Mathematical Model for Estimation of Thermal Energy Consumption in an Alumina Refinery

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Abstract

The Bayer Process to produce alumina trihydrate (ATH) from bauxite ore involves caustic digestion at elevated temperature and pressure, efficient solid liquid separation, soda recovery from bauxite residue at atmospheric conditions and seeded precipitation of ATH through natural and forced cooling of Bayer liquor, rich in alumina content. Since water is added to the circuit to wash bauxite residue, maintaining water balance in the closed circuit system through evaporation becomes essential. All of these steps consume thermal energy in the form of steam at appropriate conditions. The total energy consumed in the process depends on the process / plant design which in turn is based on the quality of bauxite that is processed. In general, thermal energy requirements are more than 90% of the total energy. Steady state heat and mass balance models (like S-Flo, Aspen, SysCAD, etc.) are available in the market, for use by engineers. These are extensively used, especially for the process / plant design purpose. Use of these models need some specialized training and hence, are typically limited to a select few in refineries. Hence, an idea was floated to develop a simplified computer model to estimate thermal energy requirements in various sections of a Bayer plant, so that many engineers in the refinery can use it on a more frequent basis and decide on the areas of concern / improvement. This paper presents the concept behind the development of the mathematical model and also a case study of applying this model in one of the alumina refineries in India.

Keywords: Bayer, consumption, energy, model, thermal.

1 Introduction

The Bayer process to produce alumina trihydrate (ATH) from bauxite is an energy intensive process. The dissolution of gibbsitic and boehmitic alumina phases in bauxite require elevated temperatures and pressures, mainly due to the nature of the dissolution reaction, which is endothermic. The efficiency of operation of an alumina refinery is determined largely by the specific energy consumption. The total energy consumption in the Bayer process is a combination of thermal and electrical energy requirements.

The total energy consumed in the process depends on the process- /- plant design which in turn is based on the quality of the bauxite that is processed. In general, the thermal energy requirement is more than 90% of the total energy [1].

Electrical energy is required mainly for crushing and grinding of bauxite to the required size and for the operation of

- various pumps, which are used to transfer liquid and slurry from one section to another and to generate required pressure and
- various agitators to keep the slurry in suspension at various points.

Energy estimation in refineries is being done through complex models which are unique to the selected refinery and cannot be used for some other operations. With the advent of steady-state

heat and mass balance software models (like S-Flo, Aspen, SysCAD, etc.) in the market, the energy estimation process has been simplified.

These are extensively used, especially for the process- /-plant design purposes. However, use of these models need some specialized training and hence, are typically limited to a select few in refineries.

Hence, an idea was floated to develop a simplified computer model in order to estimate thermal energy requirements in various sections of a Bayer plant, so that many engineers in the plant can use it on a more frequent basis and decide on the areas of concern- /- improvement.

Accordingly, an MS: Excel® based model was developed. This paper presents the concept behind the development of the mathematical model and also a case study of demonstrating application of this model in one of the alumina refineries in India.

2 Conceptual Approach

Energy consumption in Bayer process is mainly used for dissolution of bauxite in caustic at elevated temperature. Monohydrate / trihydrate alumina dissolution is an endothermic reaction. Hence, heat needs to be supplied to achieve higher extraction efficiencies. Usually, the heat is supplied from steam, generated using coal- /- furnace oil- /- natural gas as fuels. This supplied heat is utilized for increasing the temperature of liquor for achieving the target digestion temperature. In addition to digestion temperature, liquor concentration is another important parameter for achieving target digestion efficiency. In the Bayer process, liquor concentration is maintained by evaporation of spent liquor as well as addition of fresh caustic for maintaining steady plant volume. The tradeoff between the addition of thick liquor as well as fresh caustic for maintaining liquor concentration, in turn, has an effect on the overall plant specific thermal energy consumption. The model development methodology [2] is presented in Figure 1.

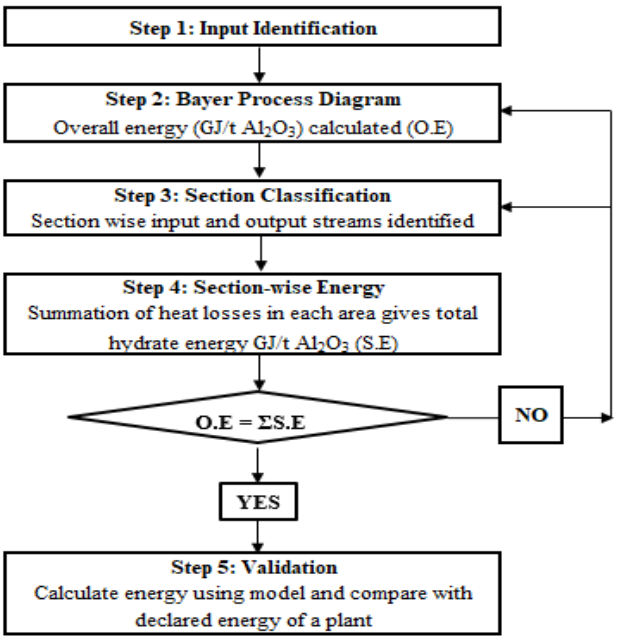

Figure 1. Conceptual flow diagram for the development of a model for Bayer process thermal energy consumption.

- Section-wise heat input and heat output streams were identified along with the physical properties, flow and consumption parameters.

7 Reference

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