THE RHEOLOGICAL AND TECHNOLOGICAL PROPERTIES
OF SILICON CARBIDE SLIPS AND CASTINGS
CONTAINING ADDED SILICON AND CLAY

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Silicon carbide refractories are produced with a silica, clay, nitride or oxynitride binder each of
which gives the product specific properties and determines its fields of application ([1], pp. 39-147).
Silicon carbide refractories are usually produced by semidry or plastic molding, ramming or drawing.
The method of slip-casting them and the properties of the aqueous slips have not been adequately investiga-
ted [2-5]. The thin-walled silicon carbide products of intricate shape now required can be made only
by casting. In this context the present writers investigated the influence of added Latnen clay and silicon
on the properties of silicon carbide slips and castings.

The experiments were carried out with silicon carbide dry-ground in a vibro mill. The grinding
time was varied 6-15 h with the type of mill and the number of grinding elements but in each case the pro-
portion of grains finer than 7 μ was 75-80% which included 55-60% grains finer than 3 μ. The moisture
content of the slips was ~40% and the pH 8.5-9.8 in all cases other than in the experiments aimed at deter-
mining the influence of the pH.

The LT-1 Latnen clay used consisted of grains finer than 0.5 mm and its composition was 33.04%
Al₂O₃, 48.56% SiO₂, 1.27% Fe₂O₃, 1.98% TiO₂, 0.53% CaO, 0.27% MgO, and 0.44% R₂O.

The silicon used was the KR-1 type consisting of 99.08% Si and 0.92% impurities in the form of iron,
aluminum, and calcium. The silicon was ground in ball and vibro mills for varying periods with a view
to determining the influence of the method and degree of grinding on the properties of the silicon – silicon
carbide slips and castings. The grain size distribution of the silicon is given in Table 1.

The influence of the pH was investigated with slips containing 10% clay or 40% silicon in acid (HCl
electrolyte), near-neutral, and alkaline (NaOH electrolyte) media.

The added 40% silicon or 10% clay produced a slight increase in the viscosity of the silicon carbide
slip in its fully disturbed-texture state at its optimum casting pH of 10-11. The limiting shear stress in-
creased correspondingly. A decrease in the pH to a neutral or even acid medium sharply increased the
viscosity, however (Fig. 1) while the zeta potential, which is at a maximum with pH 9-10 (Fig. 2), de-
creases.

The kinetic stability of slips containing added clay or silicon is higher in neutral and acid media and at a minimum
with the optimum pH of 10-11 (Fig. 3). The slip with added silicon is more stable in an alkaline medium than the slip containing
clay.

Whether the slip contains or does not contain added clay or silicon, an increase in the pH results in a significantly slower building-up rate of the casting but more particularly when the slip contains added silicon. In the latter case the rate is slower over the entire pH range (Fig. 4). Over the optimum casting range pH 9-11 the building-up rates are similar for all slips.
Fig. 1. The pH dependence of the viscosity $\eta_m$ of the fully disturbed texture of silicon carbide slips with added silicon (1) and clay (2) and without additive (3).

Fig. 2. The pH dependence of the zeta potential of silicon carbide slips with 40% added silicon (1) and 10% clay (2) and without additive (3).

Fig. 3. The kinetic stability of silicon carbide slips with 10% added clay (a) at pH 1.3 (1); 7.2 (2); and 10.2 (3), and with 40% added silicon (b) at pH 5.1 (4); 8.5 (5); and 11 (6); $\Delta W$ is the moisture content of the top layer of the slip.

An increase of the pH of slips with or without added silicon or clay greatly reduces the porosity and increases the strength of castings fired for 6 h at 1100°C in an oxidizing medium (Fig. 5). However, the porosity is considerably higher and the strength lower for specimens containing added silicon owing to the fact that during firing in an oxidizing medium at 1100°C without filler the silicon is oxidized to $\text{SiO}_2$ (cristobalite) and thus loosens the casting. The weight of the specimens increases by 7-13% depending on the initial silicon content.

After firing the castings containing silicon and subsequently silica in a coke filler at 1380°C reduces the porosity (Fig. 6) but the pH dependence of the porosity is not affected. Firing at 1380°C reduces the porosity also of castings containing added clay. Higher-density products can thus be produced by firing the castings containing added silicon or clay at an ultimate temperature of 1350-1380°C, i.e., without intermediate firing at 1100°C (Table 2). The castings will then be stronger, notably those containing silicon and thus bonded with oxynitride.

An investigation was next carried out of the influence of the proportion of added silicon and clay on the rheological and technological properties of silicon carbide slips and on the properties of the slip castings. The experiments were conducted at the optimum pH, viz. 9-11.

A decrease in the proportion of added silicon from 40 to 20% and clay from 10 to 3% produces a decrease in the viscosity of the fully disturbed-texture slip (Fig. 7) and the shear stress decreases correspondingly but the viscosity remains higher than that of a slip without additive.

The silicon and clay added to the slip reduces its zeta potential at a rate which increases with the proportion of additive (Fig. 8). The difference between the absolute values of the zeta potential of slips with 40% silicon in Fig. 8 and those in Fig. 2 is attributable to the fact that the grain size distributions of the slips were dissimilar.

With 40% added silicon the kinetic stability of silicon carbide slips increases slightly but with 10% added clay it remains almost unchanged (Fig. 9) at pH 10.2-11. The silicon used in this case was vibro-ground for 12 h and not washed. Acid washing, especially of fine-ground silicon, greatly reduces the kinetic stability since a large proportion of the fine fractions is lost during washing and subsequent decanting in addition to which the kinetic stability of slips of ball-mill ground silicon is lower than that of a slip of silicon ground in a vibro-mill for even a short period so that all subsequent experiments were carried out with vibro-ground silicon.