In-line Salt Fluxing Process With an FFD™

Industrial Experience with Box—Type Degasser

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Abstract

Since the development of the Flux Feeder for Degasser (FFD™) in the early 2000s, many units have been installed on ACDs to eliminate chlorine gas, which is hazardous in terms of HSE. This proven technology has been completely tested on ACD degassers and is indeed the best alternative to the use of chlorine gas. The FFD is now used on almost all the wrought alloy families such as 1xxx until 8xxx, including the can body and can end alloys. Being able to retrofit all box type degassers on the market is extremely important if we consider the number of units already in operation, especially since most customers are seeking an alternative to the use of chlorine. This paper presents recent results and comparisons between chlorine gas and flux injection in terms of alkali, hydrogen and inclusion contaminants when the FFD is adapted to a "box degasser" type.

Keywords

Degasser • Flux • Chlorine

Introduction

Aluminium treatment is an important and necessary step in meeting the ever-increasing customer demand for more quality in most critical applications. Aluminium is traditionally treated with gaseous chlorine (Cl_2) as a reactive agent—although this gas is unstable and toxic [1]. Increasingly, pressures related to safety, industrial hygiene and the environment push the industry to develop innovative solutions to replace chlorine in order to meet the new reality of the industry, present and future. As a result, the costs related to the safety, maintenance and upgrading of chlorine rooms are constantly increasing and drive the industry towards more acceptable and economical solutions.

The advantages of injecting solid flux ($MgCl_2$+KCl) to replace gaseous chlorine in casthouses have been known and well documented for several years [2–4]. STAS is one of the world leaders as well as a visionary forerunner in technologies using the properties of flux as a reactive agent for the removal of alkalis (Sodium and Calcium) so as to increase the metal cleanliness [5–7].

For on-line degassers such as the ACD/Aluminium Compact Degasser®, flux injection has been available to consumers for almost 10 years thanks to the FFD/Flux Feeder for Degasser® [8, 9]. It is therefore possible to no longer use gaseous chlorine for on-line treatment while meeting the high industry standards in terms of high quality cast products. Of course, this solution is integrated with chlorine-free metal treatment techniques such as the TAC/Treatment of Aluminium in Crucible® or the RFI/Rotary Flux Injector® for treatment in furnace. Figure 1 shows STAS' casthouse technologies used to treat molten aluminium without chlorine gas. The judicious selection of one or more of the above solutions may be applied depending on the type of plant and the particular needs of each customer. The products are highly successful considering the metallurgical performances as well as the human factor.

With conventional box-type degassers, however, the use of chlorine gas remains the norm. Until recently, the advantages of using flux for this type of degasser did not seem to have been fully explored.

Since the first version of the FFD, STAS has always worked to improve the technology as much with regard to the accuracy of the flow rate of the injected salt as the robustness of the equipment. Following the high expertise acquired in the degassing and fluxing industry, STAS was able to test the FFD in an AlPUR box-type degasser. These

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tests represented a significant step forward and proved once again the benefits associated with the replacement of chlorine gas.

This paper first presents the metallurgical performances of solid flux injection tests previously performed in an A622 box-type degasser. The main section refers to tests carried out with our FFD and the AlPUR box-type degasser and shows the effectiveness of this combination. This new development led STAS to optimize the FFD technology to make it also available for box-type degassers. This was the last achievement to be realized to obtain a 100% chlorine-free casthouse, even with the use of a degassing technology other than an ACD.

Brief Operating Principle of FFD

The STAS FFD as shown in Fig. 2 is a stand-alone unit that includes a control panel with a dedicated controller and its own gas panel. The principle of the FFD technology consists in conveying the salt from the FFD bin through the rotor of the degasser and injecting it into the molten metal [8, 9]. This process involves a complex algorithm developed to take into consideration variables and parameters like temperature, pressure and vibration conditions in order to guarantee the accuracy of the system. In addition, the flexible and autonomous design of the unit allows it to be adapted to all types of degassers (including box type) and all types of PLCs and controls. It is therefore very easy to retrofit the system when required. A constant flow as low as 1 g/min is ensured thanks to a STEP motor and continuous reading of the load cell regardless of the conditions. It is important to highlight that the system complies with the EPA regulations in USA.

