ENVIRONMENTAL COMPLIANCE OF STATIONARY CALCINERS FOR ALUMINA: NOW AND IN THE FUTURE

Pedersen H.V.[2], Raahauge B.E.[1], Lund C.R.[2]
[1]*FFE Minerals Denmark, Copenhagen, Denmark*
[2]*F.L.Smidth Airtech A/S, Copenhagen, Denmark*

Abstract

Rotary Kilns and Stationary Calciners producing alumina of various grades have until now almost without exception been equipped with Electrostatic Precipitators.

However, the latest Gas Suspension Calciner (GSC) Units now being built, are equipped with Fabric Filters.

The technical features of the modern FabriClean Fabric Filter, will be described and advantages and drawbacks of Electrostatic Precipitators versus Fabric Filters will be presented together with their impact on Capex and Opex to the Alumina Refiner.

1. Introduction

Over the last decades Rotary Kilns and Stationary Calciners producing alumina of various grades has almost exclusively been equipped with Electrostatic Precipitators for Particulate Emission Controle. Since typically only Particles had to be controlled and to a moderate emission level combined with the robustness of the Electrostatic Precipitators, this type of Air Pollution Control equipment has been preferred. But the situation is changing!

Requirements for control of acid gas emissions has now reached the Aluminium Industry creating a interest in dry and semidry Flue Gas Desulfurization (FGD) systems adapted to the Alumina Industry. Further the generally required emission levels are much lower than previously increasing the competitiveness of Fabric Filters. Further the resent focus in the industry on reducing the odour problems have increased the focus on Fabric Filters even more due to its proven ability to be a reactor between an absorbent and a gas phase component.

This among the reasons why the latest Aluminium Gas Suspension Calciner (GSC) Units now being build, are equipped with Fabric Filters.

More and more End-Users and Environmental Protection Agencies consider the Fabric Filter as a BATNEEC — Best Available Technology Not Entailing Excessive Cost.

2. Description of the advantages of the FabriClean Filter

The FabriClean filter is a fabric filter developed and marketed by FLS miljø a/s. The focus in the development proces of the filter was to develop a process filter for medium to high gas flow rates, while on one hand using a state of the art modern long bag length technology and on the other to maintain high availability and the low maintenance cost levels known from traditional short bag length Fabric Filters The operation cost should be minimised (i.e. long bag life, low differential pressure, low consumption of compressed air and low maintenance cost), and at the same time the capital expenditure should be minimised (i.e. low steel weight, use of standard components, minimisation of manufacturing, transportation and erection cost).

The single most unique feature in the FabriClean filter is the gas and dust distribution system that provides significant benefits for applications involving medium to high gas flows.

As the degree of flexibility of the design is high there exist an optimal filter size to any medium to high gas flow.

Figure 1 presents the filter. The bags are configured in a number of compartments that can be isolated for maintenance reasons.

2.1 *Gas and dust flow distribution system; an innovative approach*

The gas and dust distribution system applied for the FabriClean filter is a result of FLS miljø´s substantial experience within the Electrostatic filtration technology, where distribution of gas and dust is essential.

As the size of pulse jet filters increases, good gas and dust distribution becomes essential. On smaller filters the inherently high-pressure drop is sufficient to distribute the gas and dust reasonably even throughout a compartment. As compartments become larger it is important that consideration is given to control the distribution and not just leaving to chance.

When a filter is cleaned online, the direction of the gas flow in the compartment is important. The FabriClean™ filter has gas flow, which is predominantly down across the bags. This minimises the problem of reentrainment that can give rise to unstable pressure drops in poorly designed filters. Figure 2 presents the gas and dust distribution schematically.

Dust loaded gas enters the inlet duct from the process and flows through the inlet dampers into the individual distribution for each compartments. The gas expand as it enters the distribution chamber and baffles and deflector plates ensure that the most of the dust is deposited directly into the hoppers as it due to the reduced velocity is precipitated by gravity. This reduce the dust burden on the filter bags, resulting in a significant decrease in the cleaning frequency whereby the pulse air required to clean the filter bags is reduced and hence the wear on the bags.

The net result of the unique gas and dust distribution is decreasing the power consumption and extended bag life as bag life is normally strongly depending upon the number of cleaning cycles the bags has been exposed to.

2.2 *Control system and instrumentation.*

In most processes with bag filters it is extremely important to keep the filter in operation at all times. In this context of availability the instrumentation and control system play a key role in order to alarm any malfunction that may occur so adequate intervention can be made.

