Effect of Filler Particles on Sedimentation of Investment Slurry and Strength of Ceramic Shells

S. Venugopal Rao
PG Student, Department of Mechanical Engineering, JNT University, Hyderabad

Under the Guidance of Dr. A. Chennakesava Reddy, Associate Professor, JNTUH College of Engineering, JNT University, Hyderabad.

ABSTRACT

The materials used to build the ceramic shell, especially binders and refractories, play a vital role in the production of quality castings. The problems of ceramic shell making based on different binders have been discussed in many papers. But there are very few publications, where there is an exposition of physico-chemical- thermal phenomena due to refractory materials and behavior of uncontrollable (noise) variables during the preparation the dip- coating slurry, manufacturing of ceramic shells and production of castings.

Dip-coating slurries are prepared by adding the refractory powder to the binder liquid, using sufficient agitation to break up agglomerates and thoroughly wet and disperse the powder. The properties of the ideal slurry for ceramic shell process may be summarized as follows:

- It must not contribute any contaminants that lower the refractoriness of the mould, and must be completely inert at the operating temperatures.
- The slurry of filler and binder must be sufficiently fluid to allow efficient packing around the pattern
- The slurry should set within a controllable time to give a mould of high green strength.

The actual percentage composition of dip- coating slurries depends on the particular refractory powder, type and concentration of binder, liquid vehicle, desired slurry viscosity. The important characteristics of binder should be considered for effective slurry preparation is its p^H, bench life, $\%SiO_2$ and size of SiO_2 particles. With aging, the viscosity increases, and within eight months under a temperature of 6^0 C in a sealed vessel, the viscosity rises to 13.8 seconds. With a viscosity of 14.5 seconds, spontaneous of shells, made from successively ripening bonding agent falls continuously from 32

kg/cm^2 (from an aged binder) to 3-4 kg/cm^2 from a bonding agent shortly before gelation.

The most important factor of refractory filler material is its density; which in fact, results the sedimentation of filler in the dip-coating slurry as shown in fig 2.2. The sedimentation of filler in the slurry leads to non-uniform density and consequently non-uniform viscosity, which promotes non-uniform strength and permeability of ceramic shell moulds. The highest sedimentation is attained by zircon and the lowest by silica flour. For practical use, coating materials with the lowest sedimentation are advantageous. These facts led to the search for methods of reducing the sedimentation rate of refractory filler materials in compound. The sedimentation rate of silica flour can be reduced considerably by grinding the flour in a ball mill with 0.5% unburned bentonite (caluculated to the volume of silica flour). That quantity does not affect shell strength adversely and permits pattern dewaxing in boiling water without damage to the shells, but it reduces the refractoriness of the shell.

Another method of reducing the sedimentation rate of silica flour is based on grinding the flour with 1-% titanium dioxide. For alumina, grinding with other ingredients is less suitable in view of the strong abrasive effect of alumina, which results in rapid deterioration of equipment. The sedimentation rate can be lowered by adding a mixed medium of alcohol- water with an addition of glycero-alcohol to the ethyl silicate binder.

Tests of coating materials containing alumina have shown that the sedimentation rate in the mixed environment of alcohol and water decreases by a ratio of 12.5: 87.5 with an addition by volume of 2.5% hexantriol or polyoxypropylentrol so intensively that even after 90 min it is impossible to distinguish the division of the settling column. Dip-coating slu rry of 10% concentration of SiO_2 colloidal dispersion and hexantrol has the following shell bending strength: after drying 16.6 kgf/ cm^2 and 14.2 kgs/ cm^2 after firing.

The suspension viscosity and segregation in layers solidified from suspension prepared from refractory silica was investigated as a function of particle size distribution (PSD). In a concentrated suspension, the Stokes velocity is modified since hindered settling occurs and reduces the settling velocity of a particle, resulting in a longer residence time for the interaction between a particle and its neighboring particles in the hindered region where there is a higher solids concentration.

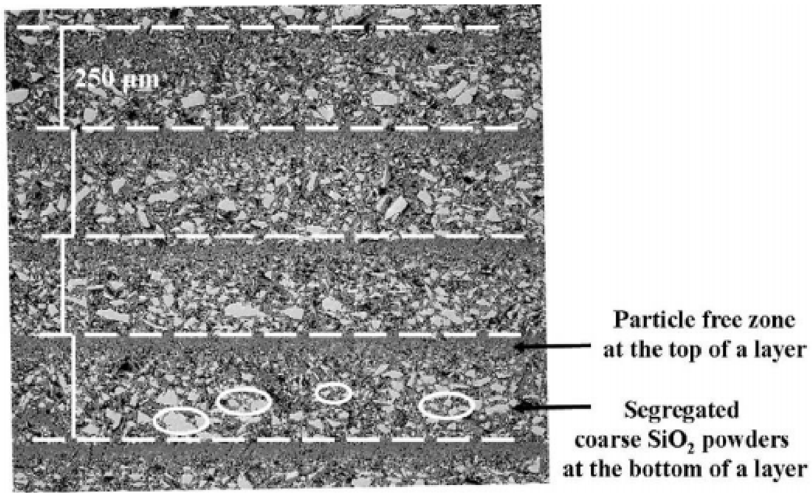

Figure 1: Different layers of ceramic shells.

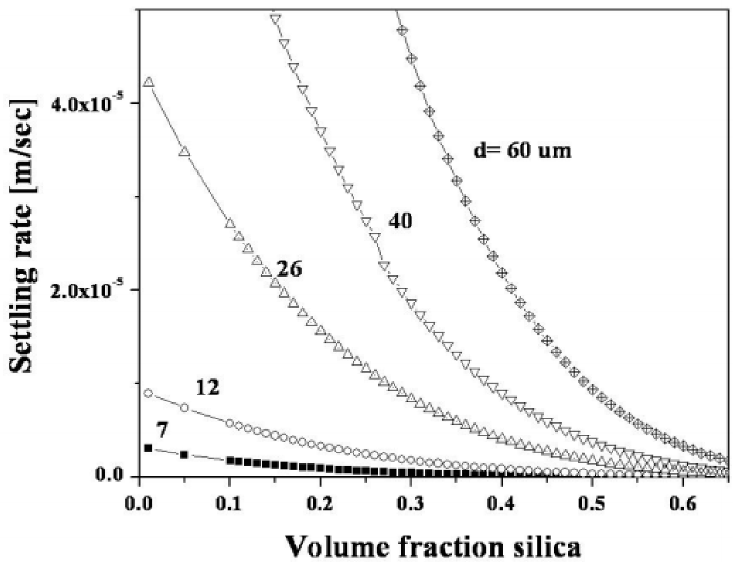

Figure 2: Settling rate as a function of volume fraction silica.

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