AUTOMATIC ANALYSIS OF ALUMINATE-ALKALI SOLUTIONS BASED ON THE HIGH-FREQUENCY METHOD

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E. A. Khotskii, V. A. Zarinskii, and Yu. A. Tonkushin

V. I. Vernadskii Institute of Geochemistry and Analytical Chemistry,
Academy of Sciences, USSR

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We have developed a rapid method for analyzing aluminate-alkali solutions by means of VU-2A high-frequency instruments. The method can be used for the laboratory analysis of solutions with respect to the falling and rising sections of the calibration curve at a constant temperature and a constant molar ratio. Automatic industrial analysis is possible if temperature compensation is introduced in a narrow concentration range.

The modern method of alumina production is based on the processing of complex aluminate-alkali solutions, the principal components of which are Al_2O_3 and Na_2O. The solutions are characterized by the molar ratio α of these components. Investigations of the physicochemical properties, in particular, the electrical conductivity [1, 2] have shown that, with an increase in the Na_2O concentration, the electrical conductivity of aluminate solutions first increases, attaining a maximum for a content of 90 to 140 g/liter, after which it decreases. The maximum value of the electrical conductivity increases with an increase in the molar ratio and the temperature of solutions and is shifted toward higher concentrations of the components of aluminate solutions.

In the final analysis, the dependence of the electrical conductivity on the concentration of components in the solution can be divided into the rising, the maximum, and the falling sections of the curve. The industrial solutions at the various stages of alumina production correspond to all three sections of the curve.

The molar electrical conductivity of aluminate solutions decreases with addition of Al_2O_3 alumina. The drop is especially sharp for a molar ratio $\alpha = 1.5$-2.0 in the case of highly diluted solutions [2]. The molar electrical conductivity changes relatively little in concentrated solutions. Hence, it follows that the concentration of an aluminate solution can be determined by measuring its electrical conductivity, i.e., the solution can be analyzed for the percentage of Al_2O_3 and Na_2O.

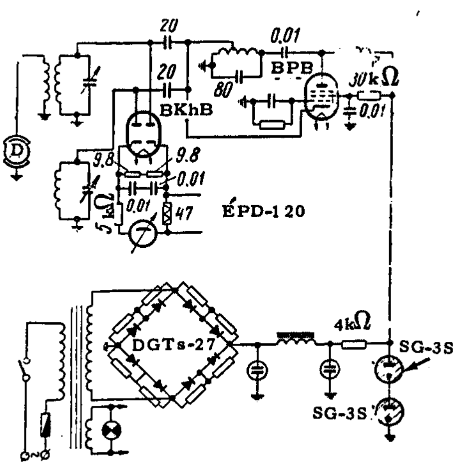

Fig. 1. Wiring diagram of the VU-2A instrument, adapted for the analysis of aluminate solutions.

However, it is not possible to analyze with a sufficient degree of accuracy aluminate-alkali solutions in a wide range of concentrations by measuring only the electrical conductivity, since this value depends not only on the absolute concentration of components, but also on their ratio and the temperature of the solutions to be measured. Therefore, methods were proposed [1, 2] in which the electrical conductivity and other parameters of solutions are measured at the same time. The problem becomes much simpler if aluminate-alkali solutions are analyzed within concentration ranges (stages of alumina production) where changes in the concentration of one of two components are negligible.

Under these conditions, by measuring the electrical conductivity at a high-frequency [3-6], it is possible to secure an accuracy which is

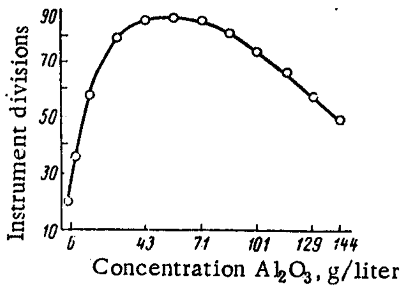

Fig. 2. Calibration curve for aluminate solutions in the range of Al_2O_3 concentrations from 6 to 144 g/liter.

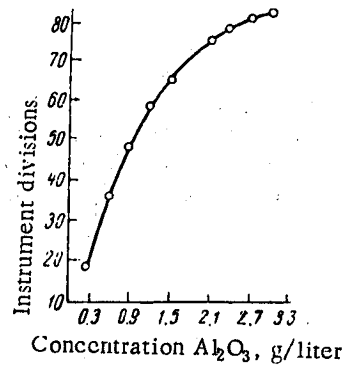

Fig. 3. Calibration curve for aluminate solutions in the range of Al_2O_3 concentrations from 0.3 to 3.3 g/liter.

sufficiently high for industrial inspection.* The rising and the falling branches of the electrical conductivity curve are used for analysis; the zone of the maximum is unsuitable for measurements because of its nonlinearity.

We used a VU-2A high-frequency instrument for measuring the electrical conductivity [7, 8]. The capacitive coupling between the data transmitter and the operating oscillatory circuit was replaced with an inductive coupling, while the oscillator frequency was increased from 5 to 15 Mc. High-frequencies reduce the capacitive (reactive) resistance of the data transmitter's walls; however, at frequencies above 15 Mc, the adjustment of the instrument is much more difficult, while the measurements have a lower degree of reproducibility, which is connected with the development of parasitic leakages and capacitive couplings in the circuit.

The wiring diagram of the high-frequency instrument is shown in Fig. 1. Automatic recording on the strip chart of an ÉPD-120 self-recorder was provided for the analysis of flowing solutions. The device was tested with different industrial solutions used in alumina production (wash water, aluminate solutions, mother liquor, and concentrated solutions). As a result of this, we plotted calibration graphs (Figs. 2 and 3) for determining the Al_2O_3 percentage. A comparison between the instrument readings and chemical analysis data showed that the minimum discrepancy was 0.3 g/liter, while the maximum discrepancy was 3.2 g/liter. The average discrepancy was 1.75 g/liter or 6.8%.

The analysis error can be reduced to 1.0-1.5 g/liter by stabilizing the oscillator's frequency by means of quartz and by introducing temperature compensation in the circuit or temperature corrections in the measurement results.

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*The effect of temperature fluctuations can be eliminated by using thermostatic control or introducing suitable corrections.