Metallurgical Performance

Comparison Between Injection of Solid Flux and Injection of Cl_2 in an A622

Tests were carried out on the injection of solid flux into an A622 box degasser (now licensed under the STAS AIR/Aluminium Inline Refiner), and the results were published in 2008 by D.C. Chesonis and D.H. DeYoung of Alcoa [10]. These tests were carried out in static and in dynamic modes, at different flow rates of flux, gas and metal. The conclusion was that the equivalent injection of solid flux instead of chlorine gas into an A622 provided equal or better metallurgical performances and no impact on the removal efficiency of hydrogen (Fig. 3).

The performance of solid flux was evaluated in terms of efficiency for the removal of alkalis, hydrogen and inclusions, and the results were compared to those obtained with the use of chlorine. The graph below summarizes the average efficiency of Sodium (Na), Calcium (Ca) and Hydrogen (H_2) removal with the use of solid flux versus chlorine gas. We can see that there are no significant statistical differences between the two (Fig. 4).

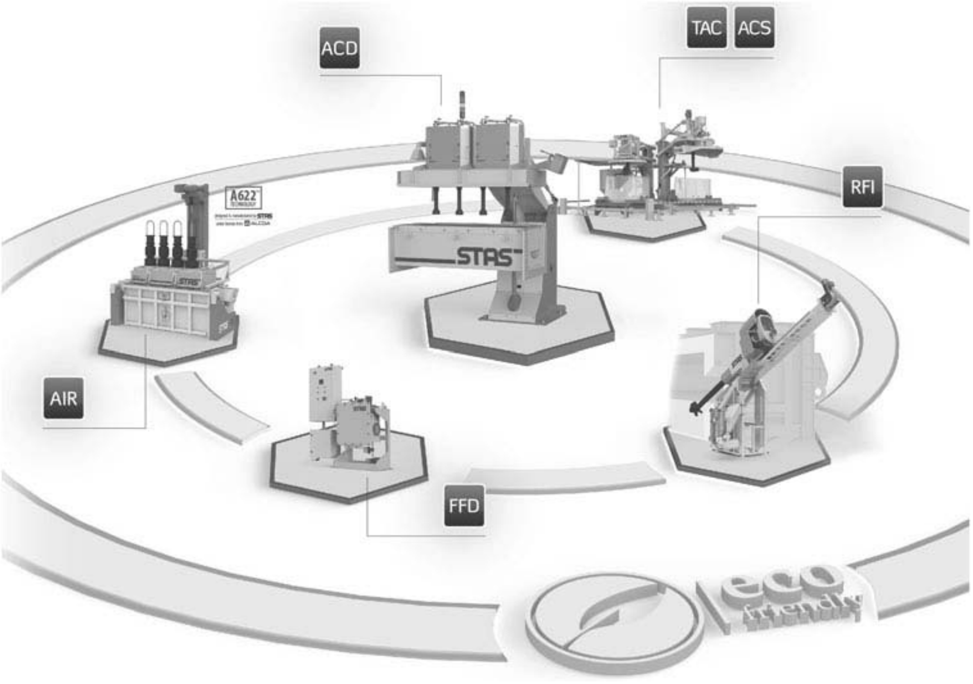

Fig. 1 STAS chlorine-free casthouse technologies

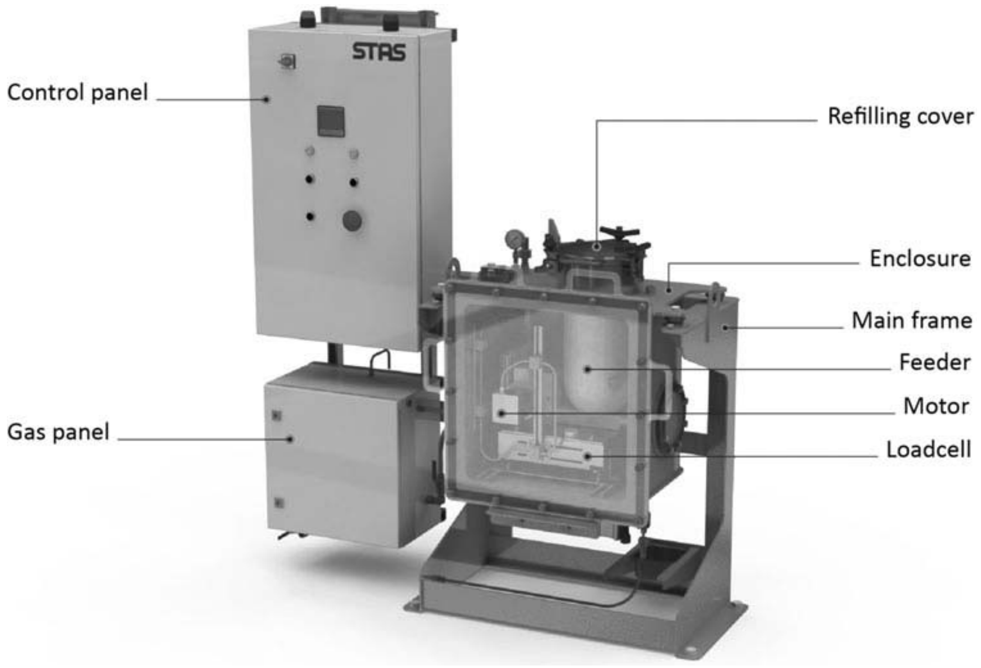