On-line maintenance can be achieved when the compartments are equipped with isolation dampers at in- and

KEY WORDS: Fabric Filter, Electrostatic Precipitator, Capital expenditure, Operational expenditure, Calciners for Alumina

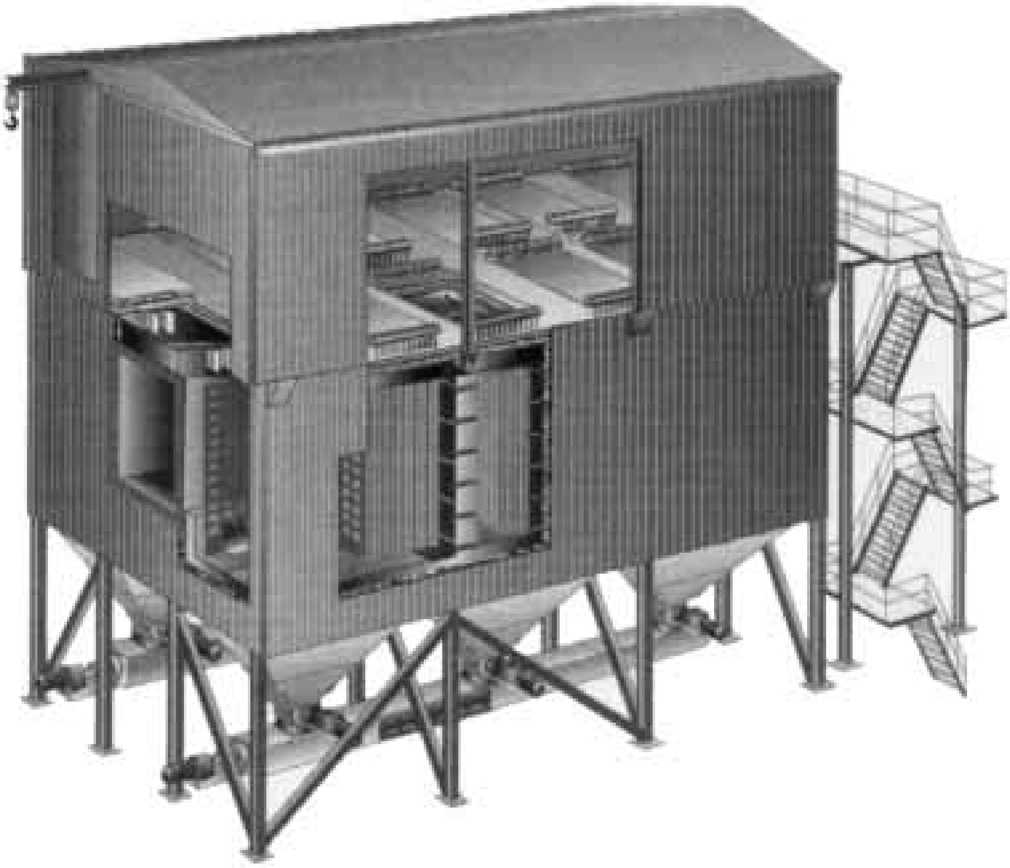

Figure 1 — Overview of FabriClean Filter.

