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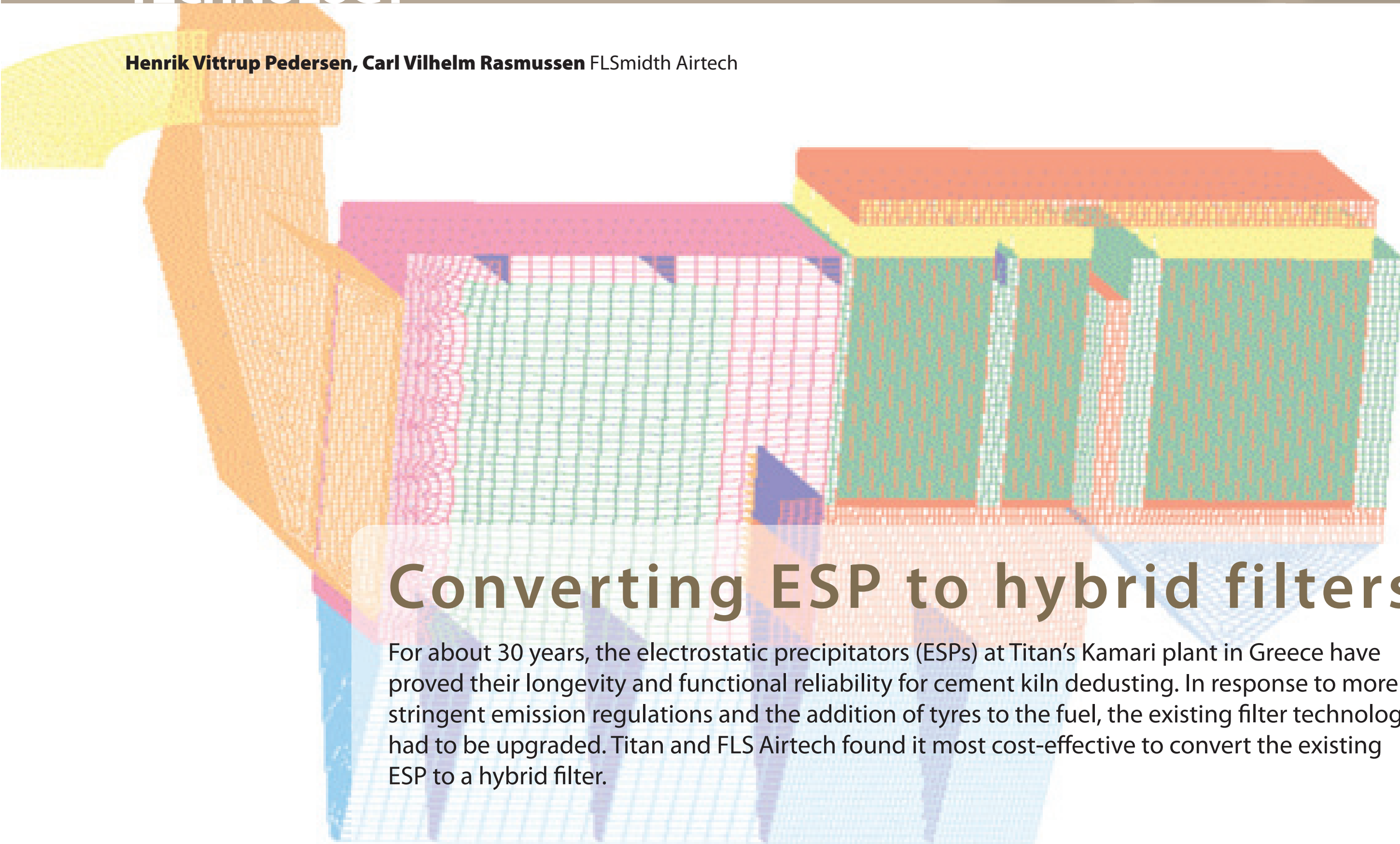


Converting ESP to hybrid filters

For about 30 years, the electrostatic precipitators (ESPs) at Titan's Kamari plant in Greece have proved their longevity and functional reliability for cement kiln dedusting. In response to more stringent emission regulations and the addition of tyres to the fuel, the existing filter technology had to be upgraded. Titan and FLS Airtech found it most cost-effective to convert the existing ESP to a hybrid filter.

