REDUCTION OF DUST FROM SINTER PLANTS [1]

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Abstract

The electrostatic precipitator is known to the steel production industry as the preferred de-dusting equipment for sinter bands. A way to improve the efficiency of a precipitator is installation of pulse systems as power supply, where ultra short (microsecond) pulses are applied to achieve a more efficient precipitation of especially high resistivity dust particles. By applying pulse systems, existing precipitator units can be improved without physical enlargement. To understand the operation better, a short description of the theory of precipitation is presented with the factors influencing the performance. Details on the design and operation of the pulse generator system are presented as well as economical aspects for operation and installation. Examples and results from upgrading of precipitator performance from steel plants in South Korea, Germany, France and Belgium are given.

Key words: Sinter band; Reduction of emission; Electrostatic precipitator; Coromax.

REDUÇÃO NA EMISSÃO DE PARTICULADOS EM PLANTAS DE SINTERIZAÇÃO

Resumo

Precipitadores eletrostáticos são conhecidos na industria siderúrgica como o sistema preferido para o despoeiramento das máquinas de sinter. Uma maneira de melhorar a eficiência de um precipitador é através da instalação do sistema de pulso como uma fonte de energia, onde pulsos de curtíssima duração são aplicados com o objetivo de obter a máxima eficiência na precipitação, especialmente no caso das partículas de alta resistividade. A implantação dos sistemas de pulso em precipitadores que estão operando pode ser feita sem grandes modificações físicas dos sistemas existentes. Para uma melhor compreensão da operação destes sistemas apresentamos uma pequena descrição sobre a teoria de precipitação, e os fatores que influenciam a performance do precipitador. Apresentamos, também, detalhes de projeto do sistema de pulso bem como os aspectos econômicos da instalação e da operação. São mostrados exemplos de aplicação e os resultados obtidos com a implantação do sistema em precipitadores instalados, e em operação, em siderúrgicas na Coréia do Sul, Alemanha, França e Bélgica.

Palavras Chave: Plantas de sinterização; Redução na emissão; Precipitadores eletrostáticos; Coromax

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1 INTRODUCTION

With an increasing demand for clean air in the environment of a steel plant there have in the last few years been focus on sinter plant de-dusting all over the world.
Sinter band dust is characterised by a very small particle size, high resistivity, low humidity and high content of hydrocarbons. All these parameters give a dust which is difficult to collect in an Electrostatic Precipitator (ESP).
The problem leads to heavy back-corona of the ESP, resulting in a low efficiency during operation with traditional power supply. The efficiency can be improved simply by replacing the existing DC power supplies with the COROMAX pulse systems. By applying pulse systems, existing ESP's can be improved without physical enlargement, or new ESP's can be installed with smaller dimensions than ESP's with traditional DC power supplies.
The introduction in 1985 of the FLS Airtech COROMAX pulse system represented an important technical and economical advance in precipitator performance improvement. The system is very compact, comprising one oil-filled tank only and a control cabinet. Physically the FLS Airtech COROMAX system is very similar to the traditional transformer-rectifier set.
FLS Airtech is the leader in sinter band de-dusting with a unique technology for upgrading of existing plants. The COROMAX pulse technique is developed by FLS Airtech and has proven its reliability during operation all over the world for more than 20 years.
Our reference list covers more than 250 Coromax pulse units, where 99 units are installed on Sinter plants.

2 SINTER BAND DUST CHEMISTRY

The difficulty in cleaning the waste gas from a sinter band can be related to content of chloride, alkali and hydrocarbons in the dust. Most plants use ore with a content of chloride of about 0.015% and alkali of about 0,3%. However, in the waste gas dust a much higher content is found, because the components are volatile leaving the bed with the gas. Further, it has been realised that the volatile components in the dust increases when the ESP dust or part of it is returned to the bed.
The resistivity level is very high in the range of $5*10^{11}$ - $1*10^{13}$ ohmcm.
For a better understanding of the difficulties in cleaning the waste gas from the sinter band two installations with the COROMAX system have been analysed.

