Volume 3, Issue 5, May - 2025 **ISSN(E):** 2938-3773

TECHNICAL CERAMICS TECHNOLOGICAL ANALYSIS

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Abstract
In the world of innovative materials, ceramics play an important role due to their wide range of properties. Ceramic technology is based on the processes of preparing ceramic masses, molding raw semi-finished products and thermal bonding. The development of a ceramic structural material that combines high strength and heat resistance has always been very relevant.

Keywords: Ceramics, fine structure, aluminum, nanostructure, aluminum hydroxide, density, composite, mechanical, pressing, complex, ultrafine, powder, fibrous crystals, heat resistance, Poisson's ratio, strength.

Introduction

In the world of innovative materials, ceramics play an important role due to their wide range of properties. Interest in structural ceramics is growing so much that it is important to characterize research in this area as a key area of modern materials science.

To obtain high-quality ceramics, it is necessary to grind the raw materials and obtain a finely dispersed structure. This problem was solved by processing aluminum waste and its alloys into nanostructured aluminum hydroxide, which made it possible to obtain ceramics with high properties.

Ceramic technology is based on the processes of preparing ceramic masses, molding green semi-finished products and heat bonding. With regard to structural technical ceramics, it is necessary to solve the following problems: obtaining products with densities close to the theoretical one, ensuring a finely dispersed defect-free structure, distributing phases and bond strength along the interfaces of composite materials, obtaining products of complex shape with minimal use of expensive mechanical processing. Traditional press-heat bonding processes in some cases do not allow satisfying the requirements imposed as a whole. A significant problem arises, for example, in the production of products from ultra-dispersed powders of submicron size, and the use of initial powders of such dispersion within the framework of traditional technologies does not allow realizing all their potential advantages in achieving a high level of mechanical properties. These problems arise at the initial stage of powder synthesis, since heterogeneity at the submicron level is necessary to stabilize ultra-dispersed structures in the material. However, even at the later stages of technological processing, it is necessary to ensure a high level of regularity and distribution of the structure throughout the entire process of converting porous raw materials into dense materials, which requires suppression of recrystallization processes occurring at the intermediate stages of sintering. To solve this problem, processes such as dynamic pressing, based on strong thermomechanical effects, have been developed. But at the same time, there is a certain optimal ratio of mechanical work performed on the mass of powder and the thermal energy introduced into it to achieve the required structural state of the material.

In connection with the above, a number of new technical solutions have been developed, based on the known structures of the behavior of powder systems under thermomechanical influences, as well as fundamentally new technological processes for the production of ceramic products.

The most important practical processes include injection molding of complex-shaped products; heating and welding in compression furnaces under gas pressure of a certain composition; hot isostatic pressing. Technological solutions based on new results of research into the properties of refractory compounds; ultra-high-speed heat welding with microwave heating; changing the shape in the superplastic deformation mode; high-speed (dynamic) compaction; Impregnation is a process for manufacturing products from composite (ceramic-ceramic or ceramic-metal-ceramic) materials by impregnating porous ceramic frameworks with metal solutions and completely or partially converting the infiltrate into a refractory compound.

Traditional processes of technical ceramics technology are described in detail in the literature. The production of ceramic products reinforced with whiskers or discrete fibers with good physical and mechanical properties includes the following stages:

- ✓ preparation of the initial components and their processing (grinding, oxidation, hardening, deagglomeration, etc.);
- ✓ preparation of matrix powders and reinforcing elements for mixing (colloidal processing);
- ✓ mixing of components to obtain homogeneous mixtures;
- ✓ preparation of mixtures for molding (drying, granulation, etc.);
- ✓ Molding and manufacturing of the final product (project) by the method of thermal bonding with or without pressure.

When creating new ceramic materials for use in conditions of exposure to an uneven temperature field (thermal shock), developers use technological methods that allow designing a structure capable of demonstrating high resistance to the development of thermal cracks (for example, creating porosity using calcined additives, introducing oxide fibers or whiskers). Materials with such a structure always have lower strength compared to high-density fused ceramics. In this case, strength has to be “sacrificed” for the sake of increasing heat resistance. This corresponds to certain criteria of heat stability:

$$R_1 = \frac{\sigma_b(1-\mu)}{E \cdot \alpha}; \qquad R_2 = R_1 \cdot \lambda$$

where σ_b - ultimate tensile strength;

μ - Poisson's ratio;

E - normal modulus of elasticity;

α - coefficient of thermal expansion;
λ - coefficient of thermal conductivity.
Therefore, to increase R_1 (for given μ and α), it is necessary to increase σ_b and decrease E. However, an increase in strength is always associated with an increase in the elastic modulus. Therefore, to increase heat resistance, the parameter E is reduced (for example, by creating porosity), but this occurs at the expense of strength (by reducing σ_b). In this case, it is necessary to try to ensure that this "loss of strength" is reasonable (for example, if small spherical pores are created, uniformly distributed throughout the entire structure of the material, then the loss of strength can be insignificant). If certain methods for designing a ceramic structure do not effectively increase its heat resistance, a second phase with high thermal conductivity can be introduced into its composition. With an increase in λ (in the case of metal ceramics), the rate of elimination of the resulting temperature gradient increases. In this case, it is necessary to take into account the possibility of destruction due to thermal fatigue (due to differences in α of different phases).
In short, the development of a ceramic structural material combining high strength and heat resistance has always been very relevant.

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