THE FIRST FIRING OF DOMESTIC PORCELAIN*

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Engineers of the Dulevo "Pravda" Porcelain Factory, I. G. Shul'man, T. A. Pashkova, E. I. Kovrigin, and N. D. Bogdanova, in their article "How Should the First Firing of Porcelain be Carried Out?" have timely raised one of the most important problems of porcelain technology [1].

As is known the first firing is introduced into the production technology for thin-walled porcelain to convert the material from a friable, soft material that during glazing has a vulnerable mechanical strength, requiring (during subsequent processing in intermediate operations) the preliminary removal of the water of constitution from the clay substances, gases produced from the combustion of organics, decomposition of carbonates, sulfates, and other minerals containing volatiles. The low mechanical strength of the unfired products and the tendency to swell during glazing sharply increases the percentage of loss. The removal of gases during any disturbance in the second firing cycle causes the appearance on the goods of firing defects such as bubbles, blibs, curtaining, crawling of the glaze, all reducing the quality of the product.

On the other hand the first firing of porcelain ware is one of the most laborious and most expensive processes in the production cycle, which requires the use of saggars or cars built up with protective baffles and also fuel for burning the products, and in addition it includes such jobs as loading and unloading the green product from the kiln, checking the quality, and repeated interoperational transporting of the semifinished articles. In this case, scrap in the form of loss and damaged goods may reach a very high proportion of the output, and cause an irregular porosity in the body, requiring sorting of the finished products prior to glazing, using glaze slips with different densities, and the introduction of breaks in the production cycle.

In connection with this, the question of eliminating the first firing has attracted the attention of specialists as being one of the important reserves in simplifying and cheapening the technical process in porcelain manufacture. A positive solution to this problem requires the development of the appropriate measures for eliminating the softening of the body during glazing, increases in the mechanical strength, and a reduction in the proportion of firing defects.

The softening (slaking) of the nonbiscuited product is connected with the swelling of the clay substance in water accompanied by volume expansion giving rise to the breakdown of the weakened body. This process occurs most intensely during the simultaneous suction of water from both sides into the body [2]. In this case the contraflow movement of the water prevents the expulsion of air from the pores, and creates additional pressure, contributing to the breakdown of the body. The softening of fine ceramic products is expressed in the breaking away of sharp edges on the body - the formation of large sloping sections with breaks in the majority of cases at the base, and also with some segregation.

Thick-walled products (more than 4 mm) can be successfully glazed on the dry body since much of the body (in the core) remains dry. It is possible to once-fire such thin-walled sculptured products as are covered with glaze, mainly only on the outside.

In the last two decades various methods have been studied which would make it possible to change over to the once-firing of thin-walled porcelain ware, for instance, by incorporating strengthening agents in the body, using double-staged glazing, applying glazes by spraying, high-temperature drying of the green products, etc. Many years' work at the State Research Institute for the Ceramic Industry aimed at strengthening porcelain body with various organic and inorganic additives have not produced positive results.

*A Discussion.

Some additives (Troshkov clay, bentonite, carboxymethyl cellulose, sulfite lye, etc.) have somewhat strengthened the dry body, but they reduce the molding properties and especially the casting properties of the bodies too much. The increase in strength is not connected with any rise in the resistance of the body to slaking (softening). The use of the double staged glazing method especially by spraying enables us to extend the range of articles which can be subjected to single-firing. The application of the glaze by mechanical spraying, as far as the uniformity glaze cover is concerned, cannot compete with the dipping method especially in the irregular layer obtained on the internal surface of hollow, narrow-necked products, in connection with which this method of glazing does not find wide use.

The dousing and drain-off methods are also used in two-step glazing. With the first glazing method, the glaze is poured into the article and then drained off. The outside of the article is glazed by dipping or spraying (covering up the throat of the vessel first). Sometimes after the first stage of glazing the products are dried and then glazed on the outside. The use of the drain-off method of glazing has enabled the M. V. Lomonosov Porcelain Factory to change over to the once-firing of certain groups of products [3] (jugs, vases, mugs, etc.) with a body thickness of 3-4 mm.

The dousing method of two-step glazing for cups and mugs [3] at present is used in a number of factories (Dmitrov, Polonsk, Riga, etc.). With this method it is not possible to prevent entirely the softening of the edges of the products; and applying paraffin or sponging with glaze is difficult and hinders the glazing operation.

The high-temperature drying (up to 400-450°) in place of the first firing has been proposed by the Ukrainian Research Institute for the Glass and Pottery Industry [4], but this insufficiently increases the strength of the body in the semifinished state, and its resistance to softening is still too low. Furthermore, in the opinion of the workers at this Institute [5] the optimum porosity of the body for a good quality glaze is 22-25.5%, and is ensured only at a temperature of 450-550°. In this respect the high-temperature drying may be considered as the low-temperature first firing.

It should be considered that with mechanized glazing methods we require a higher temperature for the first firing than with manual glazing (900-1000°).

The effect of the first firing on reducing the firing defects is slight. Many years experience at the M. V. Lomonosov Factory where the products are glazed in the green state (chemical apparatus, laboratory ware, decorative vases, sculptured products, figures, etc.) for more than 30% of the entire production, have not confirmed that there is any essential difference between products made by once- or double-firing in terms of the percentage of firing defects. This is explained by the fact that the sintering or the vitrification of the body and fusion of the glaze occur at higher temperatures than the evolution of gases. If this is not so, then it would be impossible to obtain high quality electrical porcelain and sanitary semi-porcelain ware which are fired only once.*

The authors of the article under discussion correctly state that the quality of the first firing cannot be determined merely in regard to the porosity of the body without taking into account its mechanical strength. They indicate that a mechanical strength of 125 kg/cm² and a water absorption of 18-19% would be sufficient, and consider that such factors may be obtained at a firing temperature of 900-1000°. It should be noted that they, like the proponents of high-temperature drying [5], do not consider the effect of the composition of the body, the fineness of grinding or the method of fabricating the product. If these factors did not have any effect then the quality of the first firing could be determined merely by the porosity of the body. At the M. V. Lomonosov Factory where they use bodies of different compositions, different degrees of grinding, and methods of fabrication, one body is properly glazed with a porosity of 16%, and others with porosities of 23-24%. Under the effect of the body composition and technical factors, there is an alteration in the mutual relationship between the porosity and the strength of the body. In the general case both of these factors up to temperatures of 800-900° rise symbatically, and above this temperature acquire an inverse relationship to each other. From the above, the following conclusions may be drawn:

On first firing for thin-walled (up to 3 mm) porcelain products for domestic purposes remains necessary until fundamental means are discovered of increasing their mechanical strength and resistance of softening (slaking);

*In the actual single-firing cycles for the products burned in a continuous kiln, they are distinguished by a relatively longer period of oxidizing soak — editor's note.