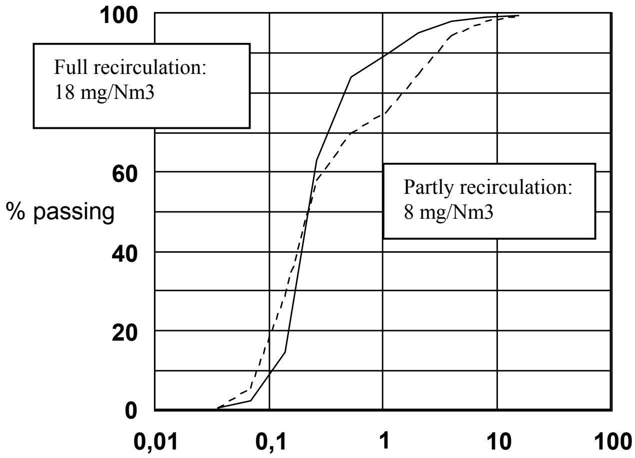
Table 1: Two installations with COROMAX system

	Plant A %	Plant B %
Fe_2O_3	53	43.3
SiO_2	7.3	6.5
TiO_2	0.2	0.12
Al_2O_3	2.6	1.24
CaO	11.8	8.92
MgO	1.2	2.42
SO_3	1.3	1.05
K_2O	4.4	4.58
Na_2O	0.25	0.45
Cl	2.5	3.4

For the 2 plants the inlet particle size distribution was measured with different degree of dust recirculation to the bed.

Table 2

Particle size distribution



The curves show the mass fraction versus particle diameter; it appears that the fines of the particles increase with the degree of recirculation.

For all measurements the particle size median diameter is approx. 0.2 ym. With full recirculation and partly recirculation dust comparison tests on the out let of the ESP were performed on the same plant and on the same operating conditions. The dust emission was measured to be 8 mg/Nm^3 for partly recirculation while it for full recirculation was 18 mg/Nm^3. The median diameter in the two tests is the same approx. 0.2 ym. The difference in the dust emission was mainly found in an increase in the amount of dust with a particle size of about 0.2 ym. Indicating that this fraction is very difficult to precipitate.

A chemical analyse of the alkali content of the dust leaving the ESP showed that about 45% was chloride. The distribution of the alkalies are:

	%
Cl	17.2
K_2O	15.4
Na_2O	3.3

As potassium is always found in an amply amount together with chloride when analysing dust from the outlet of an ESP, it is very likely that the dust fraction about 0.2 ym is a very pure form of potassium and chloride.
The above investigation has not involved analyse of volatiles, but obviously those are important when focus is set on the ESP efficiency for fine particles. The volatiles will condense on the fine particles and form a film on the surface, which decreases the ability for absorption of moister from the gas on the particles. This has two negative affects on the ESP efficiency, the attraction forces for natural agglomeration is decreased when an isolating layer covers the surface of the dust, and the resistivity is increased. Probably, those fine particles are bumping from collecting plate to collecting downstream the ESP because of its low ability to agglomerate, and further its high resistivity causes the severe back corona.

3 PRECIPITATOR PROBLEMS

In order to increase efficiency of a precipitator several solutions are possible depending on the nature of the problem. Some of the solutions are:

- Increase the size of the electrostatic precipitator
- Overcome resistivity by for example SO_3 conditioning of the dust
- Improve power supply

The first solution is normally not possible because of space limitations, and it will also require a long stop of production.
The second solutions have been tried on several plants. In some cases, and with a low degree of recirculation of the dust it might help, but the results are unpredictable, and the dust emission changes at different types of iron ore. The disadvantage of the system is high operating and maintenance costs.
The third solution have proven to be the most technical and economical one. It will require a short plant stop and will often save on running cost for the power supply.
The efficiency of a precipitator is depending on the peak voltage V_{peak}, the average voltage $V_{average}$ and the particle size D according to the formula:

$$\text{Efficiency} = V_{peak} * V_{average} * D^2$$

It can be seen that with small particles the efficiency will be low; therefore it is necessary to compensate for a small particle size by increasing the peak and average voltage.
Applying a COROMAX pulse system to the electrostatic precipitator, where the peak and average voltage can be controlled independent of each other in order to optimise the ESP operation, can do this. The ratio between the peak and average voltage varies with changes in the process, for example degree of recirculation or change in type of iron ore, with changes in temperature, dust level and resistivity. Therefore it is very important that the control system is able to automatically adjust the settings to the present operating conditions.