In efforts to achieve optimum filtration efficiency for various operational scenarios in parallel with financial sustainability, the hybrid filter appears as a relatively new technology and a competitive solution for filtration of the large amounts of gases inherent in the cement and minerals industries. The hybrid filter can be and has been applied to kiln, cooler, mill (cement mill and coal mill) and by-pass applications. FLSmidth has supplied more than 20 hybrid filters to such applications.

Hybrid filter design concept:

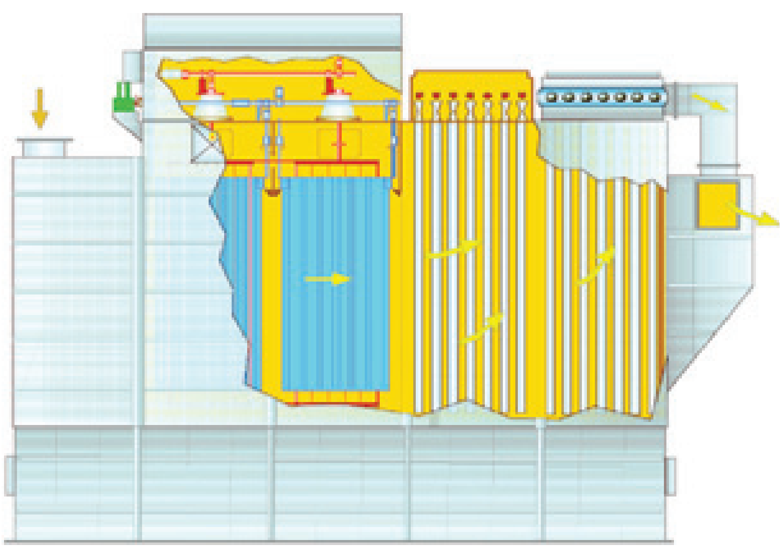
The hybrid filter can be represented by two different design concepts:

- by a fabric filter installed downstream of the existing ESP;
- by a combined installation with the ESP and fabric filter in a single casing.

In the first case, the ESP and the fabric filter are two completely separated pieces of equipment connected to each other by means of ducts. In the second case, the existing casing of the ESP is reused, some of the electrical fields of the ESP are kept, and some of the last fields of it are removed and substituted by a fabric filter. In both cases, the ESP will collect the higher dust load and the large particle sizes, and the fabric filter will control the fine particle removal.

FLS Airtech has a series of hybrid installations in its reference list. In this article priority will be given to the conversion to a hybrid filter in a single casing.

Below: The ESP and fabric filter (FF) section of the hybrid filter.



General considerations for the conversion of ESPs to hybrid filters

When upgrading air pollution control plants, besides the environmental requirements, the following aspects must also be taken into consideration:

- Capital investment;
- Operational costs;
- Availability of the equipment — stop period for implementation of changes;
- Maintainability;
- Space at site;
- Mechanical conditions of the existing ESP and dust transport system;
- Capacity of the fan and duct design;
- Process requirement — fuels burned;

Considering that there are several strategies for upgrading particulate control, the optimised solution depends on the ability to recognise the needs and

Parameter	Fabric Filter	ESP
Pressure drop [mmWG] (typical)	Conventional: 120 -150 Hybrid: 75-100	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: Max: 240-260ºC	**Typical:** 400ºC
Explosion risk	Low	High
Fire damage risk	High	Low
Absolute filter	Yes	No
Maintainability	High, on line possible	Low, only off line
Service interval	Bags: varies 4-5 years Cages: 2 set of bags	4 years typically

customers' requirements and the capability to evaluate the pros and cons for the specific plant (see table above).

The advantages of conversion compared to the installation of a new filter

There are several advantages of selecting a hybrid filter both from an emission performance point of view but also from a capital investment and operational point of view:

1) Emission performance:

a. Emissions from a hybrid filter are generally lower compared to an ESP not converted.

b. Hybrid filter is a barrier filter that is active even when ESP is de-energised.

2) Capital Investment:

a. Lower investment compared to new fabric filter (FF), due to:

i. Reuse of filter structure, dust handling, control system, etc.

ii. Higher A/C results in less quantity of bags, cages, etc.

3) Operational expenditure (normal operation)

a. Separation of approx 99% in ESP part of filter results in relative low cleaning requirement of FF part, which in turn results in low consumption rate of compressed air.

b. Total power consumption of ESP rectifier set and fan power is normally lower than fan power consumption for conventional bag filter.

