The Latest Steps in Mechanical Processing and Recovery of Aluminum Drosses

Prepared for Alusil – MVT, Moscow, Russia 2013
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INTRODUCTION

Worldwide production of aluminium continues to grow despite the past economic slowdown period, at present the annual production of primary and secondary aluminum is at approximately 70 million metric tons per annum. The production of aluminum has contributed to about 1% of global green house gases and all industry is under pressure to reduce these emissions. The industry is also responsible for 1.5 – 2.5 million tons of dross/salt slag landfill waste per year. There continues however to be pressure to reduce or eliminate this waste by the aluminum industry in general as we see pressure for sustainable processing.

The percentage of aluminum recycled, (currently moving above one third), continues to increase and may be looked upon as a cornerstone for the reduction of green house gases in aluminum processing. Recycled aluminum needs just 5% of the energy and emits only 5% of green house gases but the re-melting of scrap aluminum produces dross that presents its own environmental problems and challenges.

The development of the DIDION **RT Metal/Dross Reclaimer System** has made mechanical processing of aluminum dross a very cost effective alternative to thermal processing of these lower grade materials. The **RT** Systems contribute to the aluminum industries potential ability to lower its negative impact on the environment.

The RT is the first single piece of equipment that allows for total dross processing in the dross generators facility. The properly sized unit requires no presorting. The RT system increases the total percentage of aluminum recovered in house at the dross generator's facility. It also prepares the remaining aluminum oxide in a form that make it more readily suitable for use in the melting operation and for downstream by-products. It does so with relatively minimal capital, maintenance and manpower cost.

Mechanical dross treatment was the standard method of dross treatment before the introduction of the tilt type rotary furnace. There were four predominant systems used; ball mills, hammer mills, roller mills and horizontal and vertical shaft impactors. The first three are typically no longer used because of high maintenance and the technical aspects of the equipment and aluminum recovery issues. The classical impact crusher systems are still used today for high volume dross processors. The RT Metal/Reclaimer has now however allowed small volume dross generators to use this type of technology.

Figure1. Model RT 84 -2100 DIDION Metal/Dross Reclaimer

Key Points to RT Metal/Dross Reclaimer System of Dross and Salt Cake:

- ***Simple, low maintenance methods of separating metallics from oxides and salts.***
- ***Easy installation and uncomplicated operation requiring only basic operating skills.***
- ***Significantly increase amount of aluminum recoverable at dross generators site.***
- ***Significant environmental impact in the elimination or reduction in landfill materials.***
- ***Contributes to significant aluminum industry reduction in CO2 generation.***
- ***Preserves thousands of tons of aluminum that were a waste and can now be recovered.***

The RT System can be utilized in each basic aluminum market sector.

PRIMARY ALUMINUM PRODUCTION

Dross generation from the primary aluminum smelting process normally represents .3 – 1.0% of the aluminum production. Properly processed this material can contain up to 60% aluminum, most of which can be recycled back in the primary smelting facility if processed thru the DIDION RT System. Key factors in preserving these high metal contents are good furnace practices and cooling the material rapidly after skimming to avoid thermiting or the burning away of the aluminum.

The in house RT processed dross can be a significant resource to the primary smelting operation. The aluminum can not only be returned to the furnaces for remelting but there are reports that discuss the oxides from non alloyed material going directly back into the pots.

SECONDARY ALUMINUM RECYCLING

The amount of dross generated at secondary aluminum operations is significantly higher than at primary operations varying, widely depending on the process. White dross is produced from the melting of scrap at the many general recyclers, extruders and mills that process scrap aluminum. This dross is higher in metal content than secondary black drosses and contains little or no flux.

The secondary aluminum industry also generates black dross from the melting of scrap in side well furnaces which contain relatively low levels of aluminum and typically requires some type of mechanical processing from the dross recyclers for efficient recovery of the aluminum. The **RT** System, for the first time, gives black dross generators an economical method for removing the aluminum while producing a granulated fine material. Potentially this material can be sized for further aluminum recovery and for potential uses in flux recycling and efficient land fill options.

