The various forms of refractory heat treatment are considered: drying, initial firing, and heat treatment proper. It is possible to mechanize the treatment completely starting with the molded refractories in ring tunnel ovens with single-row shrinkers. There is a discussion of stages and causes for unsatisfactory working in Russian ultrahigh-temperature shaft ovens for making superdense products from magnesium oxide.

**Keywords:** heat treatment, drying, initial firing, heat treatment proper, ring tunnel furnace, shaft furnace.

The three processes are conducted in heat-technology plant (HTP) termed dryers and ovens. Current HTP are fairly complicated systems consisting of reactors in the form of drying or oven chambers; transport facilities; energy supply systems; facilities ensuring industrial and ecological safety and process control. The main element in any HTP is the reactor, where the process is conducted with heat and mass exchange between the product and the working body.

At this organization in the half-century of its existence we have dealt with a wide range of HTP for treating powder and molded refractories. The HTP developments have taken two lines for traditional and new forms of heat treatment. In the development of HTP for traditional forms, much use has been made of experience in operating existing plant with the improvement of individual components and the plant as a whole. In the development of HTP for new forms of product treatment, a vigorous search has been made for solutions for the reactors in drafts and design developments.

Out of all the treatment problems that institute has handled, two have not been resolved. The first is to obtain complete mechanization of the treatment, and the second is to develop an ultrahigh-temperature shaft furnace for making superdense products from magnesium oxide.

Complete mechanization has been achieved without particular difficulty in the technology of handling powder products. In the technology of making molded products (items), complete mechanization has been possible only in the production of components of simple shape using saggers of one particular style of standard dimensions. For items of complicated shape, complete mechanization is possible only with single-row saggers. The saggers should be of geometrically simple form and technologically effective for the complete mechanism of loading and unloading the product.
When there is complete mechanization, the optimality of the saggars is governed by there being a rational relationship between two functions: providing good parameters in the HTP and providing the scope for loading the initial product into the reactor and unloading the finished product. A rational relationship between the two functions is provided by single-row saggars, which allow one maximally to intensify the heat treatment while providing high quality in the finished product and completely mechanized loading and unloading for products of any shape and size.

Projects and design developments for complete mechanization have become applicable to components of any shape and size by the use of a flow line involving a press, loading and unloading devices, and a ring tunnel furnace RTF, with single-level saggars and fast treatment modes [1]. An RTF reactor differs from a tunnel oven in having a ring form and consisting of a ring tunnel and a line support moving within it. The ring tunnel has a gap for loading on to the line support and unloading the finished product. This RTF combines the advantages of two furnaces: a countercurrent recuperative scheme for a tunnel furnace reactor and a proper design for a ring furnace reactor with rotating base.

A unique development at the Institute has been the complete mechanization of treatment for refractory components at the Suvorov Mineral Corporation in the preliminary firing of large molded aluminosilicate components in an RTF by the use of single-level saggars on a lined base [2]. The furnace was constructed in 1974 and operated successfully for several years. This was the first RTF built in the USSR for refractory treatment. The use showed reliable operation, scope for complete mechanization, simplicity of process management, the provision of elevated accuracy in the temperature and aerodynamic conditions, and high quality in the finished product. Work has been continued on complete mechanization for molded refractories at this organization with the use of RTF with single-level saggars, and an RTF was built to the design of documentation from the designs office at the Kazakh refractory plant at the start of the 1980s [3]. Subsequent developments in complete mechanization have been lacking, and at present there are no project, design, or research studies on this at this organization, although the problem remains urgent.

The development of an ultrahigh-temperature shaft furnace (UTSF) arose mainly from the need to reduce the consumption of fuel and increase the density of the product based on magnesium oxide on firing an initial product of the same composition. That problem arose during the last quarter of the last century and remains current today. The topic is currently being dealt with by the Kazakh organization and the present one. Design and project developments by these institutes represented the UTSF as an HTP consisting of a reactor, energy resource systems, and systems providing industrial and ecological safety and control. The reactor as a principal element in the UTSF was represented as of vertical construction and consisting of a loading device, a vertical chamber of mainly cylindrical section, and an unloading device. The loading device was located at the top end of the chamber, while the unloading one was at the bottom end [4]. The loader consisted of a bunker and a vertical handling system together with a sealing tube. The chamber consisted of a steel body with refractory lining. The chamber was fitted in horizontal sections at various levels in the middle of the height with tubes for burners and two pipes diametrically opposite to one another at the top end for diluting the spent gases with air and removing these gases from the chamber. The working space consisted of a vertical cylindrical channel lined by refractories. The unloading device consisted of a mechanism for handling the components, a vertical handling system, and a sealing tube and dispenser.

In these UTSF developments, particular importance attached to the reactor design. The developments were handled in two stages in relation to the degree of preparation for the initial product. In the first stage, as the initial product we used natural magnesite of a certain fractional composition with two-stage heat treatment. In the first stage, the initial product was decomposed into a solid porous component made of magnesium oxide containing impurities and a gaseous component composed of carbon dioxide. In the second stage, the solid porous component was sintered to increase the density.

The main difference of the UTSF at this stage from existing furnaces lies in the form and size of the working channel, and also in the higher temperature used. It was quickly established that in a two-stage process with natural magnesite of variable composition it was impracticable to obtain a product of ultrahigh density simply by raising the temperature level.

In the second stage of developments, we used briquettes in the form of ellipsoids made of the solid porous product of stable composition with much smaller dimensions than those of the fractions of initial product from natural magnesite. At that stage, the UTSF differed substantially from existing ovens on design features and reactor dimensions, together with differences in the equipment, the throughput, the temperature and the aerodynamic conditions, the energy source systems, the industrial and ecological safety and control. The latest UTSF, including the reactor and the equipment as a whole, was built by the two institutes at the end of the past century to obtain a superdense product from magnesium oxide. The initial material consisted of briquettes of porous magnesium oxide. The maximum firing temperature in the furnace was over 2000°C, but this design was not constructed, and subsequent work on Russian UTSF was halted, and it was decided to build a UTSF designed by the firm of Maerz at the Magnesite Corporation. The design documentation for the Maerz UTSF was drawn up by this organization in the current century with the assistance of other design organizations. That furnace was actually constructed, and it is at the stage of being exploited.

The following may be noted about the results from Russian developments of UTSF as contrasted with the working and design parameters of the UTSF by Maerz as built and brought into use. Setting up a UTSF to obtain a superdense