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The relative viscosity of the liquid-glass slurry filled with cooper slag

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Abstract
Objective is to determine the influence of the content of copper slag in liquid-glass slurry, temperature and specific gravity of the liquid-glass applied on the value of its relative viscosity. The relative viscosity of the refractory slurry was determined by a standard technique in the viscometer VZ-4. The results of investigation of influence of cooper slag serving as filler on the relative viscosity of

glass-liquid slurry depending on its temperature, fullness and density of the of sodium liquid-glass are presented. It is found that with increasing copper slag content in refractory slurry (from 0.1 to 0.4 kg per 1dm^3 of liquid-glass), the specific density of the liquid-glass applied (from 1150 to 1300 kg /m^3) and temperature decrease (from 50 to 20 °C), its relative viscosity increases according to a power law. As a result of the mathematical processing of the experimental data, the empirical relationship has been obtained, the value of the relative error is less than 2.6%.
The data obtained allow us to take decision rapidly on the necessary adjustment of the refractory slurry composition in the foundry shop conditions.
Key words: MOLD, LIQUID-GLASS, TEMPERATURE, FULLNESS, RELATIVE VISCOSITY

The state of the question

Sodium liquid-glass with the value of the silicate module M_{SiO2} = 2.8…3.2 is a non-deficient and relatively inexpensive domestic bonding material, which, in particular, is used for making ceramic shell molds (hereinafter CS). Significant disadvantages of liquid-glass as a component of CS are the reasons of the fact that it is used to perform only 2 ... 3 outer layers of CS.

Powder quartz usually is a filler of such liquid-glass slurries. It is a natural material, which is obtained as a result of quartz sand grinding [1, 2]. An alternative to powder quartz of liquid-glass slurries can be powder refractory materials of technogenic origin. Copper slag is among these materials, this is a waste of an abrasive powder of copper-smelting slags, the effect of which on the properties of a liquid-glass slurry has not been known until now.

Objective is investigation of the effect of the fullness of a liquid-glass slurry with a powdered copper slag, the specific density of the liquid-glass and the temperature on its relative viscosity.

Results of the research

The studies were carried out in the temperature range from 20 to 50 °C on slurries prepared on the basis of sodium liquid-glass (GOST 13078-81) with the value of the silicate module of M_{SiO2} = 3.0…3.2 and specific density from 1150 to 1300 kg/m^3 at 20 °C. A finely dispersed copper slag was used as the filler of the slurries, the amount of which (fullness of the slurry with a powder refractory - m) in the liquid-glass was from 0.1 to 0.4 kg per 1 dm^3 of the liquid-glass. The chemical composition and properties of the copper slag are given in Table 1.

Table 1. Properties and chemical composition of the copper slag

Characteristic	Value
Density of the material, kg/m^3	3300 – 3900
Bulk weight, kg/m^3	1600 – 1900
Ferrous oxide (Fe_2O_3), %	40 – 50
Silicon oxide (SiO_2), %	25 – 35
Magnesium oxide (MgO), %	No more than 5%
Calcium oxide (CaO), %	6 – 10

Preparation of liquid-glass slurries and determination of their viscosity were carried out according to the procedure of [3]. To prepare the refractory slurry into a liquid-glass of a certain specific density, appropriate weighed portions of the previously sieved copper slag were introduced and after careful mixing the temperature and the relative viscosity were determined. The relative viscosity was determined using a viscometer VZ-4 and a stopwatch. For the true value of the relative viscosity of the slurry (τ) under given experimental conditions, its average arithmetic value was taken based on the results of three measurements, if their values did not differ by more than 5%.

To construct a mathematical model τ = f(r,m,t), the obtained data were processed according to the procedure given in [4].

As a result of mathematical processing of the experimental data, the following empirical dependence was obtained (the magnitude of the relative error is less than 2.6%):

$$y = 12{,}3\cdot t + 16\cdot\rho_{PC} + 57{,}5m - 8{,}2\cdot t\cdot\rho_{PC} - 88{,}8\cdot t\cdot m - 91\cdot\rho_{PC}\cdot m - 29{,}06\cdot t\cdot\rho_{PC}\cdot(t - \rho_{PC}) + 246{,}9\cdot t\cdot m\cdot(t - m) + 48{,}8\cdot\rho_{PC}\cdot m\cdot(\rho_{PC} - m) + 64{,}8\cdot t\cdot\rho_{PC}\cdot(t - \rho_{PC})^2 + 109\cdot t\cdot m\cdot(t - m)^2 + 32{,}3\cdot\rho_{PC}\cdot m\cdot(\rho_{PC} - m)^2 - 2027\cdot t^2\cdot\rho_{PC}\cdot m - 1445\cdot t\cdot\rho_{PC}^2\cdot m - 5126\cdot t\cdot\rho_{PC}\cdot m^2,$$

where τ – relative viscosity, s; ρ – the density of the liquid-glass, g / cm^3; m – fullness of liquid-glass slurry with copper slag, kg/dm^3; t – temperature of the liquid-glass slurry , °C, as well as dependences presented in Figure 1.