The lowest grade of aluminum containing waste is salt cake, generated in secondary smelter rotary furnaces. This style of mechanical processing does an excellent job of recovering the metallics from this material down to 3mm in size. Typical materials that were typically thought to contain 4-5% aluminum, when processed thru the RT system recover 6-8% metallics. Combine the RT with a fine particle eddy current system and they give excellent recovery results on materials that were destined for the landfill.

Crushing/Impacting of Material:

Figure 2. Primary Crushing Chamber

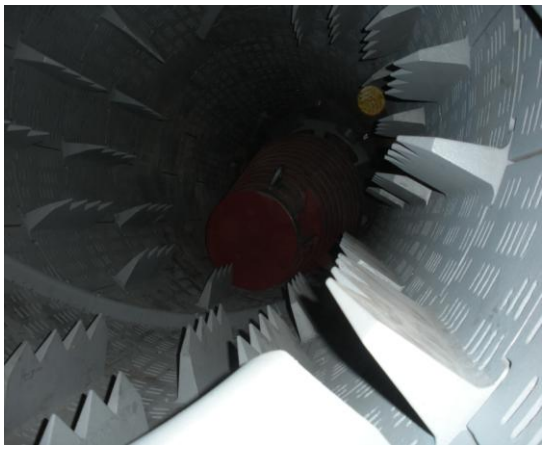

Figure 3. Secondary Crushing Chamber

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OLD DROSS DUMPS & LANDFILLS

Established aluminum processing facilities and landfills around the world are full of dross and salt cake deposits that contain significant amounts of aluminum and aluminum oxide. This material is sometimes buried or exposed to the elements. The RT Systems can efficiently, effectively and economically recover the aluminum from this material with aluminum contents down to as low as 5%. This presents the opportunity to recover aluminum units that were thought to be lost forever.

Old Dross that has been in the outdoors for many years can have a wide range of metal contents depending on the conditions it was generated and stored. Previous dross handling practices put very little value on the dross and it's aluminum content was not always in question with relatively low aluminum values in the past. Now we can do everything possible to maximize the recovery of materials. Mining these old dross dumps at today's metal values with the potential for both the aluminum and aluminum oxide products being of value is proving to be the proper environmental action plan.

EQUIPMENT AND PROCESS DESCRIPTIPON

The DIDION RT system is a very unique piece of equipment used to mechanically process dross, slag and other waste materials in which there is a malleable fraction (aluminum, brass, zinc, stainless steel etc.) that is mixed into a more friable fractions (oxide and flux). There have been three versions of the TUMBLER designed by DIDION Manufacturing. The original systems, available in the 1970's were intended to remove metal from waste sand in the foundry industry.

Many waste sand piles have been processed with the payback period of a matter of weeks not months. The unit has now been developed to remove aluminum from black dross and salt cake. It also produces high metallic concentrates from white aluminum dross and separates the various sizes of metal and oxide fractions. The system has been sold to brass and alloy steel foundries for the same purpose of preparing the metallics for in house recycling and for by products for sale. Trials and research is being done on many other materials and applications in the metals industry.

First and foremost the RT Metal/Dross Reclaimer is a semi-continuous operation. This means that the dross goes into the system, the fines -1/4"(6 mm) are continuously removed but the oversized +1/4" (6mm) are concentrated to a + 90% aluminum level no matter how low the incoming metal content of the dross or salt cake. The second important feature are the recycling flights built into the cast steel linings that move the fines to the front of the drum removing the -1/4"(6 mm) and recycling the +1/4"(6 mm) back through the system for additional concentrating of this smaller fraction.