4 PULSE ENERGIZATION

With the FLS Airtech COROMAX pulse system, pulse of a duration of 0.1 milli second are superimposed on a basis voltage, so that the total peak voltage level can reach approx. 115 kV, where the peak voltage level in normal DC operation is approx. 60 kV.

The pulses can be applied with a frequency of up to 200 pps. capable of energizing a precipitator collecting plate area of up to around 6000 square meter.
The main advantages are:

- Independent control of peak and average voltage
- Current control capability independent of precipitator voltage.
- More uniform current distribution
- Enhanced peak field strength between discharge and collecting electrodes
- Improved particle charging.

These factors will indeed have the greatest impact in cases with high resistivity dust, and small particle sizes.

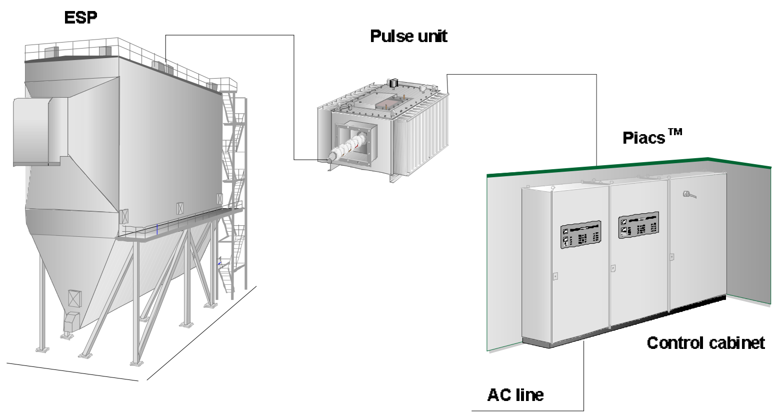


Figure 1: COROMAX installation

The FLS Airtech COROMAX pulse system consists of:
High-Voltage Tank:
A high voltage power supply comprising a three-phase transformer/rectifier for base voltage, and a pulse power supply comprising a three-phase transformer/rectifier. All are placed in a common oil-filled tank together with a firing and protection unit for the thyristor switch, and current shunts and voltage dividers for measuring purposes.
Control Cabinet:
A control cabinet containing fuses, main contactor, thyristor controller for the base high voltage supply, thyristor controller for the pulse power supply, thyristor firing unit, and the PIACS-COROMAX automatic control unit.
The oil-filled tank with the base high voltage and pulse voltage supply is placed on the precipitator roof, and its high voltage bushing connected to the precipitator section by means of a bus bar in steel trunking.
The control cabinet, which must be placed in a suitable dust free environment at distances varying from a few meters up to 100 meters or more from the tank, is connected to the tank by two three-phase power cables and one screened multicore signal cable. The installation of the system is practically as simple as for a conventional DC power supply.
PIACS-COROMAX ™ is a microprocessor control unit for manual and automatic operation of the COROMAX pulse system. The PIACS-COROMAX is installed in the control cabinet of the pulse system.

The PIACS-COROMAX monitors the pulse system (corona current, sparks during pulse, sparks between pulses) and automatically controls the base voltage, the pulse voltage and the pulse repetition frequency in accordance with a programmed control strategy aiming at maintaining maximum precipitator efficiency with the resistivity level present in the precipitator.
The PIACS COROMAX incorporates:

- Easy-to-use man/machine interface (MMI).
- Remote operation and trouble shooting via modem to engineers at FLS Airtech.
- Soft-start with self-diagnosis routine.
- Efficient spark detection with compensated voltage divider.
- Classification of sparks according to their intensity and the time of their occurrence.
- Advanced control strategies for the base and pulse voltage, and the pulse repetition frequency according to the resistivity of the dust in the precipitator.

5 A UNIQUE DESIGN

The FLS Airtech Coromax pulse system is unique in its design as 3 important parameters can be controlled and adjusted complete independent of each other. That is the base voltage, the Pulse voltage and the current. Of high importance is that the base voltage is not connected to the pulse voltage meaning that the current can be controlled both on the base voltage level and on the Pulse level. Sparking on both the base voltage level and pulse voltage level are controlled independently.