Fig. 2 Main components of Flux Feeder for Degasser®

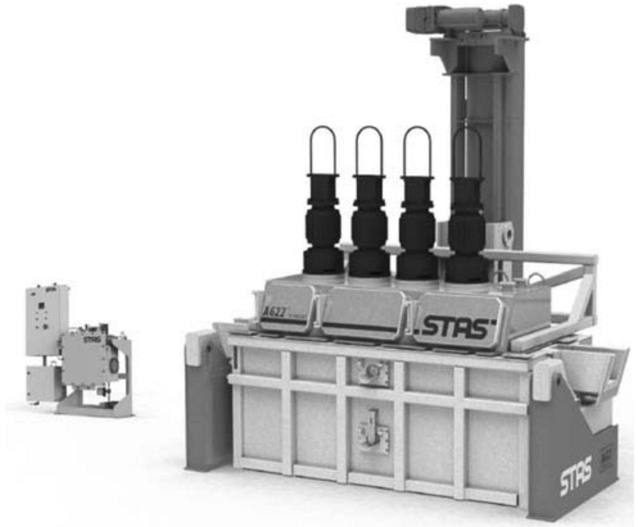

Fig. 3 STAS Aluminium Inline Refiner (AIR)

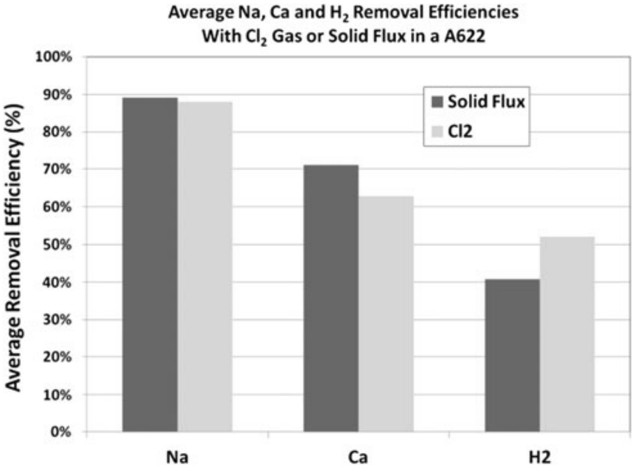

Fig. 4 Alkali and hydrogen removal performance using chlorine or flux in an A622

Metal cleanliness was also evaluated using LiMCA and PoDFA techniques. Tests with $MgCl_2$ flux produced approximately half the amount of inclusions than with chlorine gas. And the average concentration of N20 after the degasser was lower than 10 K/kg (thousands of particles larger than 20 μm per kg of metal) with solid flux and higher than 20 K/kg with chlorine. The graph below summarizes the LiMCA results (Fig. 5).

With respect to atmospheric emissions, the authors concluded that flux had no impact. Values were expected below the secondary SMACT limits.

In conclusion, the tests were very positive and confirmed that chlorine could be replaced by solid flux. The results obtained with the A622 were consistent with those obtained with an ACD [8, 9].

Comparison Between Injection of Solid Flux and Injection of Cl_2 in an AlPUR

As part of our campaign to evaluate the efficiency of the FFD in box degassers, tests with solid flux in an AlPUR were recently performed with the latest demonstration unit.