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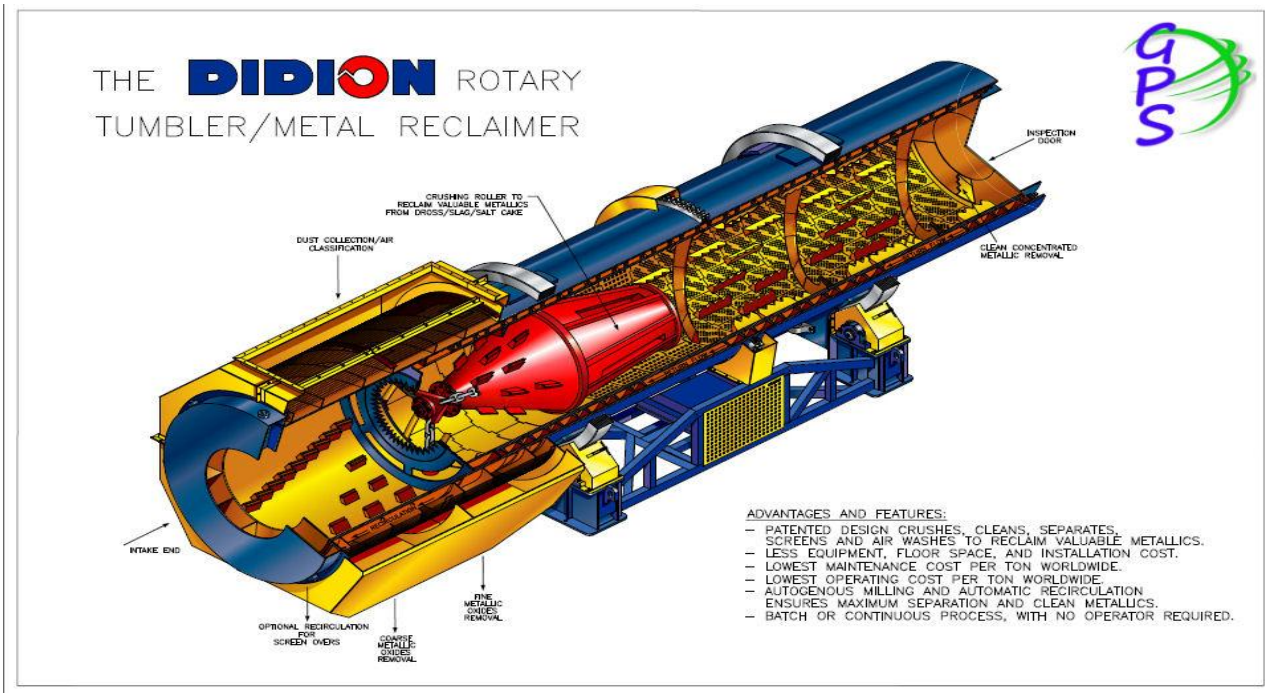
Section 1 **Section 2** **Section 3**



Section 4

Figure 4 – Schematic of RT Metal/Dross Reclaimer

Material of almost any size can be charged into the front of the ROTARY TUMBLER. Systems are sized for the generators dross/salt cake block size. The oversized materials either come out the front or back ends of the drum. All the fine materials come out the front end of drum (Section 4). The Muller Roller in Section 2 is a solid weldment that has a design allowing for the successful concentration of materials down to ¼" (6 mm).

Monthly maintenance costs have been proven to be very low. Our experiences with several earlier systems indicate the cast steel lining will last up to 8 years. The system utilizes relatively small pollution control systems, with excellent dust control.

Figure 5. – Unprocessed Dross

Figure 6. +10mm (+3/8) Processed

Figure 7. +6 mm (+1/4") Processed

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The examples above (Figures 5-7) show typical incoming unprocessed dross directly from a melting furnace and the high level concentrates produced from processing in the RT System. These concentrates are suitable for direct melting or use as feed products for other processes. The samples below (Figure 8) show a range of potential by-product sizes available to the steel and chemical processing industries.

