Process simulation in VM-CBA alumina refinery

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Abstract

Modelling of chemical processes has been developed since the seventeenth century with several authors expressing mathematical relationships between system properties. More recently, with the development of modern computational capabilities and by applying process models in numerical simulations, it has been possible to make predictions and evaluate ideas prior to making any modifications in the operation. Along with these advancements it was possible to control and optimize processes, to evaluate process improvement projects and also to train operators. The current work presents process modelling development and results of process simulation in Votorantim Metais - Companhia Brasileira de Alumínio (VM-CBA) refinery. Optimisation studies were conducted in the desilication, digestion and precipitation areas, as well as for future project opportunities such as the conversion of dual stream to single stream digestion.

Keywords: Process simulation; process modelling; numerical modelling; computational programming.

1. Introduction

Companhia Brasileira de Alumínio (CBA), of the Votorantim Group, is located in Alumínio, 74 km from São Paulo city. It is the largest integrated aluminium plant in the world. CBA started to operate in 1955 and today produces 0.475 Mt of primary aluminium.

The Bayer process can be divided into two parts, commonly referred to as the red side and white side. To briefly summarize, on the red side alumina minerals such as boehmite, diaspore ($Al_2O_3.H_20$) or gibbsite (alumina trihydrate $Al_2O_3.3H_2O$), are dissolved in a caustic solution at temperatures between 100 and 300 °C, and bauxite residue is separated from pregnant liquor. On the white side, alumina trihydrate is precipitated from pregnant liquor and afterwards the removal of structural water from this hydrate is effected in the next major process step of the Bayer Process, calcination, generating the product we call alumina (Al_2O_3).

To assist process control and the optimization and the predictability of process variables, tools and procedures were developed to monitor all areas of the plant, many of them using spreadsheets, often of great complexity. This existent modeling presents the plant operation and shows how distant from ideality it is. On the other hand, it is rarely reliably predictive.

Aiming for better predictability and flexibility, CBA teams are now utilizing Kenwalt's software SysCAD, to develop improved process simulations.

2. Developments

2.1. Pre-desilication and digestion

Pre-desilication and Digestion are both areas in an alumina refinery where significant reactions and complex energy exchanges take place. Firstly, the bauxite slurry from grinding is heated in contact heaters with flashed steam from the flash tanks of digestion area. This heated slurry then flows to a desilication tank (14C) and then to the paste heater batteries, which are heated with reflashed live steam from digestion area. Afterwards, the slurry goes to other desilication tanks (14A and 14B) with the some recycle flow to tank 14C. Then, the slurry flow follows to 3 digestion units.

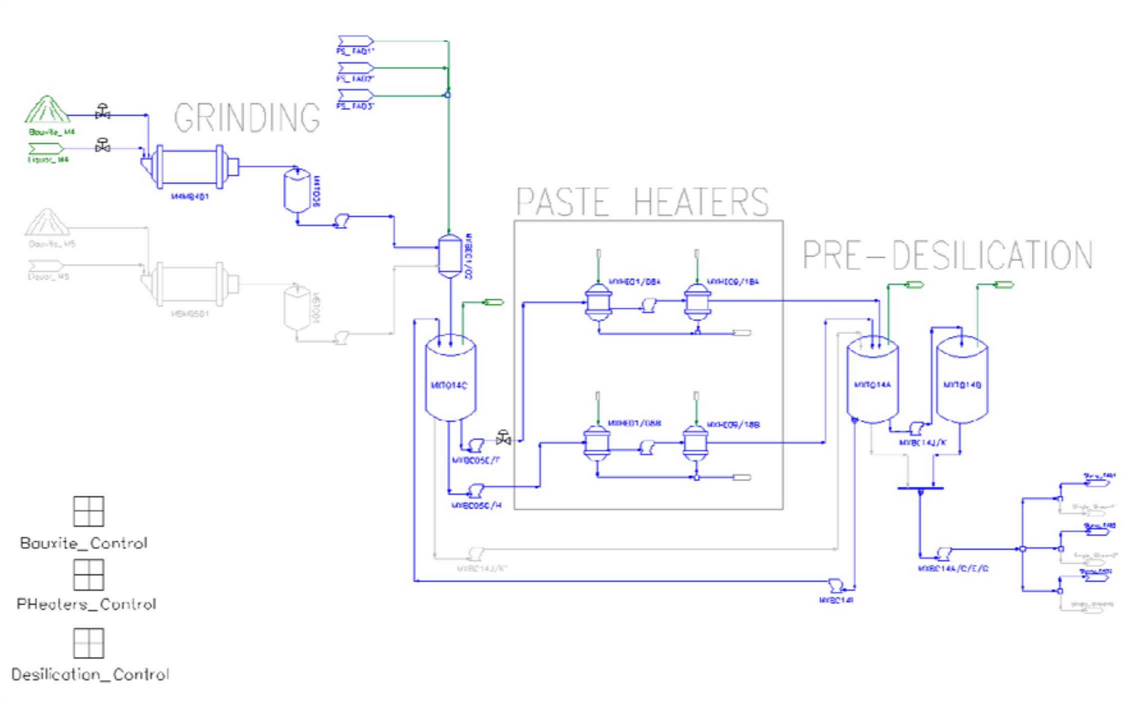

Figure 1. CBA's grinding, paste heaters and pre-deslication systems on SysCAD interface.

Digestion units include autoclaves that receive the bauxite slurry and the heated caustic liquor. This equipment setup promotes the ore's alumina trihydrate ($Al_2O_3.3H_2O$) dissolution under elevated pressure and temperature. The digested slurry from the autoclaves then flows to flash tanks in which the temperature is reduced to avoid boiling in the atmospheric decanters, the next step of process. The flashed steam is sent to recuperative heaters, where the strong liquor from the test tanks is heated. After recuperative heating, the strong liquor flows to live steam heaters and soon after to the autoclaves. The live steam flow to the live steam heaters is controlled according to the autoclaves' set point temperature (close to 144 °C). The live steam condensate is reflashed in pot tanks and its steam is sent to the desilication contact heaters. The excess steam from second flash tank in each digestion unit is sent to the paste heaters, forming a complex energy exchange system.

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