by the formulas (1)-(3) there can be calculated durability and other parameters of work capacity with the given voltage, temperature and operation time.

To learn the mechanism of asbestos-cement wear-out the attrition was conducted on MI-2 disc machine [3]. To create the process of attrition patterning the real operation conditions for a tube inner surface a metal screen was used as a controller. The weave points of the screen make blunt bulges trying to grab the material and detach it due to the power of friction.

The samples were cut out of a tube's wall length-wise and across asbestos fibre orientation as 10×10 mm cubes. A part of samples with orientation of fibre length-wise was soaked for different periods in water to learn the influence of liquids on the intensity of asbestos-cement wear-out. The researches were conducted simultaneously on two samples with different pressure of application and with room temperature 20±2 °C. Low speed (0,3 м/s) and low application pressure (not more than 2 kl/cm$^2$) did not cause big surface warm-up [3].

Wear-out speed J is calculated according to the formula

$$J = \frac{\Delta m}{t} \qquad (5)$$

where $\Delta m$ – the sample's mass loss as result of attrition; $t$ – the time of attrition.

Experimental data are shown on Fig. 3, Fig. 4. As it is shown on Fig. 3 the orientation of asbestos fibre in a tube's wall considerably influences the asbestos cement wear-out speed. The wear-out data length-wise the fibre is 4-6 times higher than that in a range of explored pressures.

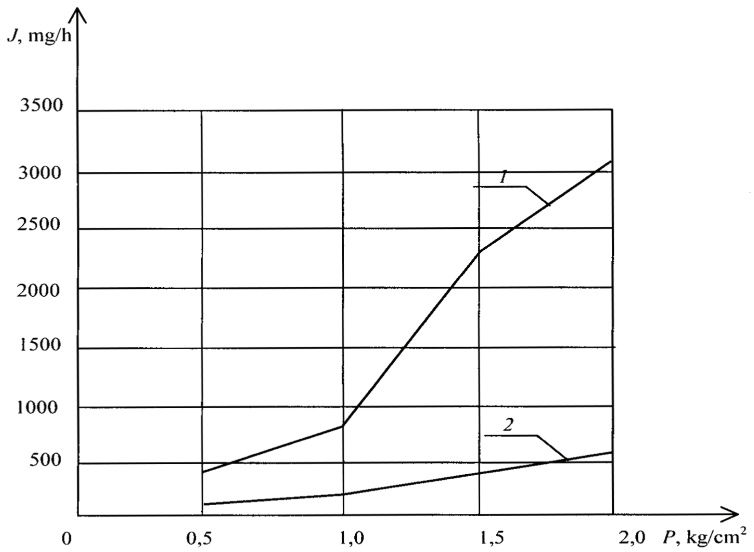


**Fig. 3 The influence of pressure and asbestos fibre orientation upon the speed of asbestos-cement wear-out:**
*1* – attrition length-wise the fibre; *2* – attrition across the fibre

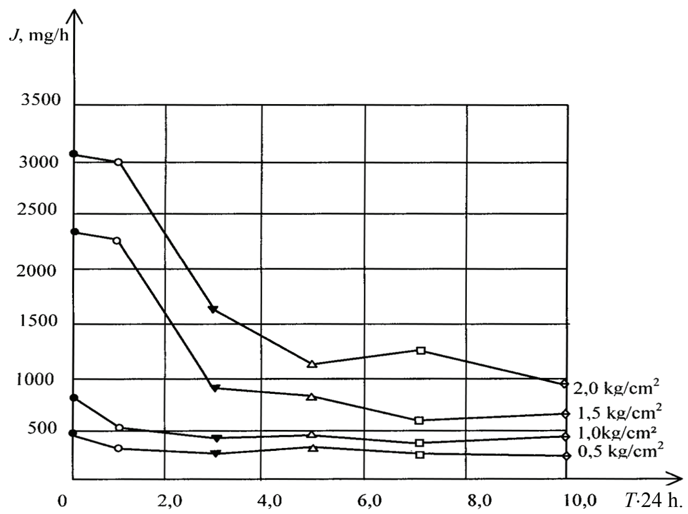


**Fig. 4 The influence of soaking period upon the speed of asbestos-cement wear-out with different contact pressures**

The dependencies of the wear-out speed on the sample's soaking time with different contact pressures is shown on Fig. 4. According to Fig. 4 the wear-out value lowers after a soaking period of 3-5 days under high pressure (1,5 and 2 $kg/cm^2$), whereas under low pressure (up to 1$kg/cm^2$) the wear-out speed after the soaking remains practically constant and does not change further. Apparently water plays the role of lubricant.

Thus, to increase the work capacity of asbestos-cement tubes asbestos fibre should be oriented in a radial way relatively to the cylinder axis; there should be no large abrasive particles in the solution coming through the tube; the tube surface should be covered with anti friction composition.

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**К вопросу о долговечности и износостойкости асбестоцементных труб**


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**Ключевые слова и фразы:** асбестоцемент; долговечность; износ; кинетическая единица; надежность; напряжение; прочность; термостойкость; энергия активации.



**Аннотация:** На основании термофлуктуационного подхода к механизму разрушения твердых тел рассматривается проблема прогнозирования и повышения работоспособности асбестоцементных труб. Полученные экспериментальные результаты открывают эту возможность при нагружении в широком интервале температур и времени эксплуатации.


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**Zur Frage über Langfristigkeit und Verschleißfestigkeit der Asbestzementröhre**


**Zusammenfassung:** Auf Grund der thermofluktuationen Einstellung zum Mechanismus des Zerfalls der Hartstoffe wird das Problem der Prognostizierung und der Erhöhung der Betriebsfähigkeit der Asbestzementröhre betrachtet. Die erhaltenen Experimentellergebnisse eröffnen diese Möglichkeit bei der Belastung im breiten Temperaturbereich und Benutzungsdauer.

**Sur le problème de la durabilité et de la résistance à l'usure des tuyaux en amiante ciment**

**Résumé:** A la base de l'approche de thermo-fluctuations envers le mécanisme de la destruction des corps solides on examine le problème de la prévision et de l'élévation de la capacité de travail des tuyaux en amiante ciment. Les résultats expérimentaux reçus donnent cette possibilité avec la mise en charge dans un large intervalle de température et de temps d'exploitation.