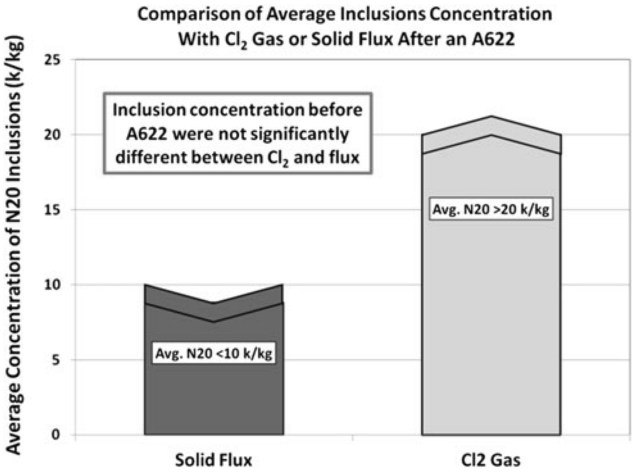

Fig. 5 Inclusion concentration after an A622 using chlorine or solid flux

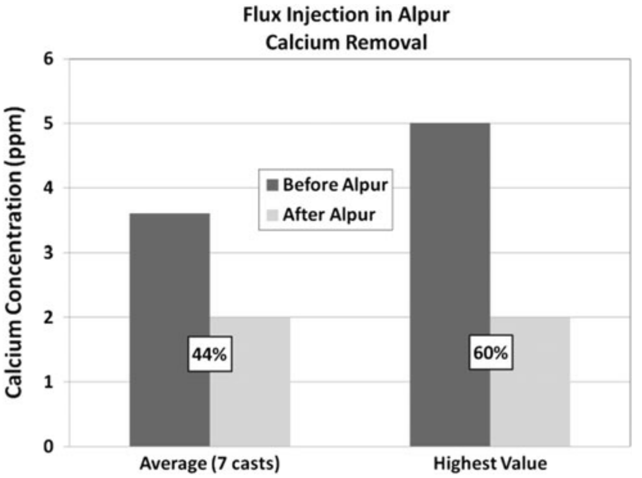

Fig. 6 Calcium removal efficiency using the FFD

1. Scope of Experiment

Tests were carried out on can body stock in an AlPUR and at a metal flow rate of nearly 1000 kg/min. After a slight modification to the driving shaft of the AlPUR, the FFD was connected to the first rotor only. Solid flux was injected with argon from the FFD to the AlPUR. As a representative comparison, the flux flow rate was equivalent to the standard chlorine flow rate (same Cl_2 weight fraction). With regard to degassing and alkali removal, the efficiency of the former was measured on 4 casts and that of the latter on 7 casts.

2. Method

The degassing efficiency was measured with the AlSCAN technology. However, the only AlSCAN unit available at the time was moved before and after the AlPUR.

A PoDFA unit was used to measure the metal cleanliness by taking multiple samples, each time one before and after the degasser (AlPUR), with another one after the filter.

With respect to alkalis, the specifications were reached in the furnace. Therefore, values for sodium and calcium were rather low. Samples were taken before and after the degasser; but since the concentration of sodium was close to 0 ppm, there is only mention of the efficiency of calcium removal in this case.

3. Results and Discussion

For the seven casts that were measured, the average calcium concentration before the degasser was 3.6 ppm, with the highest concentration at 5 ppm. In all cases, the concentration after the degasser was reduced to 2 ppm by using the FFD, and the average removal efficiency was 44%. The next graph summarizes the results for calcium removal (Fig. 6).

Before the trials, an efficiency of about 50% in terms of calcium removal was expected for this box-type degasser, this despite the low concentration of calcium at the exit of the furnace.

During the campaign, it was not possible to evaluate the metallurgical performance of the AlPUR when using chlorine gas, which makes it impossible for us to compare the two techniques in terms of alkali removal. However, the historical results obtained from an AlPUR with chlorine demonstrate the same efficiency for calcium removal, that is, about 50% under the same casting conditions. The results obtained here (AlPUR + FFD) are similar to the results of the measurements taken by STAS in previous campaigns when a FFD was combined to an ACD.

