AL11 - DIDION Rotary Processing: New Applications in Aluminum Smelters

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Abstract

Two new areas where DIDION rotary impact processing equipment can improve the efficiency of the operation and significantly reduce operational cost and advance housekeeping is in spent bath (electrolyte) processing and "basement" alumina / floor metal processing. The DIDION rotary impacting and sizing process can simply crush and size old bath or electrolyte removed from the pots, recovering the free aluminum and other metals that may be contained in the material and size the electrolyte or alumina for its reuse. This process saves accumulation of waste and unscreened materials and allows recovery of these materials preserving the value. [1,2,3]

Other DIDION uses at the smelter include crushing, sizing and recycling spent potlining (SPL), spent anodes and dross. This all can be handled with the same flexible system. Maintenance cost and downtime in ageing smelters on classic style crushing systems can be reduced by the simple DIDION system. A DIDION RT Crusher can replace and entire crushing line, encompassing several primary, secondary and tertiary crushers with one unit capable of receiving full size baked and scrap anode blocks and spent anodes at production rates up to 20 tonnes per hour.

Another DIDION application with a small modification is the anode thimble cleaning operation. This process is typically done with a series of storage hoppers and conveyors into a batch processing shot blast unit that uses steel shot as a consumable product and carbon contaminant and with age these systems become expensive to maintain. The DIDION thimble cleaner simplifies this process, requires less production space and produces a cleaner thimble.

Keywords: DIDION rotary processing, spent bath processing, SPL crushing and recycling, anode thimble cleaning, dross processing.

1. DIDION System – General Comments

The DIDION rotary impact and separation processing units are unique systems that can process several different smelter by product streams in the same processing line with very little modification for input product size or final screen sizes. This is achieved through the patented double liner configurations. The processing when coupled with a bag filtration unit of the appropriate size is a dust free operation. Very important when processing hazardous material such as SPL.

Labor requirements are low, typically one person to load and operate system with only basic training required. The aluminum smelter operation can benefit greatly from efficient recycling of their waste stream materials thru low cost, simple, rotary processing operations. Recovering many materials for recycling on site instead of shipping off site for secondary recycling or landfilling. Valuable alumina, bath and metal units are recovered.

DIDION is a proven work horse in difficult environments. It has widely developed uses and applications for rotary crushing and separation systems for the recycling and recovery of dissimilar materials that are often mechanically bonded together.

The development of this technology was started in the foundry industry in the early 1970s. The first step was the separating of metal castings from the foundry sand mold pieces in which they were created. These hot, heavy castings required the development of a very durable machine. The equipment was originally designed to run 24 hours a day, 7 days a week with minimal maintenance. This operating philosophy makes the DIDION systems perfect for the primary aluminum smelter where the attention should be focused on making aluminum and not problems with ancillary equipment. [4]

The continued improvement of the DIDION RT/RS TUMBLERS has made mechanical processing of mixed materials a very cost effective and low maintenance alternative to other processing systems. These flexible systems can perform surface scrubbing, crushing, screening and sizing in one single piece of equipment. The DIDION systems take up far less space than conventional crushing and screening process facilities. While at the same time the system requires less maintenance and manpower to operate. The RT/RS TUMBLER systems (Figure 1) contribute significantly to the aluminum industries potential ability to continue lowering its negative impact on the environment by this basic approach to bath, carbon, basement alumina, thimble, dross and salt cake processing.

Figure 1. 3-5 t/h, RT 72 Processing Unit.

1.1 Summary of Primary Plant Applications for the RT TUMBLER Processing System

- Bath crusher, sizer and separator in a single process with the ability to remove the tramp aluminum from this electrolyte in the same step.
- Tramp “basement” alumina, smelter metal floor waste separation.
- Carbon Reclaimer and Cleaner, scrubbing the bath off used carbon blocks before crushing and recycling and then crushing to the required size in the same piece of equipment.
- Spent Pot Liner Crushing and Material Separation.
- Removal of carbon and bath from cast thimbles in the anode rodding shop saving consumables and floor space over traditional shot belts methods.
- Separation of metallics from oxides and salts in dross and salt cake processing, with a significant environmental impact in the elimination or reduction in landfill materials.
- Alumina filter ball and burner ball cleaner/recycler.

2. Basic Design Features

There are four basic features of the DIDION RT Rotary Processing Systems.

