

## NOTE ON THE CASTING OF PORCELAIN GLASS POTS.<sup>1</sup>

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The procedure of casting glass pots has been described by several contributors to THIS JOURNAL.<sup>2</sup> It is the purpose of the present paper to call attention to several points of practical importance.

The characteristics of a casting slip as well as of the fired body depend, first, upon the composition—the content of grog, kaolin, ball clay, and feldspar; second, the sizing of the grog; third, the peculiar physical and chemical qualities inherent in primary kaolins as differentiated from the secondary ones, and in ball clays against the fire clays; fourth, the amounts and proportions of sodium silicate and carbonate of soda.

The following mixtures have been used successfully in the Pittsburgh Laboratory of the Bureau of Standards for the casting of glass pots:

Mixture No. 1.	
	Per cent.
Whiteware-bisque grog.....	48
Feldspar.....	7
Kentucky ball clay, No. 4 or No. 6.....	11
Tennessee ball clay No. 5.....	11
Georgia, Florida, Delaware and North Carolina kaolins, $\frac{1}{4}$ of each.....	23

Mixture No. 2.	
	Per cent.
Whiteware-bisque grog.....	48.0
Feldspar.....	7.0
Kentucky ball clay No. 4.....	8.5
Tennessee ball clay No. 5.....	8.5
Georgia, Florida, Delaware and North Carolina kaolins, $\frac{1}{4}$ each.....	28.0

<sup>1</sup> By permission of the Director, Bureau of Standards.

<sup>2</sup> A. V. Bleininger, *J. Am. Ceram. Soc.*, 1, 15-24 (1918); F. H. Riddle, this number, pp. 647-658.

Mixture No. 3.	
	Per cent.
Whiteware-bisque grog.....	48.0
Feldspar.....	6.5
Kentucky ball clay No. 4 or No. 6.....	11.0
Tennessee ball clay No. 5.....	11.0
Kaolins, as before.....	23.5

Mixture No. 3 has been used more extensively than the others.

It is evident that the composition, in general, governs the final qualities of the pots, as is true of all ceramic bodies.

The sizing of the grog, in this case the waste bisque obtained from whiteware potteries, is quite an important factor. It is especially desirable to avoid too large a proportion of fines passing the 80-mesh sieve, since they promote vitrification too decidedly. While it is intended that the pot body should be dense and nearly non-absorbent, it is not good practice to develop a glassy structure. This objection would not hold if the grog possessed superior refractoriness and the fine particles by absorption became effective in increasing the rigidity of the mass. The mechanical analysis of the grog used corresponds fairly closely with the following sizing:

	Per cent.
Between the 10- and 20-mesh sieves.....	30
Between the 20- and 40-mesh sieves.....	40
Between the 40- and 80-mesh sieves.....	17
Through the 80-mesh sieve.....	13
	<hr/>
	100

The physical and chemical qualities of the clays used are of evident importance with reference to their response to the effect of the alkaline electrolytes. The primary kaolins are most responsive, followed by the secondary kaolins, ball clays and fire clays in the order given. As a rule, the more plastic the bond clays, the smaller will be the amount of water required in the slip and the quicker the time of casting. Distinct differences were noted in the use of the several ball clays.

Slips have been made containing mixtures of three ball clays, Tennessee No. 5, Kentucky No. 4 and No. 6 in various proportions. The Tennessee No. 5 is generally very plastic and pos-

sesses good bonding properties; it increases the specific gravity of the slip and lowers the water content. At the same time it is effective in reducing the time of casting, lowering the shrinkage and the time of drying. It seems to be affected more profoundly by the reagents used, a fact associated with its fineness of grain and plasticity. The Kentucky ball clay No. 4 has fair plasticity and can be used to replace the Tennessee No. 5 clay more or less completely. It has been used alone to very good advantage but its slightly inferior plasticity necessitates the use of a larger quantity. The Kentucky ball clay No. 6 resembles a fire clay in its properties. Its plasticity and bonding power are lower than those of the preceding materials. In a slip containing some of this material the water content and shrinkage are higher, and the specific gravity lower. The strength likewise is decreased. It may be used because of its property of firing to a dense structure at lower temperatures.

From 17 to 22 per cent of ball clay has been used in our work, the higher amount giving better slips for casting. Definite limits regarding the use of any one ball clay can hardly be given since successive shipments rarely show the same physical properties. Any variation, therefore, might necessitate increasing or decreasing the quantity used. If several ball clays are used a slight change in the properties of one will not upset the working qualities of the mixture.