Regarding hydrogen removal efficiency, it has been proven repeatedly [8–10] that the injection of solid flux has no influence on the results. Four tests were taken anyway with an AlSCAN to confirm that the H_2 removal efficiency was the same as when chlorine gas was injected. The graph below summarizes the results (Fig. 7).

The results show a very good hydrogen removal efficiency of 68% on average. The average inlet value was 0.39 ml/100 g, and the average outlet value was 0.12 ml/100 g. The results were found to be equivalent to those obtained with chlorine.

Metal cleanliness was evaluated using the PoDFA technique. Samples were taken on both sides of the degasser. All samples were rather clean and below 0.20 mm^2/kg. The graph below summarizes the results (Fig. 8).

The low concentration of inclusions before the degasser is mostly due to very good furnace practices in combination with treatment carried out using a Rotary Flux Injector (RFI). The removal efficiency as shown above—with flux injected into an AlPUR—is very good considering the low concentration of inclusions. Most of the inclusions were

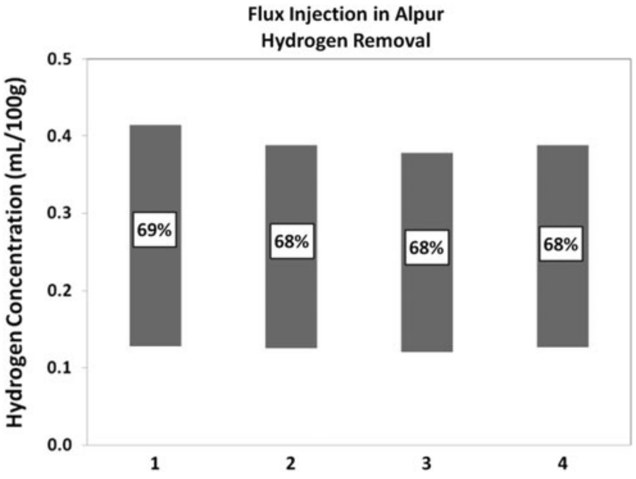

Fig. 7 Hydrogen removal efficiency using the FFD

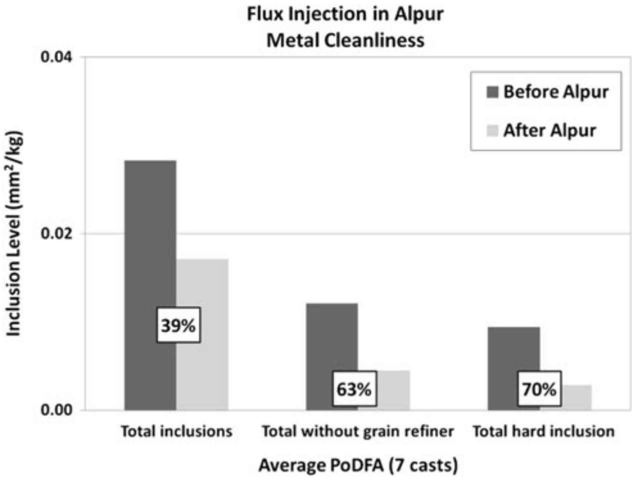

Fig. 8 Inclusion removal efficiency using the FFD

carbides and magnesium oxides (MgO and spinel), and no potential chlorides were detected after the degasser, indicating a complete reaction of the flux with the contaminants. The removal efficiency of inclusions when using chlorine under the same conditions was not evaluated, but it must be said that performances with flux are usually better than with chlorine [8, 9].

The evaluation of dross production and chemical composition was not included in the scope of our campaign. But it was observed that the dross produced during the tests was very dry and in lesser quantity than the usual production with the use of chlorine.

Conclusion

In this paper, we have presented the unique FFD/Flux Feeder for Degasser® and the results of trials carried out in box degassers. The data presented above, obtained from previous tests in an A622 and more recent tests in an AlPUR, show that solid flux can replace traditional chlorine gas with equal or better metallurgical performances. Indeed, solid flux provides the same removal efficiencies for sodium and calcium and has no impact on the degassing performance. The metal cleanliness measured with the PoDFA or LiMCA methods is also equal or better than with Cl_2.

Available since 2006 for the ACDs, the FFD is now a stand-alone unit fully retrofittable to all types of degassers, for all operating conditions and all alloy families.

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