Mathematical Modeling and Application of a Continuous Alumina Feeding to Potroom

Paulo Douglas de Vasconcelos[1], Nilton Nagem[2], Paulo Zaidan[3] and Valfredo Costa[4]
1. Consultant Engineer, researcher
TRINDADE Criative Engineering S/A, Barcarena, Brazil;
2. Process Engineering Manager Reduction Area
3. Process Engineer
4. Operational Manager
[2]Albras Alumínio Brasileiro S/A, Barcarena, Brazil.
Corresponding author: douglasic@uol.com.br

Abstract

Mathematical models are used to predict the mass flow rate and the full alumina fluidization velocity of enriched alumina and other powders used in aluminum smelters. For the validation of the models, round non-conventional air slides were manufactured with possibility of multiple outlets. The air fluidized conveyor is made of a low weight, insulating, heat-resistant material, easy to install, maintained without the need to stop the aluminum production of the pot. It also operates at very low cost compared to the conventional metallic air slides. Its air consumption is low and the system can be lifted by the hands for the installation on the top of the pot without the need of welding or disassembling any part of the reduction cell. The fluidized pipeline can be installed even in the upward direction, and it does not interfere with pot operations. The paper also focuses on the scale up of the fluidized pipeline from laboratory studies to industrial application in an aluminum smelter. The paper shows the challenges to optimize the prototype fluidized pipeline and the final adjustments to be used in the continuous pot feeding in aluminum smelter potrooms.

Keywords: Fluidized pipeline, aluminum reduction pot, minimum and full alumina fluidization velocity, alumina mass flow rate.

1. Introduction

Old aluminum smelters feed their electrolytic cells with overhead cranes as can be seen in Figure 1. This is a difficult task to be performed by operators and causes spillage of alumina to the pot room workplace. This problem is currently being solved in Albras by the development of a special multi-outlets nonmetallic fluidized pipeline [1] – see Figure 2.

(a) **(b)**

Figure 1. a) Overhead crane being fed with fluorinated alumina from a day bin by a standard air slide, b) Overhead crane feeding pot silos with fluorinated alumina.

Figure 2. Multi-outlets nonmetallic fluidized pipeline – during erection time.

The fundamentals of powder transport are illustrated in Figure 3, from the fluidized bed to pneumatic transport regime.

Firstly, the alumina used as raw materials in the primary aluminum process is characterized using sieve analyses (granulometry size distribution). Then, bulk and real densities are determined in the laboratory analyses. Based on these physical properties, powders can be classified in four types using the Geldart's diagram, illustrated in Figure 4 [2]. Most powders used in aluminum smelters belong to groups A and B.

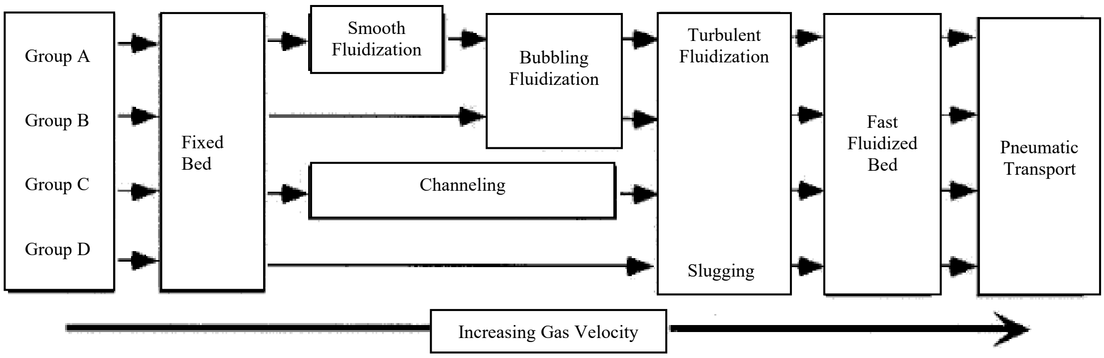

Figure 3. Flow regime map for various powders.