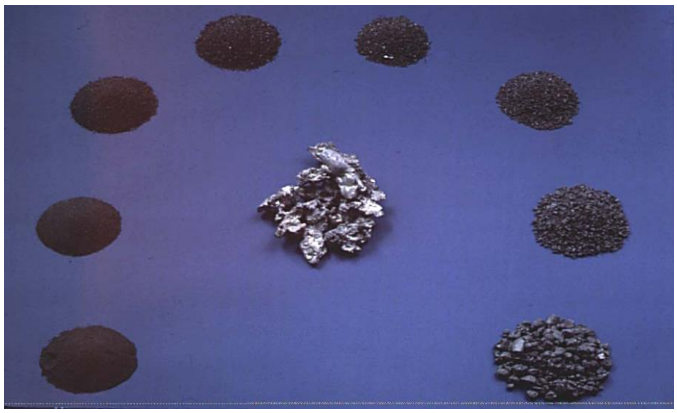

Figure8. By-Product Particle Size Control

ENVIRONMENTAL IMPACT:

- **Reduced Carbon Footprint**

  Currently there is a global emphasis on the reduction of CO_2 emissions in an effort to stop its contribution to global warming. The burning of carbon fuels is considered a major contributor to CO_2 generation.

  Mechanical processing of dross to concentrate the aluminum to a high enough level for direct charging is a real solution which can eliminate the secondary thermal processing of dross.

  The amount of aluminum produced by the secondary aluminum industry worldwide is a difficult number to pin down.

  Looking at several sources it should be somewhere between 22 – 25 million tons of production. Dross generation will vary significantly depending on the type of furnace and type of scrap melted.

  Dross generation in the range of 5 to 10% of the input material is certainly not an overstated number.

This puts the world wide dross generation between 1.5 - 2.5 million tons. This is the size of one or two very large Russian or Middle Eastern smelters. The CO_2 generated per ton of thermal processed dross is approximately 125 kgs for ton of secondary aluminum produced.

Worldwide primary aluminum production produces about 30-40 % as much of dross as the secondary aluminum industry but significantly more CO_2 emissions than the secondary aluminum processing industry. Recovery of the aluminum in this material by non thermal processes has a huge positive impact to the environment.

- **Reduction of Landfill Waste**

There are three types of dross that come from aluminum melting:

1. White dross that is generated in primary smelting and melting furnaces without the use of flux.
2. Black dross that comes from well melting operations and some tilt style rotary furnaces.
3. Salt cake that comes from tilt and fixed axis rotary furnaces.

White dross will typically have somewhere between 30 – 70% aluminum content. This material is normally recycled in either a fixed axis or tilt type rotary salt furnace. The best performance comes from the tilting rotary furnaces from both a recovery and waste generation view point. The nature of the process requires a flux to be used to recover the aluminum from the dross. Typically for every 3 kilograms of oxide that goes into the furnace 1 kilogram of flux must be added. For 1000 kilograms of dross with a 50% aluminum recovery there are 665 kilograms going to the land fill or 66.5% of the generation. If we assume 50% of the dross generated from the recycling process is white dross then conservatively 750,000 – 1,250,000 tons are going to the land fill and this material contains a minimum of 5% aluminum or 37,500 – 62,500 tons being thrown away. The use of the RT System operation would all but eliminate the landfill of this type of material because clean, flux free oxides can normally find a use and save all the aluminum units.

Black dross generated in well style recycling furnaces is usually mechanically processed inefficiently to preserve aluminum units at about 6mm for secondary melting. The remaining material is typically land filled. If we assume the other half of the material referenced above was black dross at aluminum recovery of 8 - 12% from current processing techniques 675,000 – 1,120,000 tons would be land filled. Using the RT technology on this material could yield an additional 6% of this material as aluminum contained in the fines. This fine aluminum could then be recycled. Reducing the landfill waste by an additional 40,500 – 75,000 tons

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There are many fixed axis rotary furnaces running especially in Europe producing salt cake. Most of this material however is run thru some type of flux recovery system. The process produces a salt and oxide component that is low in value.

This paper does not address this material as it is assumed that it is not going to a landfill. It is however known that in most areas of the world the salt/oxide residuals are land filled.

To summarize, using the DIDION RT System for dross processing for primary and secondary dross could preserve from 78,000 to 137,500 tons of aluminum and prevents a significant portion of the 1,500,000 to 2,500,000 tons of material from going to the land fill.