3. The ability to process very large pieces of feed in the same processing step as fines separation, up to 1750 mm blocks depending on unit size. The RT 72 pictured in Figure 1 can process up to 800 mm input material while producing down to 3.5 mm product sizes with metal remove from -800 to + 3.5 mm.
4. The ability to crush with controlled fines generation. Very good in bath and carbon recycling.
5. The ability to classify several sizes of material from bag house dust to 1750 mm in the same single piece of equipment. Useful in basic smelter basement floor sweepings and dross recycling for metal / oxide classification.
6. The ability to "scrub" a surface removing materials that are foreign to the base structure allowing for valuable base structure materials to be recycled and reused. Very useful in thimble cleaning.

2.1. Crushing of Large Blocks of Material

Handling large blocks of material (Figure 2) can be particularly difficult for most processing systems. Typically, some jaw style pre-crushing or multiple secondary crushers are required to take a bath block or carbon block from 1750 mm down to 7 mm. This is not the case with the DIDION crushing systems. The RT Systems handle large blocks and solids in the first section of the drum, taking this time consuming and often dangerous manual labor step out of the procedure. The material is normally charged by end loader (Figure 3) into a large hooded vibratory feed hopper that loads the drum. Figure 4 shows the initial crushing chamber.

Figure 2. Typical large blocks.

Figure 3. Charging DIDION.

Figure 4. Initial crushing chamber.

Large cast steel teeth lift the blocks and then crash them down on hardened spikes for an impact and autogenous milling step that can handle any material used or produced in the smelter.

Solid aluminum sows or metal spills can be inadvertently charged into this section of the drum when processing dross for example and will not cause any damage to the DIDION unit. Large un-crushable pieces such as large slabs of aluminum can be removed from the machine simply by backing out the feeder and reversing the rotation of the drum, discharging these large pieces into a waiting tub. This practice causes no damage to the equipment, which is often the case with impacting systems.

This is a valuable feature in bath, pot cleanings and dross processing applications. Allowing one piece of equipment to handle these large pieces without significantly disrupting the process flow is unique to this material's processing steps.

2.2. Crushing with Controlled Fines Generation

The impact action of the material falling on the cast steel flights in the pre-breaking and autogenous chambers combined with the action of the Concentric Crusher roller allow for severe crushing (Figures 5 and 6). The patented double liner system also allows immediately removing the fines that are generated in the process is critical to achieving process success. The key technical challenge that the RT unit accomplishes is both preserving the preferred crushed material sizing that was chosen to go thru the liners and the removal of finer materials that act as a cushioning bed lowering the efficiency autogenous impacting. The dust control hooding allows for the finer material to be continuously removed. This has been shown to be 5-6 % of the incoming process weight for carbon and bath materials. [5,6]

Figure 5. Liner interior flights.

Figure 6. Autogenous impact zone.

This characteristic becomes valuable while processing recycled bath and spent carbon anode pieces for the downstream processes. Preselecting the correct liner opening and screen size is determined by the distinctiveness of materials, accomplishing the generation of the appropriately sized fines for further processing. This normal multiple step process is not complicated with the RT/RS system. The unique size control abilities of the RT can reduce the large blocks to the exact fraction sizes that are required for use in recycling these materials. The impact breaking action of the system gives sharp fracture angles on the particles which are preferred for the green carbon

recycling process. The DIDION process in the case of spent carbon creates a preferred size range from -25 mm for use into Green Carbon Plant (Figure 7).

This impact crushing characteristics of the system also works for recycled bath processing, allowing for product sizing and for the removal of tramp ferrous metals and aluminum. The RT system provides a uniform product, in the case of recycled bath typically – 7 mm fines sizes for use in the putting material back as "pot cover" to put back on top of the reduction cells (Figure 8).

Figure 7. -25 mm spent carbon anode.

Figure 8. - 7mm recycled bath.

2.3. Classify Several Sizes of Material in the Same Processing Step

This equipment has the ability to separate up to 8 (eight) different size fractions in the same processing unit simultaneously from bag filter dust to 1750 mm blocks. This is achieved with the proper selection of the crushing chamber dam ring openings, liner openings and screen sizes.

The numerous DIDION patents for this unique piece of equipment (Figure 9) allow for this very significant trait of the RT & RS processing units. There are significant advantages from both a process viewpoint and from a general economics view point of being able to accomplish many processing steps in one unit.

