Table 1. The basic mechanical properties of $BaTiO_3$ materials after sintering

Parameter	Sample denotation		
	BT_a	BT_b	BT_c
Young's modulus E, GPa	115.5	118.0	116.0
Compressive strength R_c, MPa	655.7	913.2	486.2

Acknowledgements

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MODELLING THE GENERAL CORROSION OF A STEEL TUBE UNDER ITS OWN WEIGHT

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Corrosion causes irreparable damages of industrial and building structures and leads to reduction of their durability. Corrosion depending on mechanical stresses is known as mechanochemical corrosion. These problems have received a wide response among scientists. Publications [1-3] provide solutions for the problems of a corroding tube under a constant longitudinal force. The present article concerns a steel tube subjected to double-sided general corrosion under its own weight. It is the case of a variable longitudinal force.

A linearly elastic vertically standing or hanging steel tube loaded with its own weight is considered. The tube is subjected to inside and outside general corrosion with the rates v_r and v_R respectively, so the inner radius $r = r(t)$ of the tube increases with time t and the outer radius $R = R(t)$ decreases with time t, while its thickness $h(t) = R(t) - r(t)$ decreases uniformly. Let the inner and outer radii of the tube at the initial time $t_0 = 0$ be denoted by $r_0=r(0)$ and $R_0=R(0)$.

It is known that the corrosion rate depends on the stress state of a solid surface [1, 4, 5]. Experimental data show that for some steels, corrosion rate is often linearly dependent on mechanical stress [1, 5]:

$v_r = dr/dt = a_r + m_r\sigma(r), \quad v_R = -dR/dt = a_R + m_R\sigma(R).$

Here, a_r, a_R, m_r, and m_R are empirically determined constants; $\sigma(r)$, $\sigma(R)$ are the maximum principal stresses on the corresponding surfaces of the tube.
It is required to develope an algorithm of solution which allows finding the stress values in the tube, its thickness for $t > 0$, and to assess the lifetime of the tube. The loss of stability of the vertically standing pipe is not taken into account.
In this paper a numerical solution to the problem is proposed. The appropriate time and spatial step sizes are estimated.
Some computational results are presented below.
It is clear that the maximum in absolute value normal stress, which is the longitudinal stress, is at the upper cross-section for a hanging tube, and at the lower end for the standing tube. Qualitative behaviour of the maximum (in absolute value) longitudinal stress, σ_{zz}, over time is presented in Fig. 1. Corresponding behaviour of the external and internal radii (at the same cross-section) over time is presented in Fig. 2.

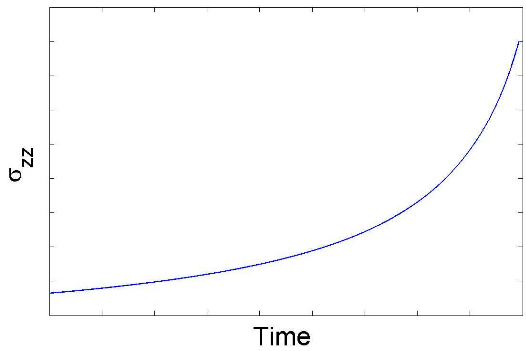

Fig. 1. The stress values over time

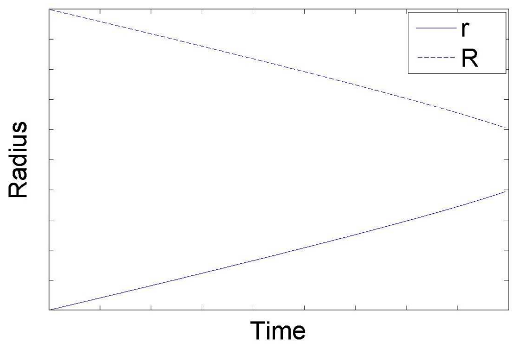

Fig. 2. The external and internal radii over time

Since the maximum stress grows with time, it may seem that the lifetime of the tube can be assessed by one of the known strength criteria. For example, for the maximum normal stress criterion, the lifetime could be defined as the time at which the maximum in absolute value normal stress reaches a strength limit. However, the residual thickness of the tube at this moment is too small. Therefore, it is more reasonable to define the lifetime of the tube as the time at which minimum tube thickness reaches a given limiting value.

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STRESS-STRAIN STATE IN THE CORNER POINTS OF A CLAMPED PLATE

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The bending of a rectangular clamped thin plate under the uniformly distributed transverse load is considered. The solution of the Sophie Germain equation is constructed by the method of initial functions (MIF). On two opposite sides the boundary conditions are satisfied exactly. Then, on the two remaining ones, the boundary conditions are satisfied approximately by the collocation method. The results of calculations of the stress-strain state at the corner points of the plate are given.

Consider an isotropic rectangular thin plate in the rectangular coordinate system [redacted] with original in the center of the plate $-a/2 \le x \le a/2$, $-b/2 \le y \le b/2$ with thickness $\delta \ll \max(a, b)$. The differential equation of the bending of the middle surface of the plate [1]

$$\frac{\partial^4 w}{\partial x^4} + 2\frac{\partial^4 w}{\partial x^2 \partial y^2} + \frac{\partial^4 w}{\partial y^4} = \frac{q}{D}, \qquad (1)$$

where [redacted] is a deflection of the plate, [redacted] is an intensity of a normal load, $D = \dfrac{E\delta^3}{12(1-\nu^2)}$ is cylindrical rigidity, [redacted] is the modulus of elasticity and [redacted] is a Poisson's ratio, can be received by the MIF in the operator form [2]

$$w(x, y) = L_{ww} w^0 + L_{w\theta}\theta^0 + L_{wM} M_x^0 + L_{wV} V_x^0 + w_{part}, \qquad (2)$$

where w^0, θ^0, M_x^0, V_x^0 are deflection, the angle of rotation, the bending moment, the generalized shearing force on the initial line [redacted] and w_{part} is a partial solution of the nonhomogeneous equation (1). The MIF operators in (2) have the following form ([redacted] is a symbol of differentiation in the respect of the variable [redacted])

$$L_{ww}(x) = \cos(\beta x) - 1/2\sin(\beta x)x\beta\nu + 1/2\sin(\beta x)x\beta,$$

$$L_{w\theta}(x) = (\nu+1)\sin(\beta x)/(2\beta) + (-\nu/2 + 1/2)\cos(\beta x)x,$$

$$L_{wM}(x) = -\sin(\beta x)x/(2D\beta), L_{wV}(x) = (\cos(\beta x)\beta x - \sin(\beta x))/(2D\beta^3)$$

and the partial solution may be taken as $w_{part} = qx^4/(24D)$.