The presence of soluble salts in clays often causes considerable trouble in that the slips stiffen as soon as agitation ceases. It has been found desirable to add 0.01 per cent of barium carbonate with the alkaline electrolytes for the purpose of eliminating the soluble sulphates.

The use of the sodium carbonate and silicate has for its object reduction of the water content, formation of a dense, heavy slip, decrease of shrinkage, and the development of a capillary structure which makes possible increased speed and safety of drying. The amount of these salts which can be used varies from 0.20 to 0.33 per cent of the anhydrous compounds in terms of the dry weight of the clay and non-plastic materials. With any one composition the relative proportion of the two salts seems to be of greater im-

portance than the total quantity used. The proportion which has given the best results is 0.12 per cent of sodium silicate to 0.09 per cent of sodium carbonate. With this ratio the water content is approximately 22 per cent of the weight of the dry materials. A water content of 25 per cent was found to be required when the salts were added in the ratio of 1 : 1. It has been shown to be desirable not to introduce both salts at the same stage of the blunging. The silicate is dissolved in the water and then the dry body materials, thoroughly mixed, are added. This mixture is blunged to form a fluid slip and the carbonate is then added. The viscosity of the slip is increased somewhat by this addition of electrolyte. The increased "stiffness" of the mass seems to be apparent as a kind of stickiness rather than greater viscosity, due to coagulation, and the slip resembles heavy molasses. A further addition of silicate at this point lowers the viscosity, which indicates that the ratio of the salts is of primary importance.

The high viscosity desired is such that the pot will cast solid over night, in approximately 17 hours. The higher the viscosity, the slower is the casting of the slip, the greater the drying shrinkage, and the longer the time required for drying. With very viscous slips but little absorption of water by the plaster mold takes place—as the mass stiffens too quickly to permit of flow. However, with such a slip the pot does not become solid for some time.

With a slip of low viscosity considerable flow occurs, due to the absorption of water. An undesirable structure may develop when the slip passes down within the partially-stiffened outer portions of the pot wall. The less viscous slips, however, become solid in a shorter time and show a lower drying shrinkage. Control of viscosity must arrive at a compromise between the two extremes.

The time of casting is controlled to a considerable extent by the proportion of the two salts. With slips of practically equal viscosity an increase in the amount of sodium carbonate increases the time required for casting. Several attempts were made to cast pots using the proportion of 2 sodium carbonate to 1 of silicate. Very little or no casting occurred and the pots remained soft for 20

hours or more. They would crack in the mold and yet be too soft to allow the removal of the core. Pulling the latter would cause the pots to soften out of shape. On the other hand, with a proportion of 1 sodium carbonate to 2 of silicate, the slip was exceedingly heavy, with a specific gravity of 1.96, and yet of low viscosity. These slips did not stiffen, when allowed to stand, like those higher in carbonate. They permitted high absorption by the mold, showed low shrinkage, and cast solid in from 11 to 14 hours. The pots cast from these slips possessed a good exterior appearance but their internal structure showed much flow and lamination. The proportion of 4 sodium silicate to 3 of carbonate invariably gave the best results with reference to good casting quality, time of setting, moderate drying shrinkage, and satisfactory strength. The drying shrinkage of such pots is about 1.84 per cent in terms of the dry length and the burning shrinkage 6.82 per cent. The condition of the mold also affects the time of casting and, as is to be expected, the drier the plaster the more rapid is the absorption of water.

Summarizing these points regarding the casting of glass pots, it is apparent that the water content must be low, usually between 22-25 per cent in terms of the dry weight of the materials, the specific gravity of the slip from 1.90 to 1.95, and the viscosity quite high. The body thus produced must have low drying shrinkage and high mechanical strength. The amount of electrolyte varies from 0.20 to 0.33 per cent of the weight of the dry materials and the best ratio of sodium silicate to the carbonate is 4 : 3. An increase in sodium silicate decreases the water content, lowers the viscosity, and shortens the time of casting. An excess of it produces flow or laminated structure.

Kaolins respond most readily to the action of the alkalies, and fire clays least. In slips the use of a more plastic clay in place of a leaner one (fire clay) brings about higher specific gravity, shortening of the time of casting, decreased drying shrinkage, and increased strength. The use of several plastic clays is recommended and the introduction of a small amount of barium carbonate seems desirable.