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UPGRADE OF AN EXISTING FUME TREATMENT PLANT AT ALUAR TO COPE HIGHER PRODUCTION IN THE NEW OPEN TYPE ANODE BAKING FURNACES

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Abstract

Aluar Aluminio Argentino has been operating with two closed type furnaces for the production of baked anodes for more than 35 years. Due to the continuous expansion by amperage increase in the potlines, these furnaces were replaced by two new open type baking furnaces, Due to present anode requirements only one was started. As a result, the existing Fume Treatment Plant had to be upgraded to cope with higher volume and temperature requirements.

This paper explains the most economical solution for an FTC concept upgrade, which integrates major existing components but in parallel enhances the plant with new equipment and process technologies to attain the targets. Finally it outlines the actual results achieved by presenting key performance figures, including emission levels.

Introduction

The Aluar aluminium smelter at Puerto Madryn (Argentina) had a production capacity of 250.000 tons/year before the last expansion project was initiated. But once the ramp-up of all new pots and the amperage increase process in the existing ones was finished, the production output was raised to 430.000 tons/year.

Other facilities of the Smelter like the anode plant had to adsorb these changes in production. Higher aluminium production output required more production of anodes. The green anode plant was expanded and designed with some extra capacity for maintenance purposes. Regarding the baking furnaces, two of the existing three furnaces were of closed type technology. The anode quality requirements for the new process conditions in the pots, as well as the difficulties to perform the refractory maintenance routines were causes, which drove the decision to replace the 2 closed type furnaces with open type technology. In addition, this modification will lead to an increase of the baked anode production.

The existing FTC as shown in Figure 1 had been designed for a nominal exhaust gas volume of 90.000 m^3/h and a maximum exhaust gas temperature of 130 °C. It was a three chambers Bag house Filter Concept with Alumina as adsorbent without cooling tower due to the low exhaust gas temperatures at the exit of the closed type furnaces.

Figure 1: Former Fume Treatment Centre at Aluar

For the higher production of anodes in the new open type furnaces, more exhaust gas volume is generated at temperatures up to 220 °C necessitates the installation of a new FTC to maintain the higher volumes and the higher exhaust gas temperatures. The specific volume per ton of produced anodes reached about 5.000 Nm^3/t of baked anodes compared to 2.900 Nm^3/t before.

Targets for a solid state upgrade

The driving idea for the new FTC design: try to keep and use as much as possible from the existing installation in order to get the best economical concept for minimum CAPEX and still reach the performance and the environmental limits.

Further targets for a solid-state upgrade of the FTC were:

1. Enlarge the surface of the filter chambers to serve for the higher capacity of 155.000 m^3/h without adding of new chambers or compartments inside the shape of the existing baghouse.

2. Insurance of a maximum reliability and operational safety to run 24-7-365 at an availability of > 99,8 %

3. High filtration efficiency of harmful components with low adsorbent consumption and filtration ratios of < = 1,05 m^3/m^2 and minute.

4. Spare capacity and redundancy for compensation of plant aging effects and for maintenance works to be performed without production stop, operation with n-1 chambers and n-1 fans to ensure 2.

5. A continuous high performance to ensure anode production at high quality with minimum OPEX and minimum emissions

6. High-level FTC process automation concept in order to guarantee an optimized and smooth FTC operation without any interruptions incl. automatic switch-over to multiple modes of operation without any interaction of the operator.

The new FTC process technology

The new planned FTC as shown in Figure2 was completely embedded around the former FTC (baghouse). A new cooling tower was added. Around this, the plant was designed to provide "ideal" movement of the gases from the furnace to the stack. This is achieved by means of calculation of optimum main component dimensions, including those of the cooling tower and fabric filter, as well as the minimisation of diversions. Pressure losses were minimized using computer modelling to ensure maximum flexibility even at high baking furnace pressure losses. The plant is operated under constant and controlled draught conditions. This negative pressure ensures that no crude gas or contaminated adsorption media are emitted to the environment. The baking furnace off-gases are taken from the end of the furnace building into a new crude gas channel and then routed to the conditioning cooling tower.

Three advanced features are implemented in the crude gas channel for operational safety and reliability (24-7-365) before the gases reach the cooling tower inlet:

1. The waste gas channel is designed as a special "emergency stack", including an "emergency damper" at the highest point of the gas channel.

2. A diesel generator supplied fan (SDS=Safety Draft System) is installed for aspiration of the furnace flue gases in case of break down of the electrical power supply.

