CASTHOUSE AND RELATED EQUIPMENT COMMERCIALISED BY STAS

Martin B. Taylor, eng., M.Sc., STAS Ltée
1846 Outarde, Chicoutimi (Quebec)
Canada G7K 1H1

Introduction

For several reasons, hydrogen, alkalines and inclusions have long been considered as undesirable in the processing and commercial use of aluminium. There are several equipments now available in the market to improve the metallurgy of the process and to ensure an improved quality of the finished metal or alloy. For example the TAC process (Treatment of Aluminium in a Crucible) developed by Alcan and commercialised in the early 80's was mainly targeted to reduce lithium directly in the crucible at the smelter [1] [2] together with sodium and other alkalines.

Lower levels of sodium are demanded not only in smelter casthouses prior to casting but also in remelt and recycle operations. Traditionally, chlorine gas in the holder furnace (using lances or rotary gas/flux injectors – RGI/RFI) or with in-line degassing equipment such as the ACD (Alcan Compact Trough Degasser) has been the most common approach to reduce alkalines, hydrogen and inclusions prior to casting into final slabs and billets.

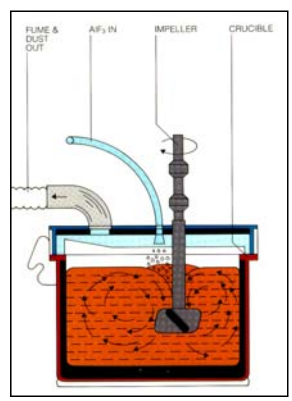
For large companies who source metal not only from smelters but also for remelt and recycle operations, the choice of metal treatment without the use of chlorine, or at least to reduce its use, is not necessarily an easy one. This paper explores some of the pros and cons of the different methods to reduce hydrogen, alkalines and inclusions in molten aluminium, mainly with the TAC for pot room metal or directly in the casthouse using either the RGI or RFI and/or in-line degassers.

TAC

The TAC process (Photo 1, Sketch 1) was originally developed to reduce lithium, sodium and other alkalines in the pot room crucible before transferring to melting/holding furnaces [3].

The TAC process does not use chlorine but adds aluminium fluoride as a salt flux to the molten aluminium directly into the crucible in which a vortex is deliberately developed using a rotating cast iron rotor. The rotation is eccentric, i.e., off-centre with the impeller positioned at the correct distance from the bottom of the crucible, whilst maintaining a suitable height of molten metal.

Photo 1



Sketch 1

One of the main advantages of the TAC is that the flux material is readily available in the smelter and can be recycled to the pots when the crucible walls are cleaned with a crucible cleaning machine. The time of treatment is typically of the order of a few minutes but is a function of the alkaline to be reduced (e.g. Li or Na); a total cycle time can be less than 15 minutes and allows up to 150,000 tonnes per year to be treated with a single station.

<u>RFI/RGI</u>

The RGI/RFI is now accepted as an efficient alternate for replacing lancing and porous plugs for injection of chlorine and manual additions of flux. Although the RGI uses chlorine gas, the total quantity per furnace batch treatment is reduced significantly compared with lancing.The RGI is a gas-only model employing nitrogen as a carrier gas and chlorine as the reactive agent. The RFI is a design in which nitrogen is used as the carrier gas, but a solid flux (often a magnesium-potassium chloride flux) is used to replace the chlorine gas and is therefore more environmentally friendly. The RGI/RFI has been modified and much improved of late, to be used mainly in the holding furnace of various shapes and sizes to reduce alkalines and inclusions. These injectors rotate as high as 500 rev/min and are designed to be either fixed to the furnace, fixed to the floor adjacent to the furnace or as a mobile unit able to treat more than one furnace in the casthouse(Photo 2, Photo 3, Photo 4).

Photo 2: Typical RFI – Mobile

It is critical that the injector is positioned correctly in the furnace whilst maintaining a proper height of metal above and below the impeller. These injectors using graphite rotors can treat up to 150 tonnes of metal in the furnace with a single machine.

The ACD is the latest development for in-line degassing. Being a modular system, 2 rotors per module, it is ideally suitable to treat flow rates from a few kg/min to as high as 1500 kg/min. It is designed to use spinning rotors with up to 8 rotors (Photo 5) immersed in the molten aluminium directly in the trough, so that there is no loss of metal during alloy changes. The number of rotors is a function of the flow rate, alloy type, as well as the desired reductions of hydrogen, inclusions and alkalines and so on.

