Bauxite digestion redundancy options

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Abstract

In the Bayer process, the Digestion area is usually a major contributor to plant downtime. For example many plants have an annual Digestion shutdown to clean and maintain equipment that cannot be accessed during normal operations. Since the Digestion area represents a relatively low percentage of total refinery capital cost (typically 5 to 15 %), having some redundant equipment in Digestion generally makes good business sense, since it increases the utilisation rate of the whole refinery asset. A range of different redundancy options can be found in practice. These typically employ combinations of (a) ability to bypass individual pieces of equipment and/or (b) ability to bypass “chains” of equipment in series (e.g., a row of heaters). The latter requires fewer isolation points but offers less flexibility. The optimum redundancy strategy is a trade-off between capital cost, refinery utilisation and operating complexity. This paper presents a comparison of different redundancy strategies and redundancy levels.

Keywords: Bayer process; digestion; redundancy; digestion shutdown.

1. Introduction

The Bayer process for production of alumina consists of a cyclic core process (the main liquor circuit) interconnected with a range of peripheral inputs, outputs and utility systems. Equipment outages (both planned and unplanned) in one part of the system potentially impact the surrounding operations.

The individual areas and equipment items in a Bayer refinery exhibit a wide range of reliabilities and operating cycles. Heat exchangers cleaning frequencies for example typically range between several days and several months, while precipitator cleaning frequencies may range between 8 weeks and 3 years. This diversity of operating cycles means that the concept of a whole refinery shutdown to carry out cleaning is impractical, and there are relatively few opportunities for coordinated shutdowns of neighbouring equipment.

In some cases, the material flowing from one section to another is amenable to storage, for example alumina trihydrate cake being transferred from Classification to Calcination. In such cases, a storage facility can be used to decouple adjacent operations and prevent outages in one area (in this example, Calcination) from forcing the rest of the refinery to shut down or reduce throughput.

In most cases however, the material flowing between sections is either unstable or too voluminous to allow sufficient quantities to be stored to enable cleaning and maintenance work to be carried out. This is particularly true for the Digestion area, which produces a hot, highly supersaturated slurry which must be processed with minimum delay. The quantity of slurry is approximately 10 - 15 tonnes for every tonne of alumina produced. A shutdown in the Digestion area therefore results in an almost instantaneous interruption of feed to the Clarification and Precipitation facilities. It is therefore desirable to design the digestion area for continuous operation, 24 hours per day and 365 days per year.

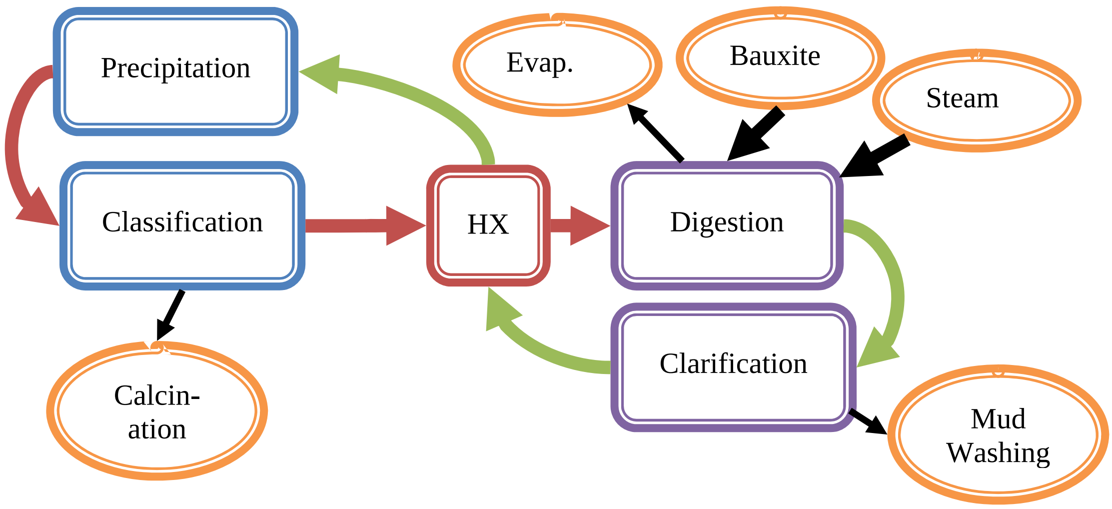

Figure 1. Bayer circuit schematic.

2. Sparing strategies

2.1 Historical perspective

The first continuous Bayer digestion units built by Alcoa in the 1930's consisted of two units operating in parallel; cleaning and/or maintenance activities required plant capacity to be reduced by half [1]. The next unit built in 1937 at Mobile incorporated bypasses of individual vessels; according to Hudson, "although the piping was complex, any vessel could be removed from service without decreasing capacity". Thus began the evolution of sparing strategies in Bayer Digestion.

2.2 Base case

The main unit operations in a typical Digestion unit are heat exchangers, autoclaves and flash vessels. This paper presents a series of sparing options configured around a base case consisting of a pump feeding through four heaters to three autoclaves, then cooling through three flash stages, which recover hot vapour to the first three heating stages. The fourth heating stage uses boiler steam.

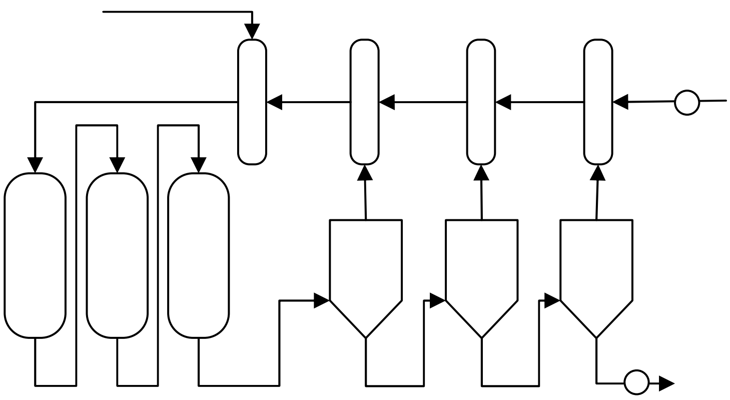

Figure 2. Base case for comparisons.

The experience and skill levels of the operators and maintainers that will be recruited to operate the new refinery can have a significant bearing on this decision.

4. Conclusion

The choice of digestion sparing strategy can have a significant influence on refinery cost and operability. The "right" selection is very much a case-by-case issue, as evidenced by the fact that, 123 years after the invention of the Bayer process, there has been no convergence towards a common solution to this challenge.

5. References

1. L.K. Hudson, Evolution of Bayer Process Practice in the United States. Light Metals 1988, pp 31–36.