- **Preservation of Resources**

  There is a significant environmental impact in not land filling 2,000,000 tons of dross material every year. This impact varies from continent to continent depending on local laws. It clearly is a significant benefit to our industry and planet as a whole.

  Looking at the 78,000 to 137,500 tons of a secondary aluminum source rather than primary production also has a significant environmental impact.

  The aluminum industry recognizes that it requires only 5% of the energy to recycle aluminum than to produce that aluminum unit from bauxite. The International Aluminum Institute's 2010 report on CO_2 emissions from the aluminum production process conservatively cites 125 kgs per ton of CO_2 for recycled aluminum production versus 2500 kgs per ton for primary aluminum. Therefore there is somewhere between 180 – 320 thousand tons of CO_2 that would not be generated because of producing the recycled aluminum product from dross headed to the landfill.

TYPICAL RESULTS:

Aluminum dross and salt cake have many different physical forms. The very high aluminum content dross or sludge is not a typical product that would be processed in this system. This material would be best processed for metal recovery directly in a rotary furnace. This type of material however represents a very small amount of the total dross generated.

Dross also varies significantly from operation to operation. The characteristics vary depending on furnace practices, skimming techniques, hot processing procedures and skim pan designs. All of these factors affect the metallics and oxides as they separate from each other in this process. The results below are typical of what we have seen after many years of operations.

Material Type: Typical White Dross*

Size	% Processed	% Al Content	Comments	Market
Coarse Concentrate	35-45 %	+85 - 90%	In-house recycling Well/ Reverb furnace	Alloyed ingot RSI
Fine Concentrate	5-20 %	+90 - 95 %	In-house recycling Well/ Reverb furnace	Alloyed ingot RSI
Coarse Fines	10-20 %	50-60 %	Recycle by rotary dross processor, By-product sale	Exothermics for steel/chemical industries
Fines	20-30 %	20-30 %	Internal reuse / Sell as By-product	Pot Line/ Cement industry/Chemical Industry
Bag House Dust	5-10 %	< 15 %	Internal reuse/ By-product sale	Pot Line/ Cement industry/Chemical Industry
Overall Results	**100**	**50-70 %**	**Avg. Sec. Rec. 60 %**	

Table 1

The aluminum content of primary dross can range from 30 – 80%. A facility using proper practices however should recover in the 60% range.

The concentrates from these materials are normally salt free and high in aluminum content. The coarse materials are an excellent charge into standard melting furnaces. The fine concentrates make a good charge for either rotary furnaces or well furnaces especially if a vortex system is available.

The remaining fines from this material are high in aluminum content and low in chloride content. These materials are unique in that the potential volumes can be relatively high and the aluminum content and sizes are consistent. These characteristics are produced by the RT System and make these materials much more attractive to by product markets.

Some fine aluminum particles and clean oxides can potentially be used back in the pot lines or marketed to the cement industry for its energy and Al_2O_3 content. They also can be used as a raw material for the water treatment chemical market and the steel industry as materials for the suppliers for deox and slag conditioners. The chemical industry is an outlet for these materials as they are used as reactants and the same goes for the exothermic products industry.

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Material Type: Black Well Dross*

Size	% of total Processed	% Al Content	Comments	Market
Coarse Concentrate	2-6%	+90%	In-house recycling – Well/Reverb Furnace	Alloyed Ingot RSI
Fine Concentrate	2-10%	+85 -90%	In-house recycling Well/Reverb furnace	Alloyed Ingot RSI
Coarse Fines	25-35%	15-40%	Recycle by dross processor or product sales/Eddy current	Exothermics/ flux/land fill
Fines	40-50%	10-25%	Sell as by-product Eddy current	Exothermics/flux /land fill
Bag House Dust	5-10%	<15%	Bag house fraction	Secondary flux recycling /land fill
Overall Results	**100%**	**15 - 25%**	**Avg. Sec. Rec. 12%**	

Table 2

Black dross metal contents or recoveries reported from the dross recycler are normally a combination of the first two fractions. This can range from a low of 5 - 6% to a high of 15-16%. The higher the levels of aluminum, the more impressive the savings will be for recycling at the black dross generator. The next two fines fractions are where the extra metal units are available. These metal units however are not for melting as is, but for selling as a by-product or briquetting for other aluminum uses. These metal units are obtainable using eddy current separation of the metallics from the oxide flux mixture.

