Automated Multi-component Detection Methods for Sodium Aluminate Solution

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Abstract

The determination of sodium aluminate solution composition is very important in alumina production. The traditional manual determination method has high cost, low efficiency and the detection results are greatly affected by subjective judgment. In this paper, a step-by-step potentiometric titration method conforming to the automatic detection logic was proposed based on the traditional detection method, a multi-component automatic analysis equipment for sodium aluminate solution with the functions of automatic recall of different concentration curves and automatic discrimination and dilution of samples was developed, which could directly measure the content of Nc, Nk and AO simultaneously, and then obtain the Nt, αk and RP values, aiming to achieve efficient, accurate and low-cost intelligent detection. During the research process, the actual sodium aluminate samples from different processes in actual industrial production were used as the experimental objects, and multi-curve fit was performed based on the reference of manual detection results, and performance tests under different sampling conditions, storage conditions and temperature conditions were carried out. The results show that the relative deviation of the device is less than 1.5 % and has good operational stability. This study can be maturely applied to industrial production, which can significantly improve the detection efficiency and accuracy of sodium aluminate slurry, reduce the detection cost, ensure the safety of personnel, and provide strong technical support for the intelligent development of alumina production.

Keywords: Sodium aluminate solution, Component determination, Intelligent detection, Potentiometric titration.

1. Preface

Sodium aluminate solution runs through almost the entire alumina production process, which is an important intermediate product, and clarifying its composition and content is an important basis for guiding alumina production. For example, the concentration of caustic alkali (Nk) and alumina (AO) directly affects the control of liquid-solid ratio, dissolution rate, decomposition rate and other process indicators in the preparation, dissolution, decomposition and evaporation of raw ore pulp [1]. The concentration of carbonate alkali (Nc) plays an important role in controlling the dissolution rate, decomposition rate, inhibiting the expansion of red mud, and improving the settlement performance of red mud. Therefore, it also determines the importance of sodium aluminate solution composition analysis and is a high frequency multi-indicator. Some automated analysis methods have also been proposed at China and abroad, among which the most studied methods are potentiometric titration [2], flow injection analysis [3], conductivity determination [4], etc.

Based on the previous work, this paper optimizes the traditional manual determination standard method and develops an automatic sodium aluminate solution analyser based on the detection principle of potentiometric titration. The automatic and rapid determination of AO, Nk and Nc in sodium aluminate solution has been achieved. This instrument is simultaneously equipped with an upper computer software, which can then calculate the corresponding values of total alkali (Nt) and caustic ratio (αk). After extensive experimental verification, this equipment is truly capable of being put into production application, replacing traditional manual analysis.

2. Measurement Theory

The traditional manual measurement method involves determining Nk, AO and Nt respectively from two samples, which is rather complex and not suitable for the development of automated measurement equipment. This study optimized the method, enabling the sequential determination of Nk, AO and Nc with just one sample.

First, the free hydroxide in the sample was titrated with a standard hydrochloric acid solution until the first endpoint. Then an excess of aluminium complexing agent was added to form an aluminium complex and release the bound hydroxyl group into hydroxide ions. Continue to titrate the released hydroxide ions with the standard hydrochloric acid solution to the second endpoint. At this point, the concentration of AO in the sample can be determined based on the stoichiometric relationship between alumina and bonded hydroxide ions. Meanwhile, the sum of the concentrations of free and released hydroxide ions is the Nk. Continue to titrate with hydrochloric acid until the third titration endpoint, when carbon alkali in the sample is titrated from carbonate to bicarbonate and obtain the concentration of Nc. The sum of Nk and Nc is the content of Nt, and the ratio of Nk to AO coefficient is the value of αk. In this process, the pH electrode was used as the detector, and the extremum point of potential change was used to determine the endpoint of titration.

