The intensity of gas-abrasive erosion is experimentally determined for three materials at temperatures of 300 and 125°K. We propose a statistical model that enables one to predict the volume erosion rate (per one impact of a particle) as a function of mechanical and thermal properties and parameters of the impact (the size and velocity of a solid particle).

The erosion fracture of metals and their alloys caused by the impact action of a gas-abrasive jet with acute-angled particles is, in a certain sense, "tough" and resembles the process of removal of microchips by the acute angles of the particles acting as microscopic cutting tools [1, 2]. On the other hand, the investigation of the surfaces of the specimens of aluminum alloys and stainless steel eroded by particles of siliceous sand with an electron microscope demonstrates that some localized regions (at the sites of collisions) are melted to a depth of at most 1 μm [1].

By using this fact, one can suppose that the mechanism of erosion fracture is affected not only by the mechanical properties of the material of the obstacle [2] but also by specific heat (connected with the local heating of the metal), melting temperature (for alloys, from the temperature range from $T_s$ to $T_L$), and specific heat of melting [3]. This conjecture became the starting point of our investigation. Specimens of D16T duralumin, VT-1 titanium alloy, and 12Kh18N10T stainless steel were subjected to erosion fracture at temperatures of 125°K and 300°K in the experimental installation described in [4]. Acute-angled particles of siliceous sand with a granularity of 100–160 μm and 200–315 μm and a density of 24 g/m$^3$ served as an erosive agent. These particles were accelerated in a flow of argon up to velocities of 30–109 m/sec at right angle of attack of the surface of an obstacle by the gas-abrasive jet.

The main aim of the present work is to deduce a general mathematical relationship between the intensity of erosion fracture, the parameters of impact action of abrasive particles, and mechanical and thermal properties of the eroded material based on the analysis of the experimental data.

In the course of the experiments, we determined the integral intensity of the process of erosion fracture corresponding to the steady stage of this process and expressed as the ratio of the mass loss of the specimen to the mass of the particles of the erosive material inducing fracture, i.e., $\Delta m/m_e$. At the same time, it is well known that the process of erosion fracture of structural materials is much better described not by the mass loss and integral intensity but by the volume loss and erosion losses calculated per one particle (impact). Therefore, we recalculated the intensity of the process of erosion fracture as the volume loss per one impact of a particle $\Delta V$ by the formula

$$\Delta V = \frac{\rho_p \pi d_p^3 \Delta m}{\rho m_e},$$

where $\rho_p$ and $\rho$ are, respectively, the densities of the erosive material and the obstacle and $d_p$ is the median size of a particle from the range under consideration.

The dependences of mechanical properties of the investigated materials (modulus of elasticity $E$, hardness $H$, and ultimate strength $\sigma_u$) were approximated by temperature functions according to the literature data [5, 6] and the results of our own experiments.
The densities of materials \( \rho \), their specific heats \( c_p \) as functions of temperature \( T \), melting (solidus) temperatures, and specific heats of melting were taken from the reference books [7, 8].

Since the intensity of erosion fracture \( \Delta V \) depends on the size of the particle \( d_p \), on its density \( \rho_p \), on the velocity \( w \) with which the particle attacks the surface of the obstacle [2], and on the mechanical and thermal properties indicated above, we can write

\[
\Delta V = A w^{a} \rho_p^{b} d_p^{c} \sigma_u^{d} H^{e} E^{f} (\rho c_p \Delta T)^{g} q_n^{h},
\]

where \( \Delta T = T_s - T \) and \( A, a, b, c, d, e, f, r, \) and \( n \) are unknown dimensionless constants that can be determined by using the theory of dimensions and the regression analysis of the experimental data.

It is worth noting that a similar approach was applied in [9] to the investigation of erosion fracture of brittle materials. In this work, the intensity of erosion fracture was regarded as a function only of five variables: the size of a particle, its density, collision velocity, critical stress intensity factor, and the hardness of the material of a specimen.

By substituting dimensions of the corresponding quantities in Eq. (2), we obtain

\[
L^3 = \left( \frac{L}{T_s} \right)^a \left( \frac{M}{L^2} \right)^b \left( \frac{M}{T_s^2 L} \right)^c \left( \frac{M}{T_s^2 L} \right)^d \left( \frac{M}{T_s^2 L} \right)^e \left( \frac{L^2}{T_s^2} \right)^f \left( \frac{L^2}{T_s^2} \right)^g \left( \frac{L^2}{T_s^2} \right)^h, (3)
\]

where \( L, T_s, \) and \( M \) are the dimensions of length, time, and weight, respectively.

By equating the dimensions of the left-hand and right-hand sides of Eq. (3), we arrive at the following system of three equations for the seven unknown exponents:

\[
\begin{align*}
a - 3b + c - d - e - f - r + 2n &= 3, \\
-a - 2d - 2e - 2f - 2r - 2n &= 0, \\
b + d + e + f + r &= 0.
\end{align*}
\]

It follows from system (4) that

\[
a = 2b - 2n, \quad c = 3, \quad f = -(b + d + e + r).
\]

By using these expressions, we reduce expression (2) to the form

\[
\Delta V = A w^{2b - 2n} \rho_p^{b} d_p^{3} \sigma_u^{d} H^{e} E^{-(b + d + e + r)} (\rho c_p \Delta T)^{g} q_n^{h},
\]

Expression (5) can be rewritten in the dimensionless form as follows:

\[
\frac{\Delta V}{d_p^3} = A \left( \frac{\rho w^2}{E} \right)^b \left( \frac{\sigma_u}{E} \right)^d \left( \frac{H}{E} \right)^e \left( \frac{\rho c_p \Delta T}{E} \right)^f \left( \frac{q_n}{w^2} \right)^g.
\]

The dimensionless experimental data (22 values) were processed by the method of multiple regression analysis by using the STATGRAPHICS applied software in six versions most of which correspond to various modifications of Eq. (6). Thus, we considered the cases where the term \( \sigma_u/E \) was successively replaced by one of the following expressions: \( \sigma_y/E \), \( (\sigma_u + \sigma_y)/2E \), \( (\sigma_u + \sigma_y)e/2E \), \( K_c/E d_p^{0.5} \). The values of the yield limit \( \sigma_y \), relative elongation