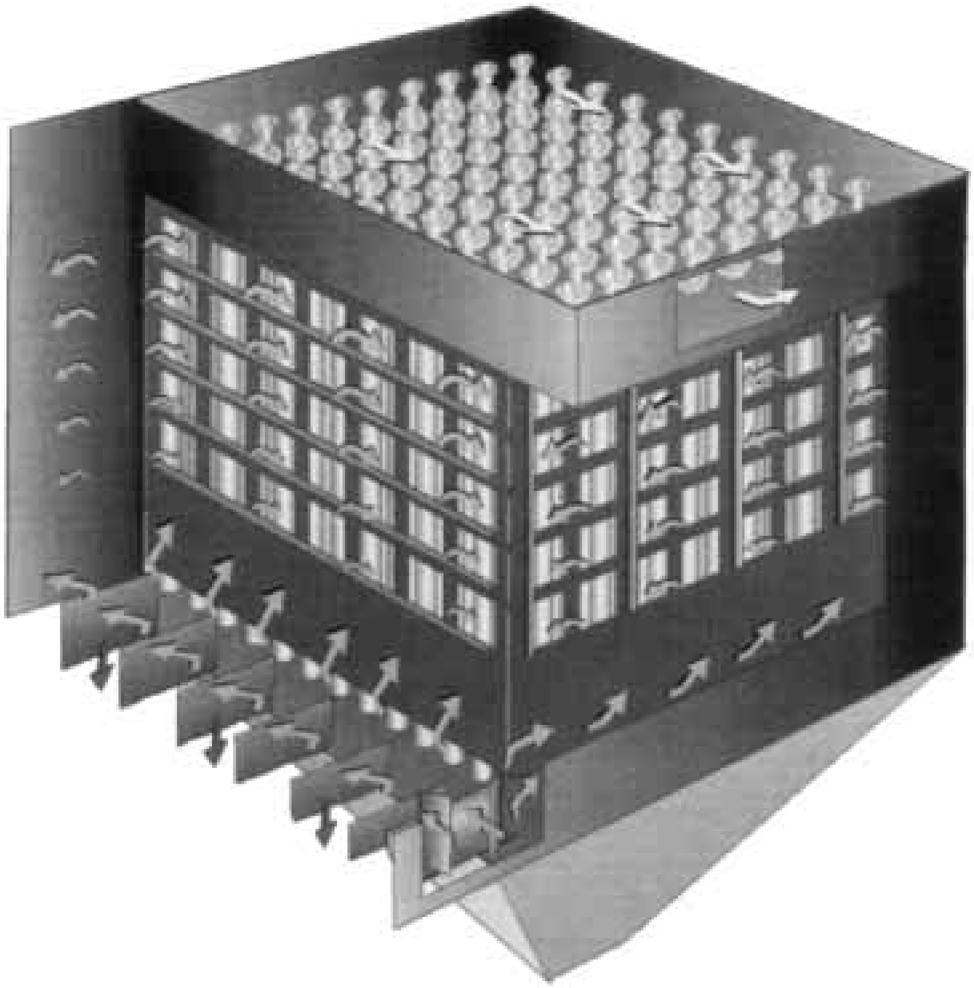

Figure 2 — Gas and Dust distribution in FabriClean Filters, figure is illustrating one half compartment. Arrows show direction of gas.

outlet to the compartments and separate dust hoppers with an isolation device.

Also instrumentation to monitor the correct function of the cleaning process and automatic valves to isolate the supply of compressed air in case of failure is standard.

FLS miljø a/s has developed a modern control system; Smart Pulse Controller (SPC) tailored to control fabric filters. The control system has built in a great number of routines that help operating the filter at a minimum cost and ensure malfunction are identified and can be attended to quickly and dealt with effectively. Examples of typical malfunctions is a broken bag in a given compartment, a diaphragm valves failing to open or close etc.

The control system is designed for either serial or parallel interface to the plant control system. Each compartment is equipped with node boxes for control of valves and dampers.

Serial communication is often used as this system is cost effective (material and time).

A differential pressure instrument monitor the resistance to flow across the filter and will, when required, initiate a cleaning cycle.

Consecutive cleaning of the bag rows will continue until the pressure drop across the filter has reached a predetermined level. The controller will then stop the cleaning sequence. When the pressure drop rises again above a predetermined level the controller will re-activate the cleaning cycle from where it stopped.

The compressed air manifolds for each compartment will be fitted with a pressure transmitter to monitor the correct performance of the diaphragm valves. When the diaphragm valves are activated the pressure in the compressed air manifolds is detected to monitor that the valve open and closes correctly.

Each compartment outlet duct is fitted with a simple dust monitor. The function of this instrument is to provide an alarm in case bags fails and starts to pass dust to the clean side.

3. Comparison between state of the art Fabric Filter and Electrostatic Precipitator

The principal advantages and disadvantages between the Fabric Filter and the Electrostatic Precipitator will be discussed in this paragraph.

The environmental compliance has in most process of a medium to high gas treatment capacity been secured by the use of Electrostatic Precipitators. This type of filter has up to recently proved to been the state of art equipment, however the Fabric filter is now considered an attractive economic alternative. A higher Environmental awareness world wide is in general establishing a upward trend on the required environmental performance of any filter technology with respect to cleaning efficiency and on-line availability, i.e. the required emission level is lowered year by year. The electrostatic precipitator will reduce its competitiveness, when Capex and Opex is evaluated, as the required outlet emission is reduced. This is because the required number of electrical fields in the filter increases, and so does the associated cost.

