of contamination, for example. At different temperatures the level of this effect may differ, which is one of the reasons for the divergence recorded.

It follows from analysis of cases 6 and 7 that recrystallization may cause a marked reduction in \( \beta \) and \( \Delta \) under stable comparable conditions. Accordingly, statistical analysis of experimental data selected with consideration of the class of material, type of treatment and other factors, may facilitate the exposure of characteristic values of \( \beta \) and an increase in prediction accuracy taking account of these values.

Thus, this analysis indicates that the ASR method makes it possible to perform rapid determination of long-term strength properties for refractory materials with \( S \leq 14\% \). During processing of the experimental results it is possible to establish corrections statistically and by taking these into account prediction accuracy is improved.

LITERATURE CITED


CONSIDERATION OF THERMAL STRENGTHENING IN CALCULATING ALLOWABLE STRESSES

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Mass production of articles for cryogenic technology necessitates a reduction in metal consumption. For steels and alloys which retain quite high levels of ductility and toughness, and exhibit an extreme type quasibrittle fracture, a possible route for solving this problem is increasing the allowable stresses as a result of taking thermal strengthening into account.

For pressure vessels and apparatus whose loading by internal pressure is static the allowable stress for a wall of austenitic steel having a temperature below 273\(^\circ\)K is determined as the minimum of two values [1]:

\[
\frac{\sigma^{293}_{f}}{n_f} \text{ and } \frac{\sigma^{293}_{\gamma}}{n_{\gamma}}
\]

Fig. 1. Types of connection between structural strength and cooling temperature: a) static connection \( 0 < \xi^2 < 1 \); b) functional connection, \( \xi^2 = 1 \); c) no connection \( \xi^2 = 0 \).

Specimen strength with static uniaxial tension taking account of the effect of basic technological factors such as welding, stress concentrations, etc.

where \( \sigma_{Y}^{293} \) is the minimum nominal yield point at \( 293^\circ\text{K} \); \( \sigma_f^{293} \), minimum ultimate strength at \( 293^\circ\text{K} \); \( n_Y \) and \( n_f \), safety margin coefficients equal to 1.5 and 2.4, respectively. Thus, an increase in strength with reduced temperature is not taken into account and it forms part of the safety margin. A similar approach was reflected in [2]. The use of higher allowable stresses is only recommended in technically fundamental cases after verifying sufficient safety under operating conditions [3]. Results for examination of cryogenic equipment in operation indicate that it is possible to raise allowable stresses for 12Kh18N10T type steels. According to the data of [4] during chilling by cryogenic liquid vessel stresses exceed allowable levels by a factor of 2–2.5, and not one case of failure is known. At the same time, it is known that the effect of thermal strengthening obtained in laboratory tests on basic metal specimens is much higher than during tests on actual structures of their models. This creates difficulties in working out allowable stresses taking account of the increased strength of metal specimens due to cooling, since it is not known what proportion of thermal strengthening it is possible to use.

Workers in [5] arrived at a solution to this problem by considering the energy absorption capacity of the material. However, it is not clear in what way one should account for the set of structural and technological factors that ultimately govern structural thermal strengthening.

The present work proposes a scheme whose basis is a structural approach for calculating allowable stresses taking account of increased strength at reduced temperature.

Let the temperature dependence of structural strength which increases uniformly with decreasing temperature (Fig. 1a) be known for a specific thin-walled cryogenic vessel with given operating conditions. Let the basic factors governing structural strength also be known. We add a variation for values of the ultimate strength of metal specimens obtained with static uniaxial extension taking account of the effect of individual basic factors on the structural strength curve for several temperatures. It is possible to establish from Fig. 1a a connection between structural strength and cooling temperature by calculating a value of correlation ratio \( \xi \). Then it is proposed to determine the allowable stress \( [\sigma]^T \) at design temperature \( T \) as the lesser of two values:

\[
[a]^T = \left[\sigma_{Y}^{293} + \frac{\Delta \sigma_f^{T}}{n_f} \xi^2 \right] \varphi; \quad (1)
\]

\[
[a]^T = \left[\sigma_{Y}^{293} + \frac{\Delta \sigma_{Y,0}}{n_Y} \xi^2 \right] \varphi; \quad (2)
\]