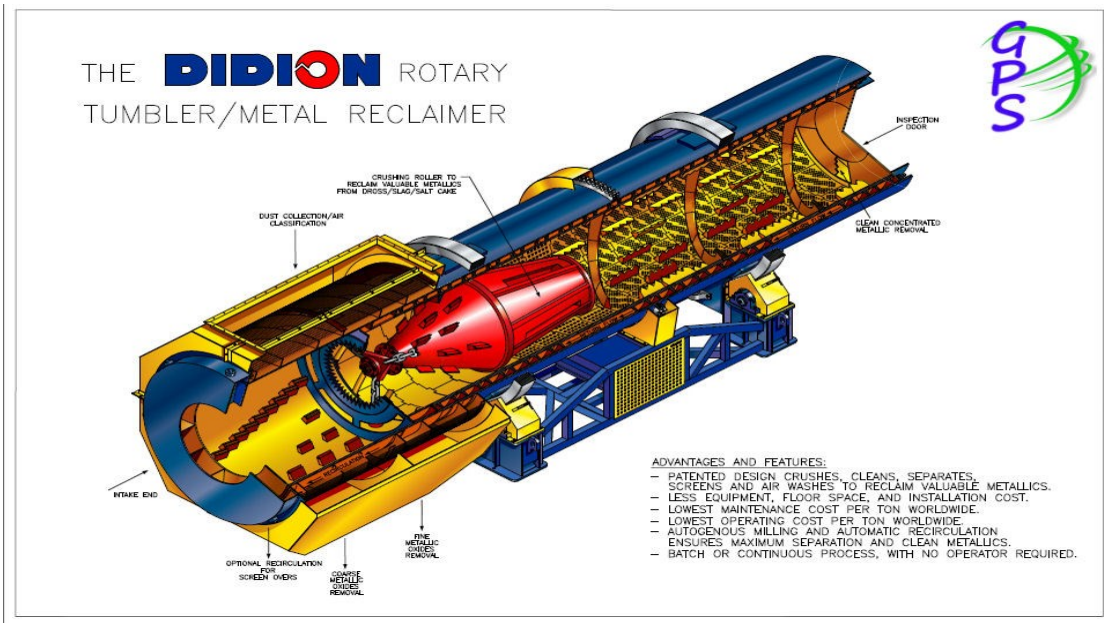

Figure 9. Material flow diagram and fines separation – RT.

Two applications in the smelter that this is particularly good for is “basement” alumina and floor sweepings processing and dross processing (Figures 10 and 11).

A large primary smelter generates monthly hundreds of tones, of “Basement” alumina and floor sweeping containing various amounts of alumina, bath and aluminum metal that is valuable to the smelter and trash that has no value to the aluminum smelter. The issue is that these materials are mixed together and not easy to separate under normal circumstances. The combination material has no value and is a land fill dump item. Manual separation is labor intensive and time consuming. Processing thru the DIDION however with a 3.5 mm screen can reclaim all the alumina and separate most of the aluminum metal from the fines and larger trash items.

Figure 10. Basement “cleanings”.

Figure 11. Manual separation of “chunks”.

On site dross processing is the other application that is ideal for several size classification. In the primary smelter, pressed dross or rapidly cooled dross has significant free metal in the +25 mm range that can be charged back directly into the holding furnaces. The -25 + 10 mm may be able to be charged depending on the condition of the dross and pre hot processing of the dross such as pressing or RIA In Furnace Dross Process for example. The – 10 mm + 3.5 mm metal concentrates is a good raw material product for sales to steel mill deox providers. The -3.5 mm material is a good product to sell to the steel slag conditioner suppliers. The bag filter dust also goes to steel slag conditioner markets. This can cut down the amount of waste stream generated form secondary recycling. Particle sizes are shown in Figure 12.

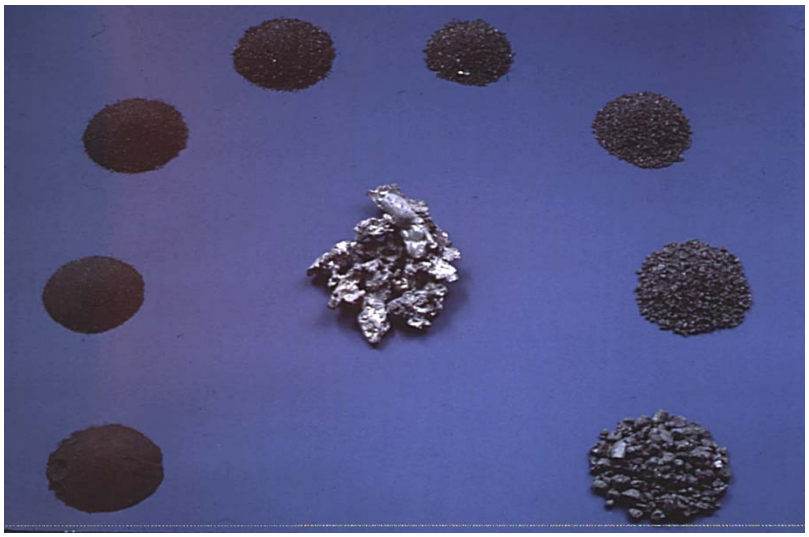

Figure 12. Particle size control for aluminum dross.