3. A spark detection system is installed in the crude gas channel followed by automatically operated "extinguishing" ring nozzles.

In case of break down of electrical and air supply, the FTC will automatically switch over to the status "Natural Draft" and together with the SDS-System to the Mode "Forced Natural Draft". This mode will keep the furnace building free of pollutants; further movement of the furnace equipment will be possible.
The spark detection and extinguishing system operates independently from all other systems and ensures that sparks emitted from the bake furnace will be automatically extinguished without any interruption of FTC operation as a preventive fire protection system.

Figure 2: The new FTC in operation

Cooling tower

The conditioning cooling tower is designed as direct current cooler. The off-gases are guided to the top of the cooling tower (gas inlet) and leave the cooling tower at its base. A special design ensures that the off-gases are treated with atomised water produced by a two-phase nozzle technology in an area where "plug-flow" is reached. The cooling tower design is optimized with regards to the following tasks:

1. Adequate evaporation distance
2. Even "plug-flow" within the evaporation distance
3. No deposit build-up at the inner surface of the cooling tower
4. Dry condition at cooling tower hopper - outlet
5. Dry discharging of heavy particles at tower hopper

These tasks are verified and optimized by a CFD study of the cooling tower design, as shown in Figure 3.

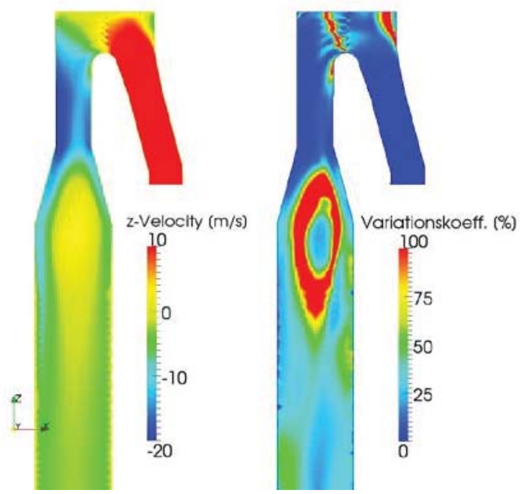

Figure 3: CFD Study Cooling Tower

The off-gas temperature at the conditioning tower outlet is maintained constant at ±0.5°C by automatic control of the water flow injection. The tower's conditioning system is provided with full redundancy and automatic handling of breakdowns. This allows lances and nozzles to be inspected and/or maintained without interruption or setting the FTP to bypass mode.

A final, special surface coating protects the tower against corrosion, acid attack and deposits. Deposits and particles such as packing material from the baking furnace have already been extracted in the lower part of the tower by means of a cyclone and a double pendulum damper. Figure 4 shows the new cooling tower in operation.

Figure 4: The new Cooling Tower in operation

The performance of the cooling tower is also dependent of the quality of evaporation. The lance system provides a dual-phase nozzle technology, which generates finest droplets of less then 25 µm. Figure 5 shows such a spray nozzle system, consisting of 5 nozzles per lance.

Figure 5: Dual phase spray nozzle system

The pre-cleaned and conditioned off-gases are guided through the lower side conical outlet into the main reactor chamber. Fresh alumina, sourced from the alumina silo, is directly injected after the cooling tower and entry of the main reactor duct by a special alumina injector. The injection of fresh alumina early after the cooling tower is a key parameter for the performance of the FTC, especially for the bonding of preliminary phases of acids.

The enriched off-gases are then guided into individual secondary reactor chambers and finally to the fabric filters. The secondary reactor chambers are also charged using the alumina injector. This injector is fed with re-circulated secondary alumina from the individual fabric filter chambers. As a result, the recirculation takes place at high concentrations of alumina, resulting in high adsorption rates for all kinds of pollutants. Finally due to the long sections of the reactor chambers and intensive mixing of the adsorbent media, the aerosols not only adsorb off-gases but fines in the media also absorb them and both are extracted at the fabric filter cloth as “filtration cake”.

As a secondary benefit, the consumption of primary alumina is very low (< 800 kg/h) and still achieves maximum off-gas efficiency in terms of HF, organics and other acids.

Duct systems and Dampers

The duct system guides the gases through the FTC. The existing Duct Systems and Dampers had to be checked carefully. Non-optimized layouts with multiple bends and elbows lead to high pressure losses (hpl). The same applies for special types of dampers. A proper design of the duct system is the basic task to minimize these pressures losses. Also the change of a damper design can improve the performance of the FTC tremendously. For the overall system, consisting of ducts, dampers and filter chambers, a compromise between low-pressure loss and longest dwell period of with alumina enriched flue gas had to be found. Figure 6 shows the “optimized low pressure loss” design to optimize flows and minimize pressure losses.