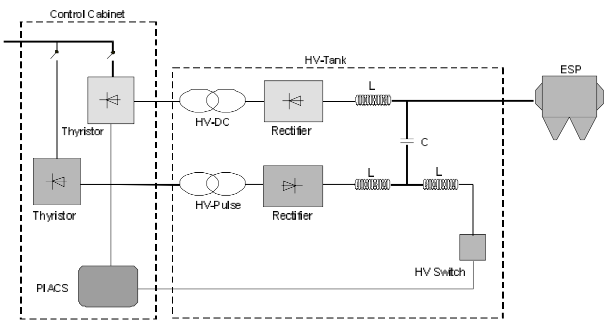


Figure 2: A unique design

6 POWER CONSUMPTION

A special advantage when using the COROMAX pulse system is the low power consumption, when dealing with difficult dust.
In the normal DC transformer the current cannot be controlled independent of the high voltage, and therefore current will flow at a high value also when the resistivity is increasing. The current creates back corona and this current is wasted in the collecting process, and it only gives high power consumption without doing any good.
With the FLS Airtech COROMAX pulse system, the current can be controlled independently by both the base voltage and of the pulse voltage level.
With increasing resistivity, it is a must that the current is reduced in order to avoid back corona. This gives two effects, one is that the dust emission is reduced (no back corona) and the power consumption is at the same time decreased (lower

current). With the FLS Airtech COROMAX pulse system all current is used for the collection of dust and no current is wasted.

7 EXPERIENCE

The FLS Airtech COROMAX pulse system was developed more than 20 years ago and more than 250 units are currently in operation all over the world.
On Sinter plants are installed the following numbers of units:

Table 3: Experience on Sinter plants

Plant	No. of units
BLUE SCOPE, Australia	6
CSA, Brazil	8
CHINA STEEL, Taiwan	8
ACERALIA, Spain	4
KREMIKOVTZI, Bulgaria	3
KOSICE, Slovakia	12
POSCO, South Korea	48
RAUTARUUKKI, Finland	3
SIDMAR, Belgium	7
SALZGITTER, Germany	6
SOLLAC, France	10
THYSSEN, Germany	8
TRINECKE ZELEZARNI, Czech Republic	6
VOEST ALPINE, Austria	4
Total Sinter Bed	133

8 TEST RESULTS

In the following are given some results from various installations.

Table 4: Test results

Plant	Gas flow Nm^3/h	Before pulse installation mg/Nm^3	After pulse installation mg/Nm^3
POSCO, KY no. 1	1,300,000	52	19
POSCO, KY no. 2	1,300,000	35	17
POSCO, KY no. 3	1,300,000		22
POSCO, KY no. 4	1,300,000		29
POSCO, Pohang	1,635,000		20
Aceralia	750,000		
Thyssen Stahl	1,200,000	80	40
Sidmar no.2			40
Sidmar	470,000	25	10
Kosice	315,000		50
Kremikovtzi	245,000		50
Salzgitter no. 6	450,000		50
Sollac Fos sur Mer	650,000		50
Sollac Dunkerque	475,000	120	60
Trinecke Zelezarni	290,000		50

9 CONCLUSION

The fine particulate dominates the efficiency of the ESP for the sinter bed. The size of the dominating dust particle is about 0.2 ym and consists mainly of potassium chloride. The content of the fine dust particle depend on the recirculation of ESP dust to the bed. The fine dust particle together with hydrocarbons is the cause for the

severe back corona condition in the ESP and the related low efficiency for dust removal.
A mean for solving the problem is to use the COROMAX pulse system.
With the FLS Airtech COROMAX pulse system it is possible to compensate for the small particle size of sinter band dust. It is unique in its design as the base voltage and pulse voltage levels are completely independent, and therefore a very precise adjustment to the resistivity level can be done. The emission reduction factor is equivalent to an increase of the collecting area in a DC or semi-pulse ESP by 50 %.
The most economical solution to an existing electrostatic precipitator is installation of the COROMAX pulse system.
The FLS Airtech COROMAX pulse system has been in commercial operation during the last 25 years and the FLS Airtech experience is based on more than 250 installations for a wide range of industry applications.