All of these sizing steps occur inside the DIDION system. Providing products that can be recycled as is or moved on further for use. Environmentally dust is strictly controlled by the bag house/pollution control system installed with the unit or attached to the plant system.

2.4. "Scrubbing" Surfaces Removing Materials that are Foreign to the Base Structure

The flexibility of the interior design of the DIDION RT systems can allow for multiple sections accomplishing a variety of processing goals. The scrubbing or removal of foreign material from the base material is a standard application for DIDION rotary equipment (Figure 13). In the original foundry applications for the units, it was the removal of sand from the base casting. The process had to remove the sand without damaging the castings. [7]

Three areas where this feature of the systems have applications in the primary aluminum plant are in the removal of bath from the spent anodes, the removal of carbon from the thimble casting after they have been removed from the rod and finally the removal of metal and oxides off alumina filter balls.

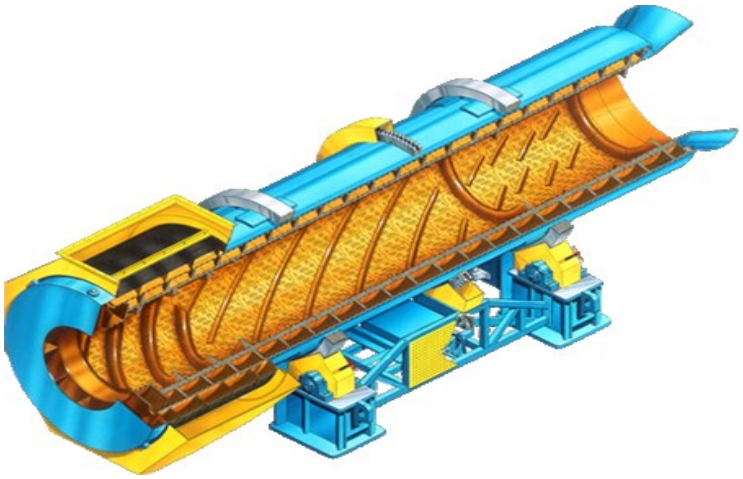

Figure 13. Heavy duty rotary separator / thimble cleaners – RS.

The system works by using the bits and pieces of materials to process itself, relying on the size differences of individual pieces of the material to clean even in the pockets where small amount of bath or carbon may be trapped. During this cleaning step, the friable material crush into fines and are removed form the process.

In the case of removal of the bath from the anodes or carbon from the thimbles the standard practice of shot blasting is inefficient and time consuming. The steel shot is an expensive consumable that can be carried over into other aspects of the process. The cleaning efficiency of that system is not perfect and significant amounts of sodium/bath contamination can move to the next phase of the process. These salt contaminants typically cause problems with the refractories in the carbon backing furnaces and in the thimble casting furnaces. The RT/RS processing technique stops the majority of the bath and carbon carry over into the next part of the production process improving if not eliminating the induction furnace refractory issues. Dirty and clean processed thimbles are shown in Figures 14 and 15.

Figure 14. Dirty thimbles.

Figure 15. Clean RS processed thimbles.

An additional unique application for the Rotary Separator is the "cleaning" of alumina balls that are used in aluminum filter applications and in regenerative burner applications. These unique materials are an expensive consumable in the aluminum casting facility within the smelter. There is currently no widely used recycling method for the recycling of the balls used in the aluminum filter beds. They typically go out with the dross and are processed for the small amounts of aluminum attached to them. This aluminum, although valuable is worth less than the high alumina balls (Figure 16). These alumina balls are also used in regenerative burner systems. They typically are cleaned on a regular basis by washing them with water in a separate process, dissolving any contaminants that may be stuck to the surface. The wastewater from the process must be dealt with and is often a water discharge problem. The RS processing of these balls produces a clean, reusable ball (Figure 17), along with easily disposable fines. This is a minor generation area of waste but when looking at overall recyclability, reductions of land fill and reuse of materials. Every opportunity can be an important effort for the environment.

Figure 16. Spent alumina balls.

Figure 17. Processed alumina balls.

3. Summary

The commercial advantages on having a DIDOIN unit on site for general smelter by product processing are significant. The key bonus is the fact that this unit is able separate many different types of materials into various size categories as follows.