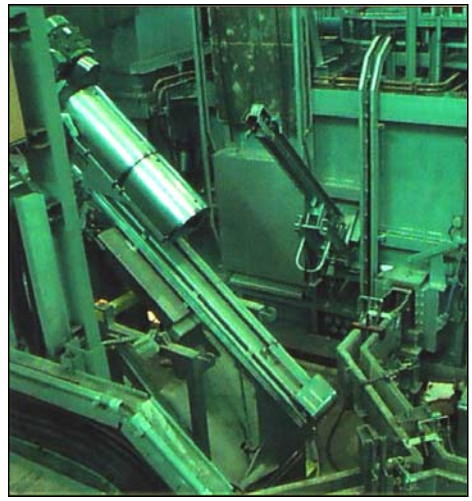


Photo 3: Fixed RGI for 2 Furnaces

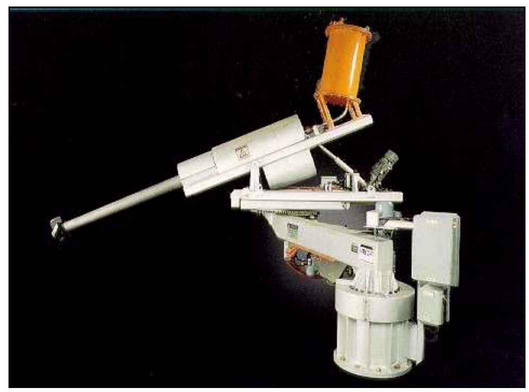


Photo 4: Typical RFI – Fixed

<u>In-line Degassing</u>

Argon and chlorine gas is injected to the spinning rotors; and with stoichiometric additions of chlorine gas, alkalines can be reduced by up to 90% with typically between 65 and 75% being obtained [5]. Where chlorine gas is not available, the ACD can be operated successfully without its use. In fact, there are several units now operating world-wide without chlorine gas.

Photo 5: 8-Rotor ACD

Applications

TAC Applications

Based on experience over the last 20 years, there are several factors used today to design and operate a TAC station. Obviously, the specific alkaline and volume of metal to be treated need to be targeted to calculate the time of treatment and quantity of flux. One or more stations may be required.

Other factors also play a role in the design stage:

– *Location of the station(s):* In the pot room, or in a separate building, or in the casthouse.

– *Skimming:* Need to avoid bath material, which, if present, may stop the rotor and also may lead to pick-up of unwanted elements in the holding furnace. Skimming may also be required after treatment.

– *Rotor:* The rotor size, configuration and position in the crucible are determined for a given application. The rotor impellers are of cast iron with a life expectancy of up to 500 treatments. Iron pick-up has been studied and is found to be negligible. There is a slight build up of flux material on the rotors, which retards its abrasion.

– *Crucible transport:* The transport method determines the type of station; for example, a drive-through station is preferred, if there is no lid to be removed, where the operator stays with the "transporter" and operates the TAC by remote control.

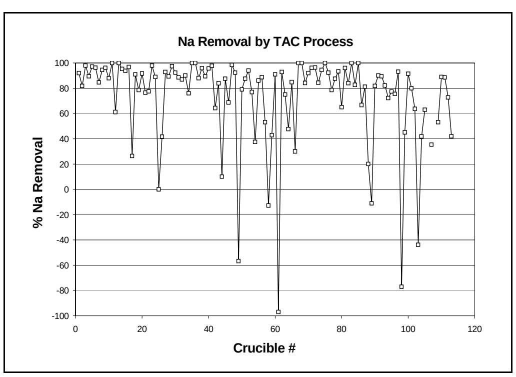
Need For Sodium Removal

When the first papers were presented by Alcan to describe the TAC technology, the emphasis was on lithium removal; but more recently, as higher and higher amperages are used in the electrolytic cells, sodium levels are increasing to as high as 100 ppm or more in the molten metal after siphoning, and sodium removal is the focus.

No chlorine is used and therefore the process is considered environmentally sound.

