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M2M-TECHNOLOGY: THE NEW STANDARD TO MINIMIZE BAUXITE RESIDUE

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Bauxite residue disposal is the paramount environmental issue in alumina refining and a top priority is process innovation to minimize bauxite residue generation M2M-Technology™, developed by Alcor Technology and Alfa Laval, provides this innovation through a novel, patented combination of well known process and equipment technologies.

M2M-Technology also makes alumina refining more sustainable due to full bauxite utilization (i.e. virtually no extractable alumina losses with residue), leading to increased alumina production. M2M-Technology has very attractive economics and can be conveniently implemented in existing and green-field refineries. It is envisaged that M2M-Technology, in combination with dry residue stacking, will become the international standard for bauxite residue management.

The benefits of M2M-Technology for a specific refining project are readily established through a project study. Supplier of M2M-Units™ is Hencon, with technology support from Alcor Technology and Alfa Laval.

BAUXITE RESIDUE DISPOSAL

Current primary aluminium production is some 38 million tons per year, requiring alumina refineries to convert about 210 million tons of bauxite into 74 million tons of alumina and some 85 million tons of bauxite residue. In India, with several alumina projects in the pipeline, annual residue generation will soon exceed 10 million (1 crore) tons.

International practice is to store residue, also labelled red mud, in large, purpose built areas. Residue storage is a significant environmental issue in the alumina industry because of volume and caustic soda content.

Hence it is no surprise that the industry has made huge efforts to develop residue applications, with the objective to reduce the amount of residue which has to be stored. However, up to this point in time no application has been found, which would provide a significant outlet for bauxite residue. Hence the focus is now on residue

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management methods, which minimize environmental impact comprising the following elements:

- Minimizing caustic soda concentration in the liquid associated with stored residue. This is achieved in residue wash lines, involving high rate decanters, using modern flocculants to obtain high underflow solids concentration.
- Storing reside in such a way that environmental emissions are minimized This involves storage of residue at high solids concentration, avoiding the release of associated liquid to the environment. This method is referred to as dry residue stacking or thickened mud disposal.
- Minimizing residue generation by minimizing extractable alumina losses with residue. This approach, which also increases the amount of alumina produced from a given bauxite input, is the subject of this paper.

ALUMINA EXTRACTION AND CRYSTALLIZATION

Production of alumina from bauxite comprises cycling of a caustic soda solution as extraction liquor through an elevated temperature digestion stage, for dissolution of extractable alumina, and a low temperature crystallization stage, for crystallization of pure alumina hydrate.

In digestion ground bauxite is mixed and heated with caustic soda solution with a low A/C ratio [1] labelled spent liquor, resulting in a caustic soda solution rich in dissolved alumina (high A/C ratio), labelled green or pregnant liquor, and an un-dissolved residue containing some extractable alumina due to incomplete extraction. The green liquor is super-saturated with alumina, whilst un-extracted gibbsite in mud acts as seed for premature gibbsite crystallization, also named reversion. The digestion discharge slurry is fed to decanters for separation of clear green liquor from mud slurry. The decanter underflow passes through mud washers where reversion continues.

Profit versus Environment

A practical aspect is that as the green liquor A/C ratio increases, alumina production increases, but the rate of premature crystallization of gibbsite on mud also increases, resulting in more extractable alumina losses with residue. Hence operating conditions in the digestion stage are determined by two conflicting objectives: High alumina <u>production</u> requires “overcharging” the extraction liquor with bauxte, resulting however in more unextracted alumina left in residue (i.e. exacerbating the environmental issue), and High alumina <u>extraction</u> requires “undercharging” the extraction liquor with bauxite, resulting however in less alumina production (i.e. less cash generation).

The end result is that a refinery is run at conditions reflecting a compromise between these objectives, which in turn are determined by bauxite quality and market conditions.

Optimum Alumina Loss

Obviously extractable alumina losses can be minimized by operating a refinery at a very low green liquor A/C ratio. However, at a very low A/C ratio the plant alumina production is also low, which is not economic. By increasing A/C ratio, plant production increases, thus improving production economics. However as the A/C ratio increases, extractable alumina losses increase, i.e. bauxite and caustic soda consumption per ton of alumina produced also increase. Hence an optimum A/C ratio exists, beyond which a further increase in green liquor A/C ratio becomes uneconomic. This aspect is described in a paper by Den Hond [2], which concludes that higher extractable alumina losses with residue are economically justified in case that:

- The bauxite has a low reactive silica content;
- The bauxite cost is low;
- The alumina price is high.