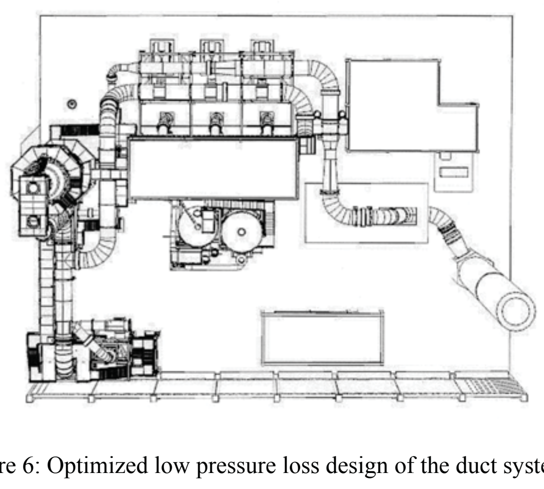

Figure 6: Optimized low pressure loss design of the duct system

In order to ensure a good alumina transport without sedimentation within the ducts, a minimum flue gas speed of 12 m/s is necessary. Especially during different phases of FTC operation with only one or two furnaces in operation, the minimum flue gas speed has to be maintained. For these dynamic conditions an automatic controlled flue gas recirculation system was designed and implemented.

Filter chambers

The adaptation of the existing filter chambers is strongly depending on the existing infrastructure and the existing design. The process requirements for a redesign of an existing filter chamber was easy to formulate, but not easy to realize. The design target was the enlargement of the fabric surface in the space of the existing filter chambers. An additional chamber was no option due to economical aspects. The future value of the filter surface load should be favourable in a range of <= 1,0 m^3/m^2 and minute. High gas flow rates in a range of 18 m/s in the ducts and reactors have to be reduced in steps to less than 1 m/s in the area of the filter bags. The separation of heavy particles (agglomerates) needs to be executed prior to the filtration cake. In this area gas speeds of < 2 m/s are obligatory.

The gas flow onto the filter bags has to be oriented in a wide area from bottom to top. Technical solutions, which contain a horizontal flow, generate an early tear and wear of the fabrics by partial overloads and in parallel inactive areas inside the filter chambers.

In a first approach all disturbing installations had been eliminated. After that the filter chamber was fully furnished with a maximum possible amount of filter bags. In addition a new pre-separation chamber has been designed and installed in front of each filter chamber to ensure the staggered deceleration of the gas speed.

It would have also been possible to raise the filter chambers and to prolong the filter bags. But the maximum length is limited by the efficiency of the pulse jet cleaning system and the maximum physical load on the filter bags during the cleaning cycle. Filter bags up to 6 m are feasible, longer bags need to be examined with care. Figure 7 shows the inner part of the modified filter chamber.

Figure 7: Inner part of the filter chamber

For daily operation and fast maintenance of the filter bags two main topics have to be considered:

1. The Production must be possible even with n-1 chambers in operation, means 1 chamber isolated
2. The change of one complete set of filter bags for one chamber should be possible during one production shift

Consequences for the fans

The existing fans had a power of 160 kW each. To ensure the desired flow, 3 new fans with a power of 200 kW each for nominal and 1 spare fan for extra capacity had to be installed to reach the necessary volume flow and draft with enough spare power for compensation of future plant aging effects. An operation mode of n-1 is implemented, because every malfunction of a fan would disturb the furnace production immediately. Systematic maintenance incl. turn-down of fans is mandatory to reach the desired performance and reliability. Figure 8 shows the new fan system in operation.

Figure 8: Fan system in operation

Conclusion

After all these aspects have been technically realized, the desired performance for higher production was available. As a positive effect the dosing of fresh alumina after fine-tuning was minimized to 800 kg/h; this corresponds with a fresh alumina load of 7,8 g/Nm^3 flue gas.

If the right balance is found between fresh and recirculated alumina, the wear and tear in all aspects of the FTC will be minimized on long term and the adsorption ratio respectively the cleaning effect is maximized. This leads to minimum emissions in the clean gases, which are vented to atmosphere.

Operational results

The fluorides and total dust values were obtained following the US EPA13a method. Each monthly value was obtained as an average of two or three individual values.