Confirmation of the efficiency of the TAC process has been more recently obtained:

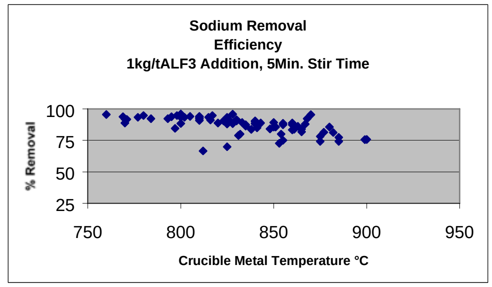
a) At an Alcoa plant where sodium reductions averaging between 80 and 100% have been obtained (Graph 1).



Graph 1

b) One where molten metal is delivered to a nearby client's casthouse with tight restrictions on maximum permitted sodium levels. Although an average of approximately 60% reduction was required with two TAC stations able to treat 140,000 tonnes per year for a cycle time of 7.5 min, a much higher reduction has been obtained. An even shorter time is possible to meet the requirements.

c) One installation which illustrates the influence of metal temperature on the reduction of sodium.



Graph 2

It is to be noted that sodium is highly reactive and is removed during transfer of molten metal and even during holding periods in the crucible. For example, in some of the older pot rooms, siphoning of a one-tonne quantity into a holding crucible of, say, five tonnes before transporting to the casting centre allows some of the sodium to be removed, due to its high vapour pressure. Or when transporting molten metal to a casting centre several kilometers away followed by transfer to a furnace, some sodium removal is obtained.

RFI Applications (No Chlorine Gas)

Depending upon the incoming levels, sodium for example can be reduced by up to 70% or more for a 20-25 minute fluxing period. A simple calculation will show that for starting levels in the holder of 20 ppm sodium, it can be reduced typically to 5 ppm with the RFI.

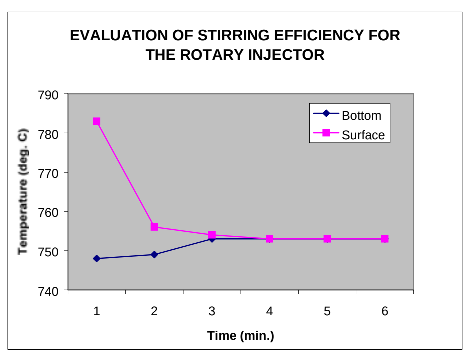


Figure 1

Bilodeau, Lakroni and Kocaefe [4] reported the results of extensive modelling of the rotary fluxing technology with the objective of optimising the process. The work established that the furnace mixing achieved with the RFI was highly effective (see Figure 1 for an example of stirring efficiency when measured with thermocouples for the surface and furnace bottom). It was stated that the RFI process performances are governed by the dispersal efficiency of the rotor.

There are various fluxes on the market, environmentally friendly substitutes for chlorine fluxing, many of which are based on a fully fused Magnesium chloride/Potassium chloride composition. Successful applications of fused fluxes have shown good reductions at a remelt plant and at a smelter.

Case 1 – A Remelt Plant

Table I presents typical results obtained with the RFI. The results show excellent sodium and calcium removal even at low starting levels.

Table I: Alloy Grade 3XXX

	Average	
	Ca	**Na**
Furnace before RFI treatment	10.7	3.1
Furnace after RFI fluxing	4.2	0.8
Efficiency(%)	60%	75%
Removal rate, Kinetic, K (min-1)	0.037	0.054

Case 2 – Smelter

Table II: Alloy Grade 6XXX

Na (ppm)	Na (ppm)	(%)	K (min-1)
30	8	73	-0.05

Figure 2 shows simply how alkalines are removed according to experimental results which fit well with those calculated.

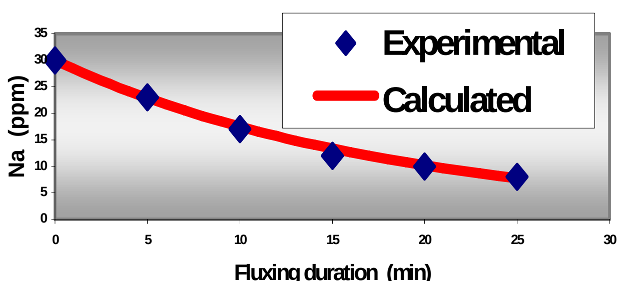


Figure 2

RGI Applications

In one example, there has been a shift away from the TAC to reduce lithium to be replaced by the RGI. Overall, due to handling and furnace treatment with an RGI, the lithium is reduced by more than 72%, the sodium by 97% and the calcium by 75%, even allowing for calcium pick up during alloying in the furnace.