1. The ability to take almost any size initial feed. The only restriction being the selection of the overall diameter of the unit. Systems are available in diameters up to 4.5 meters. The unique reversing feature of the system with the units incorporating the primary impact chamber allow for solid aluminum to be processed cleaned and discharged into tubs after retraction of the entry feeder. Individual units handle block sizes as large as 1750 mm to 600 mm.
2. The coarse and fine particle removal is the next stage that can be key to the value of the materials in processing general site waste and dross. The screens in this area can be

any opening less than the liner holes. This hooded area is designed for two screens that allow for different opening sizes in each panel. These screens can quickly be removed and changed for other sizes if downstream process parameters change requiring different fractions of fines materials. Typical fines screen selection will range from -10 mm to + 3 mm.

3. The ability to select recirculation or direct discharge in the machine of the intermediate materials classified by the liner holes is important for processing flexibilities. In bath carbon processing it can control the size and characteristics of the particles moving forward to the next process step. When processing materials that contain metallic aluminum, this element allows for high concentration of metallics that can be efficiently melted or sold for high metal contents. The liner holes/slot sizes typically range from 20 mm – 50 mm.
4. The autogenous milling section will reduce friable materials down to the size of the liner openings. None friable or metallic materials can then exit the back end of the drum. These materials usually will be -250 mm + 50 mm. They can be further sized with a rotary classifier attached to the end of the drum into three additional cuts depending on customer requirements.
5. The air flow of the bag house system provides the final product sizing possibilities. The pollution control device normally removes -.5 mm materials. This fraction can be subdivided by use of a cyclone separator before the bag house. This can have a value in dross processing depending on sale values of by product streams.

The installation space requirement for the largest unit (Figure 18) is an envelope of approximately 6 x 30 meters. This layout would assume that discharge into tubs. Conveyors can be added to the system for continuous removal of the products. These conveyors can be set up in many configurations for additional separation steps such as eddy current processing, magnetic separation and/or product bulk bagging.

Stand-alone systems that are used for dross or salt slag processing typically require 2 people per shift for the operation of the entire system. One man can operate system but safety requirements normally set the standard for two.

The systems are very reliable. They were designed to be part of manufacturing lines in high production automotive foundries that run 24 hours a day seven days a week. Any unscheduled downtime is unacceptable to this industry. This reliable performance is achieved by the selection of simple dependable parts and extremely heavy-duty components.

Figure 18. RT 108 System with magnetic separation.

Operational costs are very low. The largest unit operates with a 200 Kw drive motor, the smallest with a 22Kw drive motor. Processing cost per ton will vary with the size of the unit. The largest unit processing 20 tph has an operating cost of .75$/ton, considering all monthly maintenance capital cost and a cast liner replacement after 7 years of operation.

This processing cost/ton is exclusive of local labor cost. Certainly, with all labor included processing through these large units is less than $10.00/tonne.

Custom sizes thru puts and processing configurations are part of the DIDION philosophy of equipment design and can always be evaluated and normally accomplished.

The flexibility of the design configurations of the DIDION rotary processing equipment has many potential applications in the aluminum smelter environment. A single unit can independently process several different types of materials. These dynamic systems can lower overall processing cost by reducing manpower, maintenance, energy consumption and lowering the plant area required for the above-mentioned materials processing practices.

4. References:

1. David J Roth, Retrofit opportunities in aluminum smelter using DIDION rotary thimble cleaning and carbon crushing equipment, *Proceedings of 33rd International ICSOBA Conference*, Dubai, UAE, 29 November – 1 December 2015, Paper CB09, *Travaux* 44, 487-494.
2. David J Roth, Overcoming solid waste in aluminum production, *TMS 2018, 147th Annual Meeting & Exhibition Supplemental Proceeding,* March 11-15, 2018, Phoenix, Arizona.
3. David J Roth, Metal recovery from dross thru rotary crushing and separation producing products instead of waste – *REWAS 2016 Sub session 5,* February 14-18, 2016, Nashville, Tn, 241-246.
4. DIDION International Inc., Riverside Industrial Centre, 7000 W Geneva Dr., St Peters, Mo 63376 USA, https://www.didion.com. ecole des ponts business school ecole des ponts business school ecole des ponts business school ecole des ponts business school
5. Charles J. Didion, Granular and aggregate blending, cooling and screening rotary drum, *US Patent* 7,204,636 B2, filed July. 1, 2003, granted April 17, 2007.
6. Michael S. Didion, Rotary tumbler and metal reclaimer, *US Patent* 7,942,354 B2, filed July. 29, 2008, granted May 17, 2011.
7. Michael S. Didion, Rotary tumbler and metal reclaimer, *US Patent* 2,768,450, filed July. 21, 2009, granted April 24, 2018.