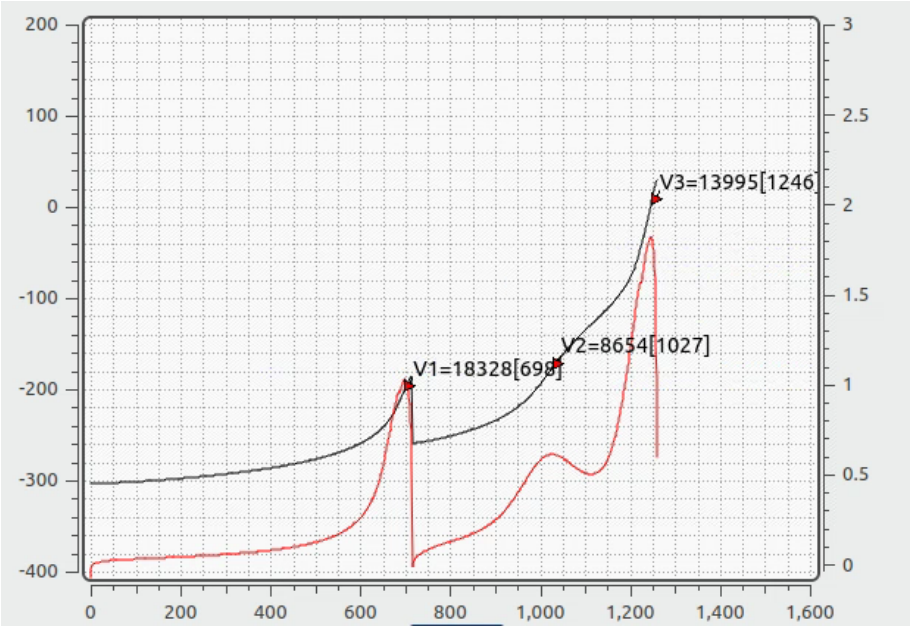


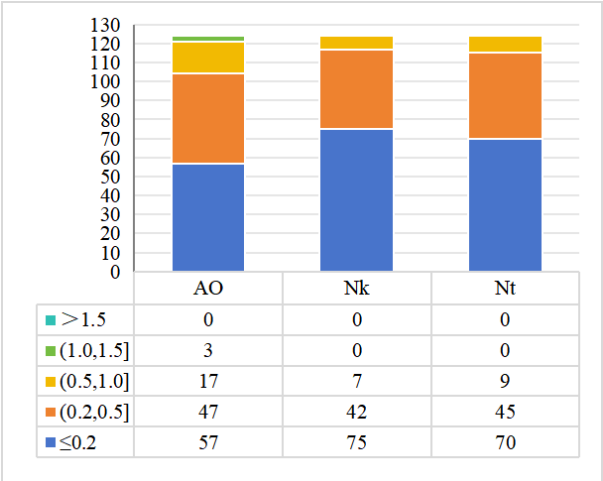
Figure 1. Titration potential variation trend diagram (3 titration endpoints V1/V2/V3).

3. Automatic Detection Equipment Development

Based on the above measurement theory and following the design logic from the development of split modules to the assembly of the entire machine, the design and development of an automatic

4.4.2 Precision Experiment

Measurement precision refers to the proximity between the results obtained by repeated measurement of the same sample, in accordance with the control requirements of inspection and testing, the precision test of the instrument, by the instrument under the optimal conditions after the above verification of 124 batches of sodium aluminate slurry samples a total of 372 items, the overall two rounds of repeated measurement, AO, Nk, Nt determination pass rates were 94.4 %, 100 %, 99.2 %, the total pass rate reached 97.9 %, and the relative deviation (PRD) was less than 1.5 %. The relative deviation distribution of each index is shown in Figure 8.



	AO	Nk	Nt
>1.5	0	0	0
(1.0,1.5]	3	0	0
(0.5,1.0]	17	7	9
(0.2,0.5]	47	42	45
≤0.2	57	75	70

Figure 8. Distribution of PRD for each indicator.

5. Conclusion

According to the above experimental results, it can be clear that the sample holding temperature and sample storage conditions have a great impact on the measurement results of the instrument, and after test verification, the optimal condition is determined to be a constant temperature of 45 °C and the original cup is laminated, under this condition, the equipment runs stably, and the measurement accuracy and precision fully meet the requirements of the measurement index.

In addition, when the instrument measurement results are truly applied to guide the production of alumina, they must be compared with the measurement results under the original manual measurement system. This experiment verified through multiple comparisons and analyses between manual and instrument measurements, determining that under the optimal conditions, while ensuring that both manual and instrument sampling conditions are the same, and when multiple people in the inspection team are conducting measurements simultaneously, the comparison pass rate of the measured results is nearly 90%, which can basically meet the needs of guiding production. In particular, if other conditions remain unchanged, the total pass rate of comparison is increased by 1.86 % compared with the instrument measurement, and the pass rate of AO and Nk reaches more than 90 %, which further shows that the reliability of the instrument measurement can be maturely applied to industrial production.

6. References

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