Table III shows how the alkalines are all reduced to varying concentrations just by handling of the crucibles, waiting time before treatment and the transfer of metal from pot crucibles to transfer crucibles in the cast house (up to 25% for sodium and even 10% for lithium). Once transferred to the furnace, there is another reduction of the alkalines; and once fluxing with an RGI is completed, another 70% reduction in lithium is obtained, for sodium 90% and calcium by 90%.

Overall, due to handling and furnace treatment with an RGI, the lithium is reduced by more than 72%, the sodium by 97% and the calcium by 75%, even allowing for calcium pick up during alloying in the furnace.

Table III

	Average, A356 alloy		
	Li	**Na**	**Ca**
Before crucible transfer (pot room)	0.0011	0.0036	0.0004
After transfer (cast house)	0.0010	0.0027	0.0002
Furnace before RGI fluxing	0.0007	0.0009	0.0008 *
Furnace after fluxing	0.0003	0.0001	0.0001

* *Pick-up was due to alloy additions in the furnace.*

ACD Applications

The ACD is as efficient as any other degasser available commercially in reducing hydrogen. Typical results are attached for reference (Table IV).

The degasser is able to complete the alkaline reduction to customer's specification. Further reduction can be obtained in an in-line compact degasser to an average of 70% [5].

As an interesting example of overall process efficiency, it is noted that whilst average sodium levels in the holding furnace were 20 ppm, these dropped to less than 2 ppm after degassing in the holder and the ACD.

Table IV
H_2 removal (Alloy 7013)
Alscan readings

Metal Flow (kg/min)	Relative Humidity (%)	Ambient Temp. (°C)	Outlet Furnace		3 Metres before ACD		"Post" ACD	
			H_2 (ml/100 g)	Metal Temp (°C)	H2 (ml/100 g)	Metal Temp (°C)	H_2 (ml/100 g)	Metal Temp (°C)
250	23	24	0.34	764			0.11	696
250	23	24	0.61	767			0.10	706
250	23	24	0.44	766			0.11	720
325	28	19	0.39	760			0.10	699
325	28	19	0.45	746			*	705
325	28	19	0.42	742			0.12	700
325	**30**	**18**			0.36	**730**	0.11	} Average 700 °C
325	**30**	**18**			0.32	**729**	0.11	
325	**30**	**18**			0.34	**728**	0.10	
325	**30**	**18**			0.35	**731**	0.10	
325	**30**	**18**			0.36	**732**	0.10	

* *Problem with probe*

Summary/Conclusion

The TAC process is still very much an option for reducing alkalines for pot room metal at the smelter. It is not only efficient but also chlorine free. Sodium is present as high as 100 ppm or more as smelters use higher and higher amperage. It is becoming more and more unusual for final product specifications not to demand maximum sodium values, often below 1 ppm. Therefore, the TAC process is regaining a certain amount of popularity to reduce sodium in the crucibles as well as retaining its usefulness to reduce lithium where required.

The RGI reduces the amount of chlorine used in holding furnaces compared with chlorine lancing, and it can reduce alkalines quite efficiently whilst providing an homogenous melt. It has been shown that even lithium can be reduced as well as sodium and calcium, particularly where there is extensive metal handling between the pot room and the furnace.

The RFI is chorine free and not only reduces efficiently alkalines but also provides an excellent stirring to provide a homogenous melt. Alkaline removal can now be efficiently obtained in the casthouse with a combination of rotary injectors and a degasser. Results have shown that at starting levels of 20 ppm, for example, sodium in the holding furnace reductions to less than 2 ppm can be obtained after the degasser. It has been shown that reductions of up to 75% or more can be achieved in the holding furnace with further reductions of between 65 and 75% in the in-line degasser.

The ACD is an efficient degasser capable of reducing hydrogen, alkalis and inclusions to levels achieved by other commercially available degassers. It can be used with and without chlorine gas according to customers' needs.

Acknowledgement

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