Figure 4 summarizes the fluidized bed hydrodynamics related with powders classified according to Geldart's criteria. Once the velocities associated with each mode of operation are determined, the pressure drop of the regime is calculated so that the gas-solid flow is predicted using suitable modeling and software to optimize the industrial installation.

air flows in the pipelines during the whole alumina feeding process (detection of empty silos, alumina filling and high-level in the silos). Orifice plates with different size holes will be employed to balance the air flow rate from the first to the last Pot: this process is believed to guarantee an even air flow in each Pot's individual fluidized pipeline. This laboratory survey will also validate how much alumina is exhausted in the de-dust system and collected in the bag-house during an 8-hour shift cycle.

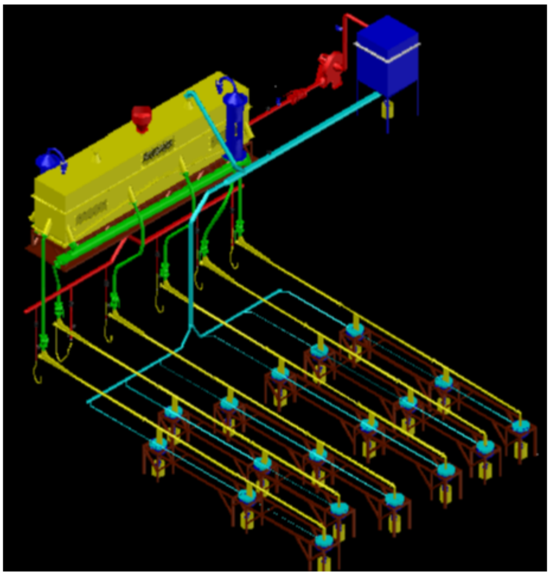

Figure 17. Overview of the test rig outside Albras.

5. Conclusions

The objective of this paper is to focus in the application of alumina continuous feeding of aluminum reduction pots at Albras, and in other aluminum smelters, with a competitive system when compared against conventional systems available on the market.

Powder handling at very low velocities, such as illustrated in Figure 3, is employed in several industrial applications. The developed equations aim to help design engineers in conceiving air slides of low energy consumption, based on the desired solid mass flow rates. In order to design an air fluidized conveyor, one must possess knowledge of the rheology of the powder that will be conveyed.

In the application at Albras, the experimental results for the small conveyor were higher than that predicted ones for horizontal and upward inclinations when considering velocities less than the minimum fluidization velocity, due to the fact that Equation 4 does not take in to account the height of material in the feeding bin. The challenges faced during the field trial with the fluidized pipeline prototype in the Pot 239 were also discussed, and the lessons learned with this experience will be useful to modify the system. The new conveyor includes a de-dust system to survey the amount of alumina collected in the bag-house and also to eliminate any alumina dust emission to the environment.

6. References

1. P.D. Vasconcelos, Fluidized Air Pneumatic Conveyor - Case Study Applied to the Primary Aluminum Smelter, *Doctorate Thesis*, Federal University of Pará at Belem, 2011
2. D. Geldart, Types of Gas Fluidization, *Powder Technology*, 7, 285 – 292 (1972).

3. D. Kunii and Octave Levenspiel, *Fluidization Engineering*, 2nd Edition, Butterworth-Heinemann, Boston (1991).
4. David Mills, *Pneumatic Conveying Design Guide*, Butterworths, London, (1990).
5. Paulo Douglas de Vasconcelos and A.L. Mesquita, Experimental and Theoretical Study on the Fluidization of Alumina Fluoride Used in the Aluminum Smelter Processes, *Light Metals* 2012, 821-826.
6. Paulo Douglas de Vasconcelos and André Luiz Mesquita, Gas-solid flow applications for powder handling in industrial furnaces operations. Chapter 10, ISBN 978-953-307-585-3. *Intech open access Publisher*, Rijeka, September (2011).