Usually a refinery operates at optimum economics when the alumina loss with residue to storage is around 6%, with higher numbers being recorded for plants processing low cost bauxite with low reactive silica content. A lower alumina loss with the residue usually points to a refinery producing at a rate which is below the optimum economic point.

For a specific plant the actual extractable alumina loss with residue is readily established by analyzing the mud which is transported to disposal areas.

M2M-TECHNOLOGY

M2M-Technology solves the dilemma of conflicting digestion objectives by replacing the single step digestion process for Gibbsitic bauxite by a two-step (or double) digestion process. M2M is short for Mud-to-Money, referring to the profitable recovery of alumina from red mud. M2M-Technology is applicable to Gibbsitic bauxite digestion including atmospheric digestion and sweetening digestion variations, i.e. for about 50% of the global alumina production capacity.

The M2M-Technology patent [1] comprises process and apparatus for the two-step digestion of Gibbsitic bauxite reflecting a novel combination of the well known redigestion process (double digestion) and spiral heat exchanger technologies.

The M2M Process

The existing first digestion step aims at maximizing alumina <u>production</u> and produces, after decantation, the main green liquor flow and a residual bauxite slurry flow. The latter is mixed with additional spent liquor and subjected to an additional, second digestion step, which aims at maximizing alumina <u>extraction</u> and produces an additional green liquor flow and a reduced residue slurry flow. The final residue is washed and transported to disposal areas.

By inserting the second digestion step in the transfer line between decanter underflow and first residue washer feed (Figure 1), the new two-step digestion process combines the best of two worlds: Increased alumina production and minimal extractable alumina loss with residue, minimizing environmental impact.

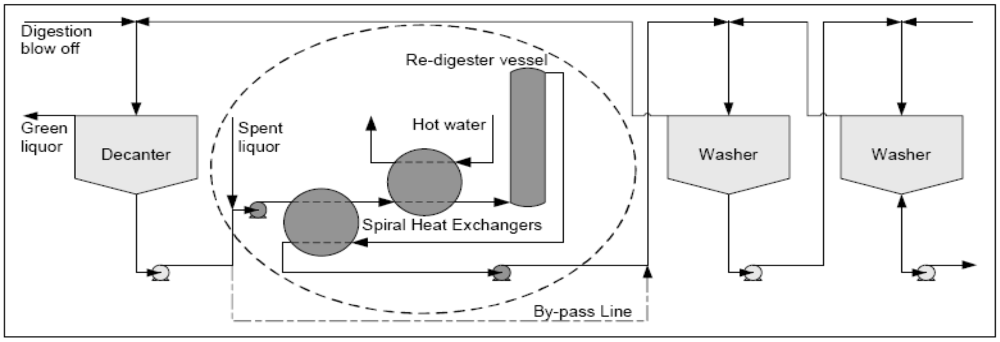
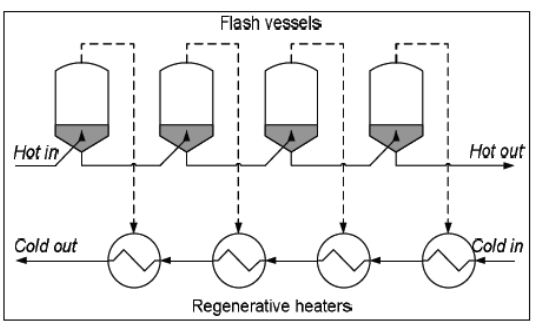


Figure 1 Second, re-digestion step between decanter and first washer

The success of M2M-Technology is based upon the use of modern flocculants and flocculation technologies in decantation, reducing the amount of green liquor associated with the residue, significantly reducing the amount of slurry to be re-digested.

Capital and operating costs of the second digestion step are relatively low because refinery residue production is reduced and hence the required residue wash water intake. The resulting reduction in plant evaporation requirements enables a second digestion step without a conventional flash vessel -heater system for heat recovery. Instead a spiral heat exchanger system (Figure 2) is used for heat recovery. Spiral heat exchangers have a much higher heat exchange efficiency because heat is transferred without the use of flash steam as intermediate energy carrier, avoiding liquor boiling point rise, and because heat transfer follows a continuous counter-current pathway rather than a discontinuous, staged pathway.



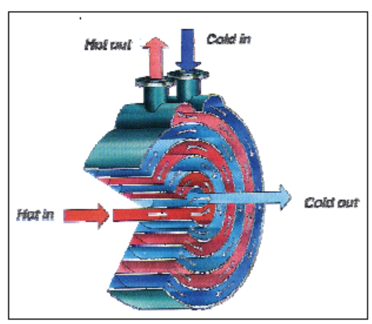


Figure 2 Flash vessel -heaters (left) versus spiral heat exchanger (right)

As a result, the external heat supply requirement for the second digest is relatively low. In addition the capital cost of a spiral heat exchanger system is much lower than the capital cost of a conventional flash vessel -heater system because the spiral heat exchanger system involves substantially less equipment.