The condensed soluble tars values were obtained following EPA429 method and correspond with international standard test measurements. The total dust concentration obtained by this method during these measurements was 0.54 mg/Nm^3, which is equivalent with the monthly average obtained by the other method.

For gaseous fluorides the following emission values were measured:

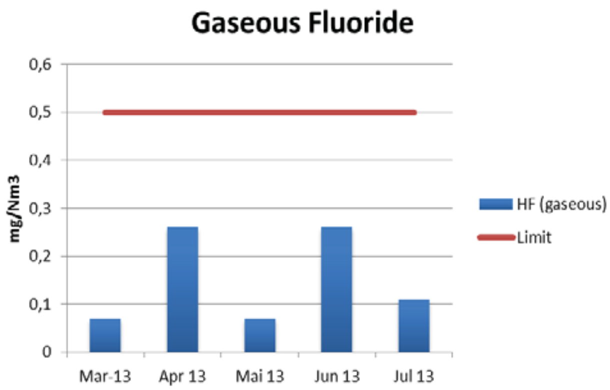

Figure 9: Measurement of gaseous fluorides

For the particulate fluorides the following emission values were measured:

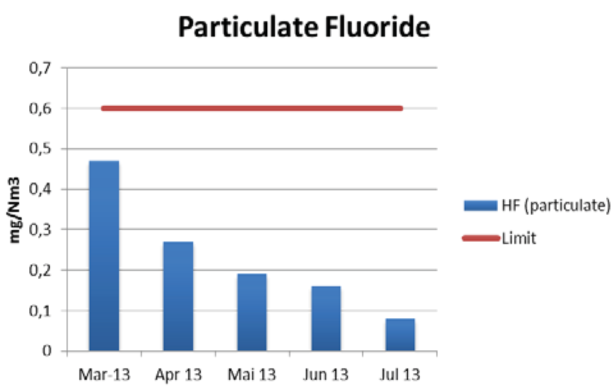

Figure 10: Measurement of particulate fluorides

Total dust at stack was measured and shows values far below the environmental limits:

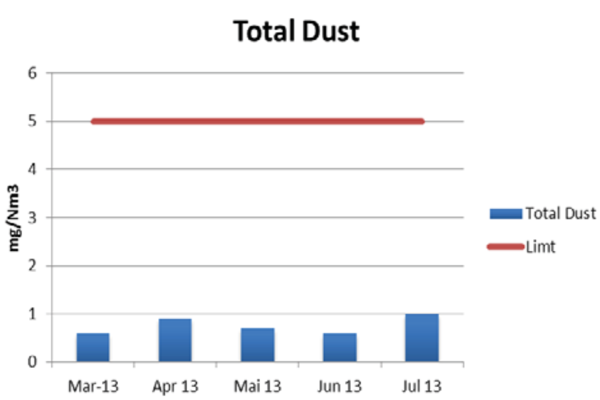

Figure 11: Measurement of total dust

The emissions of condensed soluble tar is shown in the following figure:

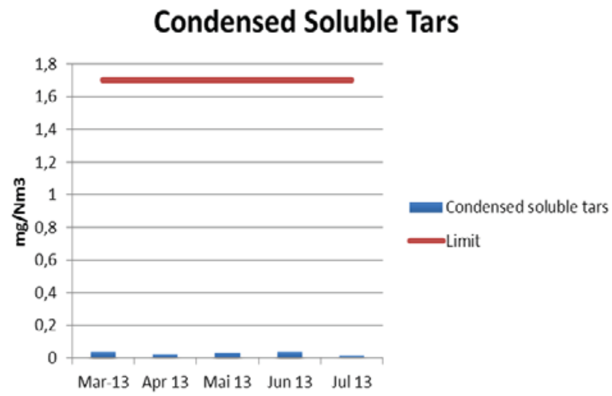

Figure 12 Measurement of condensed tar

The very low condensed soluble tar values (< 0,008 mg/Nm^3) correspond with the design criterias but also with an optimum pre-process condition for the FTC, i.e. the excellent adjusted interactions between furnace, firing system and a professional baking process conduction by the carbon team.

Summary

The major target to conserve and reuse as much from the existing equipment was reached. Other targets with regard to the availability and consumption of adsorbent are observed continuously. The FTC, designed and built by innovatherm is operating since February 2013 without any down-times. The results presented above show that the upgraded FTC technology in the given boundary conditions have achieved or even surpassed emission values stipulated by international regulations by far.