جامعة الإمارات العربيــة المتحدة
United Arab Emirates University

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Master Thesis Defense

Entitled

TOWARDS AUTOMATION OF ALUMINUM CELL RAMMING PROCESS

By

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Abstract:

Newly installed cathode blocks in an aluminum reduction cell, expand due to rapid increase of temperature when passing high current at the start-up of the cell. High thermal stresses may result if cathode blocks are lined without gaps, and this can lead to cracking of the cathodes and failure of the cell. On the other hand, leaving gaps would cause failure due to molten metal infiltration in the gaps. To overcome these problems carbon-based ramming material is used to fill these gaps. Currently 'Filling' is carried out manually or partially automated, but this needs to be fully automated in line with Industry 4.0. Automation here means the making of an apparatus, a process, or a system to operate with minimum inputs from humans and produce consistent filling of the ramming paste. The main objective of this project was to establish the needed characteristics of ramming paste under different conditions so that one can make decisions to optimize the life of the carbon paste in the cell, while designing the automatic system. Experimental analysis was carried out to visualize and investigate the manual compaction of ramming paste in the gaps and identify forms and defects after the compaction. Building on this, characterization of ramming paste was carried out under different conditions by varying applied pressure. At room temperature it had the ability to bond and solidify under pressure with increasing young's modulus value as pressure increases. But it was observed that over-compaction initiated internal cracks in the solidified sample. Then, characterization was carried out by varying the baking temperature, so blocks were fabricated to be heated to different temperatures and then investigate their behaviors, the baking temperatures were from 200˚C to 600˚C. The achieved yield strength 200˚C was high however similar strength was achieved at room temperature for unbaked samples as well, on the other hand, it was observed that the higher the temperature with presence of oxygen the more fragile ramming paste became. Further, to achieve consistent flow of the ramming paste into the filling, Principle of Fused Deposition Modelling was tested to extrude ramming paste using a nozzle with different nozzle profiles and various applied loads. This set of experiments concluded that ramming paste cannot be extruded using a nozzle as it gets compacted at the nozzle exit and compaction builds up on the top layers. The paste does not flow because of its strong bonding nature and the resulting consolidation under pressure. Based on the findings a machine was designed and built to extrude ramming paste using a two-stage process comprising of, firstly a screw conveyor to positively convey the material and secondly a roller to compact the material coming out from the screw conveyor. Test runs were carried out with the machine and the results show that the machine can produce ramming paste flow, at the desired density in a consistent fashion. Based on the findings of this research and the prototype machine, industry scale machines automating the 'Aluminum Cell Ramming Process' can be built.

Keywords: Aluminum reduction cells, Ramming paste, Automation of cell ramming, Cell relining, Extrusion of ramming paste.