Electromechanical Characterization of the Ramming Paste and the Aging Effect on its Performance

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Abstract

The ramming paste plays a fundamental role in the life of an electrolysis cell and its energy efficiency. On the one hand, it prevents the infiltration of liquid aluminium into the cell and, on the other hand, it seals the cathode blocks, which protect them from damage and ultimately from failure. The aging of the coal tar pitch based ramming paste, due to the evaporation of the softeners ensuring its malleability at room temperature, is likely to influence its physical properties. Also, during the compaction of the coal tar pitch based ramming paste, the binder present in its composition releases carcinogenic products such as polycyclic aromatic hydrocarbons, which constitutes a real danger for health. To overcome this problem, several eco-friendly ramming pastes have been developed in recent years. However, the physical properties of these new pastes and their effects on the process efficiency are not yet well known. This work aims to study the aging effect on the physical properties of the ramming pastes. In this perspective, a standard coal tar pitch based ramming paste and an eco-friendly one were investigated. The characterization of the aging effect is focused on the measurement of quantities such as apparent density, mass loss, volumetric change, Young's modulus, Poisson's ratio, compressive and tensile strength as well as electrical resistivity. The results of this study reveal that the aging of the ramming pastes mainly affects the mass loss and the Poisson's ratio.

Keywords: Aluminium electrolysis, ramming paste, eco-friendly ramming paste, ramming paste aging, physical properties.

1. Introduction

In the aluminium electrolysis cells, the cathode blocks are sealed with the ramming paste. The main role of this paste is to prevent electrolyte bath and molten aluminium infiltration into the lining and to absorb the thermal expansion of the cathode blocks. The standard cold ramming paste is a mixture of dry aggregate (mainly calcined anthracite and artificial graphite) and a binder containing coal tar pitch. To lower the softening point of the paste and make it compactable at room temperature, softeners are added to the binder. As these softeners are volatile materials, the paste aging is likely to influence its physical, mechanical and electrical properties. Few papers have been published on the effect of the paste aging. Allard et al. [1]

have investigated the evolution of two properties (the rammability index and the volumetric expansion) versus the months of storage for the eco-friendly paste NeO^2. The results revealed that after 12 months of storage the rammability index has undergone a slight increase, synonymous with a dry paste, whereas the volumetric expansion has undergone a slight decrease which, nevertheless, remains above the threshold of 1 % recommended by the authors of the study. Therefore, the authors concluded that the ramming paste NeO^2 could be stored for at least 11 months.

The emanations generated by the standard ramming paste have harmful effects on health and the environment. As a result, migration from standard to eco-friendly paste seems inevitable. Therefore, the characterization of the eco-friendly ramming paste becomes a priority. The objective of this work is to evaluate the aging effect on the performance of the ramming paste. To fulfill this objective, a standard and an eco-friendly ramming paste were used. The mechanical and electrical tests undertaken as well as the results obtained are presented in this paper.

2. Experimental Methods

2.1. Materials

In this work, two ramming pastes have been studied: i) a standard coal tar pitch based ramming paste, used for many years in the industry and ii) an eco-friendly ramming paste of a new generation, recently introduced in Alcoa smelters. Upon receipt of the pastes, they were divided into several sealed containers and stored at room temperature to simulate storage conditions in the factory. The aging of the pastes has been followed during a period of 10 months, between the age of three and twelve months. Each month, one container of each paste was used to fabricate samples and thus to analyze the paste properties.

2.2. Sample Fabrication

Four-inch laboratory samples are required to obtain a significant radial deformation for the calculation of the Poisson's ratio. St-Arnaud et al. [2, 3] have proposed a compaction method using a Proctor Mechanical Rammer, based on a multilayer approach, to acquire the desired samples. This test method provides samples with a green apparent density comparable to the average density of a representative assembly for the peripheral seam [4]. However, the density distribution within the compacted samples is not uniform. In this work, in order to fabricate samples with homogeneous density distribution, the Proctor was instrumented by a feeding system (Figure 1) presented in Chen et al. [5]. This feeding system introduces the ramming paste continuously into a split cylinder steel mold with an internal diameter of 101.6 mm (4 in). The compaction took place as the rammer, with a diameter of 50.8 mm (2 in) and a weight of 2.49 kg (5.5 lb), falls freely through a distance of 457.2 mm (18 in) over the tamped surface and repeatedly in a circular pattern. After the sample being compacted, its upper surface was trimmed to remove excess material. Finally, the average dimensions of the sample are 101.6 mm (4 in) in diameter and 230 mm (9 in) in height.

6. References

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