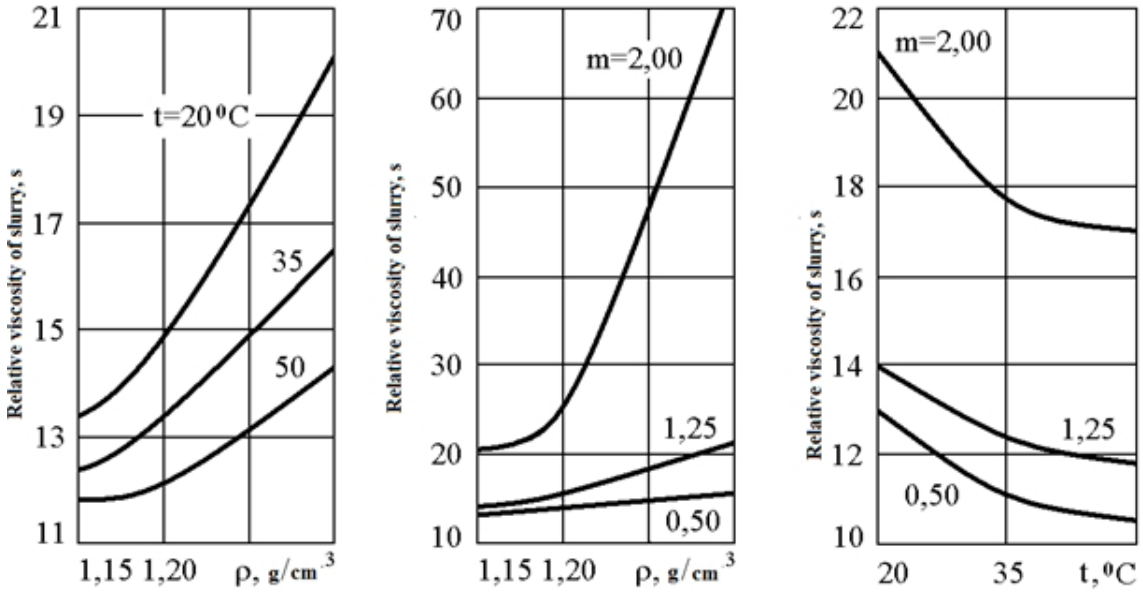

Figure 1. The relative viscosity dependence on the density of the slurry of liquid-glass and temperature at fullness of slurry m = 1.25 kg/dm^3 (a), on the density of the liquid-glass and the fullness of the slurry t = 20 °C (b), on the fullness of the slurry and temperature at ρ

Analysis of the course of dependences in Figure 1 shows that the relative viscosity of the slurry based on liquid-glass and copper slag increases with a decrease in its temperature, an increase in the slurry density and its fullness with a copper slag.

With an increase in the temperature of the slurry from 20 to 50 °C, the content of the copper slag in it can be increased by 3 ... 4 times without changing its relative viscosity. The most intensive change in the conditional viscosity is observed with an increase in the specific density of liquid-glass more than 1200 kg/m^3, fullness of more than 1.8 and a temperature of over 35 °C. The nature of the received dependences is similar to the dependences for the liquid-glass slurries filled with powder quartz or ash from Pridneprovsk thermo power plant [1].

Conclusions.

1. The objective influence of copper slag, as a filler, on the relative viscosity of a liquid-glass slurry was established depending on its fullness and temperature, and also the density of the sodium liquid-glass used.

2. When using a copper slag in a liquid-glass slurry in a foundry shop conditions, the dependences obtained will allow us rapidly make a decision on adjusting its composition in order to provide the required level of properties of the manufactured ceramic shell molds.

References

1. Zhegur, A. A. (2011) Uslovnaya vyazkost' zhidkostekol'noy suspenzii [Relative viscosity of a liquid-glass slurry]. *Metall i lit'ye Ukrainy* [Metal and casting of Ukraine]. No 4, p. p. 29–32.
2. Usenko R. V. (2016) Osobennosti vozniknoveniya zasora v zhidkostekol'nykh kombinirovannykh keramicheskikh obolochkovykh formakh [Peculiarities of clogging in liquid-glass composite ceramic shell molds]. *Metallurgicheskaya i gornorudnaya promyshlennost* [Metallurgical and Mining Industry]. No 4, p. p. 31–33.
3. Repyakh S.I. (2006) *Tekhnologicheskiye osnovy lit'ya po vyplavlyayemym modelyam* [Technological foundations of investment casting]. Dnepropetrovsk: Lira. 1056 p.
4. Zhegur A. A. (2010) Metodika postroyeniya empiricheskikh matematicheskikh modeley [Method for constructing empirical mathematical models]. *Lit'ye Ukrainy* [The casting of Ukraine]. No 11, p.p. 10 – 19.