However, there are also some disadvantages or issues which must be evaluated. These include:

The maintenance concept for modern fabric filters for kiln raw mill filters is normal to include online maintenance, which facilitates maintenance (i.e. bag change, etc), can be done without disturbing the main process. Converting to a hybrid filter is normally with an offline maintenance scenario, since it is difficult to implement compartments with inlet dampers. A hybrid filter is thus normally designed with an offline maintenance schedule similar to an ESP.

The ESP part of the hybrid filter captures a significant part of the dust (~99%) which clearly is an advantage, as described above, however the remaining dust tends to be very rich in fine particulates, which is normally not an advantage for the FF part mainly due to the filter cake will be more dense, because it is composed of uniform fine particulates. This phenomenon has been witnessed in our measurements .

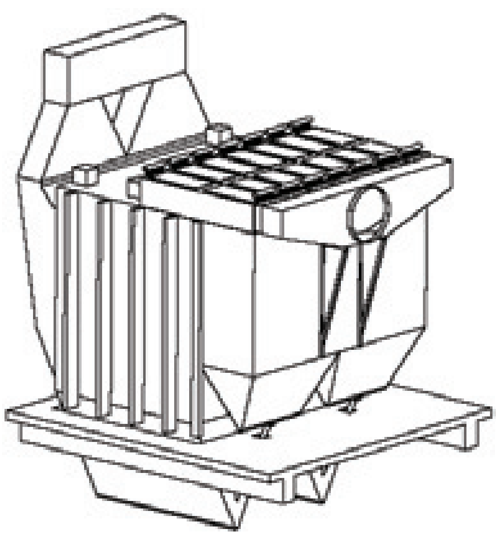
The smaller fraction of dust collected on the bags in the hybrid filter will be charged—which is said to assist the dust collection process on the filter bags. The filter cake is said to be porous even though it is composed of fine particulates, due to the effect originating from the charging. This has been described in the literature, and some technologies have attempted to benefit from the described effect. These attempts have not been very successful and a very limited number of installations have been installed.

What happens when the ESP part is de-energised? This is a vital scenario to investigate. In the event that the ESP efficiency drops the bags will ensure that the filter will not increase its emissions, however the cleaning frequency will increase as a result. The expected differential across the filter bags should be evaluated, and particularly the compressor capacity for cleaning of the filter bags and the ID fan should be investigated in detail and laid out accordingly.

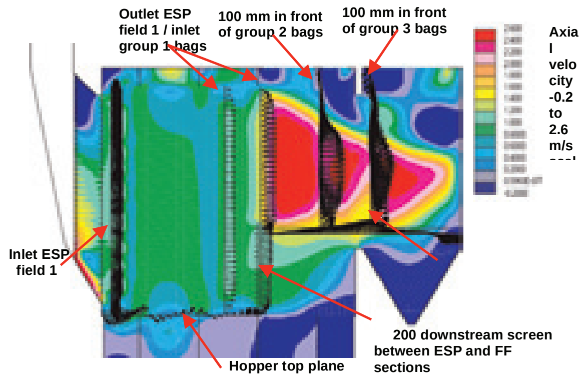
The conversion of the ESP at Titan Kamari kiln/raw mill line 2

Titans Kamari's interest in hybrid filter technology has mainly been motivated by the more stringent emission requirements imposed on the plant in general, which led to the conclusion that the existing ESP could not meet the new emission requirements.

The Kiln/raw mill filter is an ESP supplied by FLSmidth, and in principal Titan requested a new fabric filter to replace to the original ESP supplied in 1977. A strict focus on minimising the down time of the cement kiln concluded that it was not an option to replace the existing ESP with a fabric filter at the same location.



Right: The hybrid filter. The filter extension and the top boxes are visible, as well as the filter gas outlet. The bags are distributed in the seven top boxes, each fitted with an outlet damper. The purpose of the outlet damper is to provide option for off line cleaning and most important provision of semi on line maintenance.



Above: The result of the CFD simulation. Colours signal the flow velocity, in accordance with the scale bar at the right. Incoming flow is well distributed both at the filter inlet and also from the ESP section to FF bags. Velocity magnitude is 2.5m/s which is acceptable for a side inlet bag filter configuration. Too high velocity can result in dust wear on bags, or bag to bag wear originating from bags swinging, and must be avoided.