The cost of a fabric filter will on the other hand generally not change, when the required emission is lowered because the outlet emission do not depend very much on the Air to Cloth ratio.

Another environmental advantage to the Fabric Filter is its ability to maintain environmental compliance when the process is in upset condition or for instance when the power supply fails.

Table 1 illustrates the aspects that normally are recognised as the differences between the two types of filters seen from a process and a operability point of view.

Table 1 illustrates the main characteristics of the compared de — dusting technologies and differences between them mainly from a process point of view. A remarkable point is that the fabric filter is fail safe in case of power failure. The Electrostatic filter has however a higher degree of robustness in case of deviations to process parameters, where the Fabric filter is sensitive to correct temperature and correct start and stop procedures.

4. Analysis of Capex and Opex of a specific example

In this paragraph we will compared Capex and Opex for a specific example. Table 2 illustrates the process data for a specific Alu Calciner, for which a Fabric Filter and an ESP has been selected and sized.

Table 1 — Comparison of General advantages and disadvantages.

Parameter	Fabric Filter	ESP
Pressure drop [mmWG] (typical)	150	25
Emission levels [mg/Nm3, wet]	Typical: 5–20 Possible: < 5	Sized to suit Possible: 5
Emission Sensitivity to process variations	Low	Medium to high
Temperature resistance	Dependant on bags: Typical: 240–260 deg C	Typical: 400 deg C
Explosion risk Fire damage risk	Low High	High Low
Absolute filter	Yes	No
Maintainability	High, on line possible	Low, only off line
Service interval	Bags: varies 2–5 years Cages: 2 set of bags	4 years typically

Table 2 — Main process data for recent Alu Calciner filter plant.

Gas flow [Am3/min]	10900
Temperature [deg C]	155–240
Outlet emission [mg/Nm3, dry]	30

Table 3 — Main equipment data, for Fabric filter and Electrostatic filter.

	Fabric Filter
Steel weight Casing Support Access Weather enclosure Bags + cages Total [ton]	336,4
Insulation surface Total [m2]	1160
A/C [m/min]	1,1
Consumption of compressed air. [Nm3/h] Electrical heaters — Installed [kW] — Normal operation [kW]	281 48 30

	ESP
Steel weight Casing and frames Support Access Misc. Collecting plates Total [ton]	640,8
Insulation surface Total [m2]	2830
Gas velocity [m/sec]	0,94
T/R set — Installed [kVA] — Normal operation[kW] Electrical heaters — Installed [kW] — Normal operation [kW]	 687 184 115 58

Table 3 illustrates the main characteristica for the two technologies, including the main cost drivers for capital and maintenance expenditure. Both technologies have been selected to meet the same environmental performance for the same process conditions (i.e. flow, temp and pressure) when applying same local conditions (i.e. wind load, earthquake load).

Table 4 shows the Fabric Filter is lower in initial investment cost compared with the ESP. However the operational cost for the Fabric Filter is higher than the similar cost for the ESP. The present data for CAPEX and OPEX has been entered into a NPV (Net Present Value) analysis made for a 20 year period. The result is a break even point after approx. 9 years.

The operational expenditure for the Fabric Filter is depending on the type of filter media applied and obviously the estimate for the lifetime of the filter media. Present data is based upon a bag with lifetime expectations of 3 years.

5. Conclusion

The state of the art Fabric Filter "FabriClean" filter has been presented from a technological point of view and the CAPEX and OPEX for a specific project has been estimated and compared with an ESP for the same duty. The numbers presented support why the FabriClean Filter is considered a "BATNEEC". (Best Available Technology Not Entailing Excessive Cost).

Table 4 — Cost comparison between a Fabric Filter for a recent order to a stationary Calciner and an Electrostatic Precipitator for same duty.

	Fabric Filter	ESP
CAPEX (capital expenditure)		
Imported parts	789.000	687.000
Local parts	545.000	633.000
Installation cost	656.000	1407.000
Total CAPEX, US$ Flange/Flange	1950.000	2727.000
OPEX (operational expenditure per annum)		
Baglife is assumed to be 3 years and cage life is assumed to be 2 set of bags.		
Power consumption, fan, kW	302	50
Power consumption, Hopper heaters, kW	24	58
Power consumption, T/R set, kW	NA	184
Power consumption, compressor, kW	25	NA
Total OPEX, US$, based on 0,06 US$/kWh	230.000	138.000
Summary, US$		
CAPEX	1970.000	2727.000
OPEX (per annum)	251.455	138.337

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