M2M-Units™

M2M-Technology can be readily implemented in existing refineries or incorporated into greenfield projects by inserting one or more M2M-Units, comprising M2M-Heaters and M2M-Digester vessels in which gibbsite, auto-precipitated or not yet extracted, is recovered from bauxite residue.

Like bauxite, its residue differs from plant to plant and some basic analytical work is needed, to optimize the design of the M2M-Units for each refinery. In addition to installation of modular M2M-Units some construction work in the refinery is required, e.g. charge and relay tanks and a hot water system. Supplier of M2M-Units is Hencon, with technology support from Alcor Technology and Alfa Laval.

Figure 3 illustrates an M2M-Unit which represents the equipment shown within the dotted circle of Figure 1. The original connection between decanter and first washer remains in place as a by-pass, which returns the plant to its pre-M2M configuration in case of maintenance of the M2M-Unit.

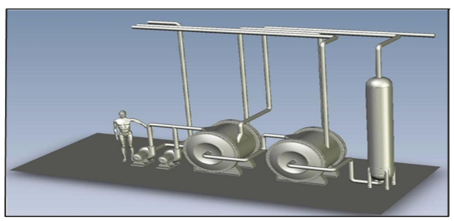


Figure 3 M2M-unit

The decanter underflow slurry feeding the M2M-Unit has already been de-silicated in the main digestion units, i.e. scale formation is not a concern. The design of the spiral heat exchangers, including feed and discharge arrangements and construction material, is such that they can handle the dense and abrasive slurry, avoiding both erosion and slurry build-up. M2M-Technology was developed in close co-operation with Alfa Laval which has extensive experience in design and supply of spiral heat exchangers for mineral processing applications.

MUD-TO-MONEY

Less mud - Environmental Benefits

After implementation of M2M-Technology virtually all available alumina is extracted from the residue, bauxite utilization is maximized and residue generation is

minimized. Greenhouse gas emissions per ton alumina remain constant.
Following are typical numbers:

- Residue generation per ton alumina reduces with 8%;
- Bauxite consumption per ton alumina reduces with 4%;
- Caustic soda loss per ton alumina reporting to the residue reduces by 4%.

The reduced environmental impact, including reduced residue disposal area requirements, may facilitate environmental permitting in case of greenfield or expansion projects.

More Alumina -Economic Benefits

Main aspects influencing project profitability are operating cost, capital cost and construction time. The additional alumina production from M2M-Technology is indicatively 4% and does not require bauxite mining, crushing, transportation, grinding, slurry holding, liquor decantation, residue washing, evaporation and impurity removal. Hence the operating cost of the incremental alumina production is limited to energy costs (power, steam and calcination fuel) and incremental fixed operating costs. Economic evaluations indicate that implementing M2M-Technology provides an economically attractive project with a typical payback period of about one year.

The M2M-Unit is stand-alone, and its installation does not interfere with routine refinery operations, i.e. installation can be carried out without an overall plant shutdown. Implementation of an M2M-project could be achieved within a year.

Once a refinery has implemented M2M-Technology improving its cash flow and environmental performance, additional benefits are feasible. With the issue of conflicting objectives in digestion being eliminated, it is possible to increase green liquor A/C ratio beyond the old optimum level. As a result refinery production could be increased by indicatively 5 to 10% at marginal operating and capital costs.

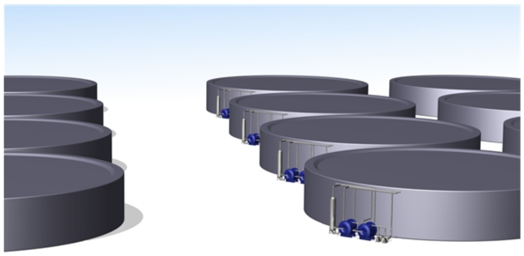


Figure 4 -M2M-Units in Washers and Decanters Area

CONCLUSION

M2M-Technology is a novel, patented combination of well known process and equipment technology. Implementation of the technology typically reduces residue generation by 8% and increases alumina production by 4%. An investment in M2M-Technology typically has a payback period of one year. Implementation of the technology does not interfere with routine refinery operation.

It is envisaged that M2M-Technology, in combination with dry mud stacking, will become the international standard for bauxite residue management.

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