However, as the space required for a new fabric filter could not be found, this option was also not feasible and Titan Kamari finally selected a hybrid filter. The specific filter data and filter code is shown below:

Design data at filter inlet

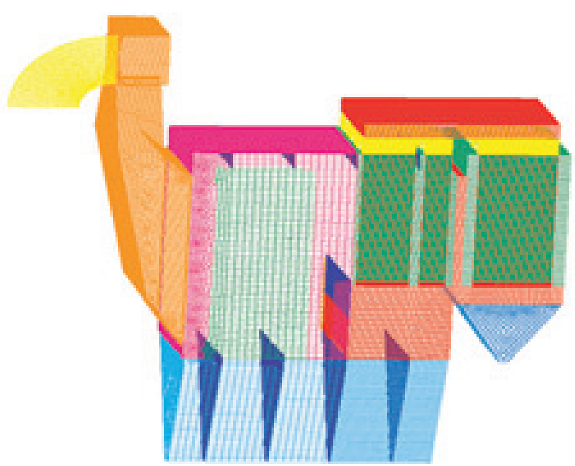
FLS-AT ESP filter code: FAA 3636-145110/T/T/L2D
FLS-AT FF filter code: RC/PJ/2268/8x127/(18x9)x2x7/1/S/7LS
Design point gas flow rate: 390,000 Nm^3/h
Bags: 2268 off 8m Wowen glass bags incl ePTFE membrane.
Operating temperature: 118ºC
Static pressure: –400 mmWG
Flue gas density: 0.84 kg/m^3
Dust load: 93 g/Nm^3 (dry).

Description

The solution that was selected was based on 8m ø127mm bags in order to reduce the footprint required for the FF part of the hybrid filter. As the illustrations of the hybrid filter show, it was necessary to implement a casing extension to house the bag filter area required to meet an A/C of ~1,3m/min. The extension is implemented without adding additional load points to the concrete structure.

The bags are distributed in seven top boxes, each fitted with an outlet damper. The purpose of the outlet damper is to provide option for off line cleaning and most important provision of semi on line maintenance. In case a filter bag fails the compartment, where the faulty bag is in, can be isolated and the problem can be dealt with during a planned shut down.

Below: An illustration of the numerical model used when a CFD simulation was conducted prior to the design work taking place at Titan's Kamari plant in Greece. The green shading indicates the new fabric filter section.



Flow analysis

A numerical model including more than 2.5m cells was established and

CFD (computational fluid dynamics) work has been conducted to analyse and ensure that the gas flow patterns in the filter are under control. The result of the CFD simulation is pictured (left). Colours signal the flow velocity, in accordance with the scale bar at the right. Incoming flow is well distributed both at the filter inlet and also from the ESP section to FF bags. Velocity magnitude is 2.5m/s which is acceptable for a side inlet bag filter configuration. Too high velocity can result in dust wear on bags, or bag to bag wear originating from bags swinging, and must be avoided.

The performance of the hybrid filters at Titan Kamari

The filters have now been in operation for around 12 months and the operation is accordance with the expectation. The performance data achieved at site is summarised below:

Flow: 620.000m^3/h, combined mode, coal mill out.
Temperature: 118 ºC
Emission: <10 mg/Nm^3
Pressure drop Flange to Flange: 80-85 mm WG
ESP part:
Voltage: 34kV
Current: 170mA
FF Part:
Filtration area: 7239 m^2
Cleaning pressure: 2½ Bar
A/C: ~1.3-1.4m/min

Capex/Opex comparison to new fabric filter

The Capex (capital expenditure) and Opex (operational expenditure) is estimated and compared to a new fabric filter installation which also can meet the required environmental performance.

Capex (hybrid versus new fabric filter)

New fabric filter was ~Euro1m higher in capital investment comparison, including duct, fan and stack and installation. Above is evaluated by Titan, that simultaneous to the hybrid filter project also installed a new fabric filter for the kiln/Raw mill for line 1.

Opex: (hybrid versus new fabric filter)

New fabric filter :
Fan power: 150mmWG/400.000Nm^3/hr/118ºC=312kW
Compressor: 295m^3/hr @ 2½ baro~30kW
Total: 342kW
Hybrid filter:
ESP part: 34kV/170 mA x 1,2 = 69,4 kW
FF Part 80 mm WG/400.000Nm^3/hr/118ºC= 166kW
Compressor: 75m^3/hr @ 2½ baro ~ 7.5kW
Total: 243 kW
Conclusion: ~40 % power saving when hybrid filter is selected!

Above estimates conclude that both from a capital investment point of view and from operational costs it has been attractive to select the hybrid filter.