The recovery of this material can increase the overall metal content recovered by 6 – 10%. Depending on the value placed on this material it can significantly impact the overall available savings.

The largest technical challenge is finding a use for or recycling the remaining material. So far this challenge has not been overcome but is being actively pursued. This fraction is approxamlty 85% of the incoming black dross material. The worst case scenario would be for it to go to the landfill as it presently done in the US. If this occurred, it would mean that after RT processing approximately 15% less material would be disposed of than in today's normal black dross recycling process. This being the result of the extra fine aluminum particles extracted from the material. This would represent a small environmental improvement but an improvement all the same. The remaining fines are approximately 1/3 salt flux and 2/3 oxides and other minor contaminates.

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These are materials that with effort should be useful for some industrial purpose in the right size and quantity. This material is now reprocessed into usable oxide and flux in most of Europe. The possibility of systems to do this at large generators site is now a real option. This solution is becoming more likely with the potential of selling the oxides to the cement industry and the very high current cost of flux which is not likely to go down. Flux recycling systems are a real potential now worldwide instead of only Europe.

Material Type: Salt Cake*

Size	% Processed	% Al Content	Comments	Market
Coarse Concentrate	2-4 %	+90 %	In-house recycling Well/Reverb furnace	Alloyed ingot RSI
Fine Concentrate	2-4 %	+90 %	In- house recycling Well/Reverb furnace	Alloyed ingot RSI
Coarse Fines	30-50 %	15-20 %	Recycle by dross processor, By-product sale	Exothermics for steel/chemical industries
Fines	40-50 %	10-15 %	Sell as By-product	Secondary Flux Recycling/land fill
Bag House Dust	5-10 %	< 15 %	Bag house fraction By-product sale	Secondary Flux Recycling/Land fill
Overall Results	**100**	**5 – 15 %**	**Avg. Sec. Rec. 6 %**	

Table 3

Many secondary aluminum processors have installed tilting rotary furnaces in their operations for processing a wide range of lower grade scraps. These types of furnaces are effective at doing this; they however generate salt cake that typically has very low metal content.

This salt cake material has been a land fill item in the US, Europe and other areas of the world. The RT System can process these materials allowing for maximum aluminum recovery at all aluminum particle sizes. This System also prepares the fines for the salt reclamation process without the need for additional primary or secondary impacting.

CONCUSION:

The advantages to the Primary and Secondary aluminum industry for mechanical dross processing in the RT Systems are laid out above. The primary and secondary aluminum industries have additional opportunities for improving it environmental impact thru better dross processing and management.

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Old dross dumps and landfills present another opportunity for this unique system. One piece of equipment can process all of the above materials. The equipment can be operated by the lowest labor grade in most facilities. It is simple to run, low in maintenance and batch operated to keep unlike materials and alloys separate.

In the evaluation for the capital expenditure for this type of system all these factors must be added together to determine the capital and environmental return on investment. The capital dollars however are not extraordinary by most measures; the environmental returns are extraordinary by any measure.

The coarse and fine aluminum concentrates can be recycled at most operations. The markets for the aluminum, oxide and flux rich fines fractions are local in nature. Individual customers must ascertain which solutions present themselves for their regional markets and which environmental solution is acceptable in their operating sphere.

***Aluminum dross and salt cake are non homogeneous materials and vary significantly from operation to operation. The numbers in the above tables represent results from test we have performed and our experience at production facilities. Most dross and salt cake materials will fall within these ranges, some may not. We consider all of our numbers on the conservative estimate side.**

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