Hybrid filtration of sinter plant process fumes

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1. Introduction

Nowadays the steel supplied by ArcelorMittal, is coming from two main sources namely iron ore and scrap. Iron ore as the only source can lead to different types of steel with very different properties. By reusing scrap this is not possible.

The conversion of iron ore into pig iron requires a sinter process that changes the mineral into a permeable material that later can be used in the blast furnace to create pig iron. The sinter process agglomerate different types of iron ores with limestone and fuel to create a permeable iron concentrate material called sinter. During this process the material is agglomerated in mixing drums, disposed on a sinter belt and ignited in a furnace in the first step of the sinter machine. Once the fuel content in the mixture ignites, the sintering process starts and the wind boxes located under the sinter belt, sucks the air through the sinter bed transporting the heat from the top to the bottom of the layer. During the sintering process dust and fumes (CO_2, SO_x, NO_x…) goes through the sinter wind boxes to the filtration units.

Currently there are two main technologies focused in the air pollutant control of sinter plants. Those technologies are Electrostatic Precipitators (ESP) and Fabric Filters (FF). The ESP is a technology capable to achieve sinter dust emission level values below 40 mg/Nm^3. In case of the FF the average value proposed is 15 mg/Nm^3 [1]. The trend in many plants that need to reduce the dust emission is to use FF, which is thought to be the only technology capable of reaching very low and stable dust emission levels in sinter process over long operation time [2].

Using a FF to meet the new emission level requires a completely new installation downstream the ESP and the main process fan. Considering the volume of gases in typical sinter plants (500 000 m^3/h to 2 700 000 m^3/h) it has been necessary to think in a direction that can give the best performance while minimizing the impact on the sinter plant's productivity, economy and process. The sintering process produces worldwide around 1200 million tons of sinter which generates around 3000 billion of Nm^3/h of process fumes.

Looking for a possible solution that can be combined with an existing ESP and aiming to comply with the new emission limits in the future, it was decided by ArcelorMittal to investigate in the technology of Hybrid Filter (HF) together with FLSmidth by designing a pilot filter for sinter plant fumes. This technology has been considered not able to handle sinter plant process fumes due to the difficulty and instability of the gases in the sinter process. Such as submicron dust, rapid changes in temperature, changes in moisture levels, alkali content in the dust etc. [2].

2. Hybrid filter technology

FLSmidth has installed several HF for cement processes usually by a partial conversion of an ESP [3]. Any HF consists of an ESP section followed by a FF section which in principal is a two stage filter.

This conversion allows sinter plants to convert existing ESP technology into a Hybrid Filter technology that can abate fine dust by reusing the same casing.

Converting an ESP is typically done due to a demand for a lower emission. It may also be that the existing ESP needs thorough maintenance. A full ESP to FF conversion may also be an option but usually it is cheaper in terms of total cost[1] to perform a partial conversion (HF). Some customers may prefer FF against HF which makes the choice very case and customer specific.

The HF technology cannot be transferred directly from the cement or power plants into a sinter plant. The complexity of the sinter dust and the variations of the process make it difficult. Therefore it was decided to do tests in a pilot filter scale where all the necessary modifications could take place, and could be analyzed individually.

For the sinter process the HF pilot filter is being tested by FLSmidth at Asturias sinter plant owned by ArcelorMittal. The primary goal of the tests is to prove the benefits of the HF technology against the alternatives for reaching very low emission of the sinter plant process fumes. The tests primarily focus on emission performance and stressful situations such as shutdown, startup and emergency situations. A secondary target is estimating total cost of the HF technology comparing the pressure drop through the filter, and the life time of the bags in both technologies [4].

[1] Total cost is considered to be capital and operational expenses including maintenance

The test setup consists of a pilot filter that takes a bypass of the sinter plant process fumes before the existing ESP. The fumes pass through the pilot filter driven by a fan and are then returned to the existing ESP.

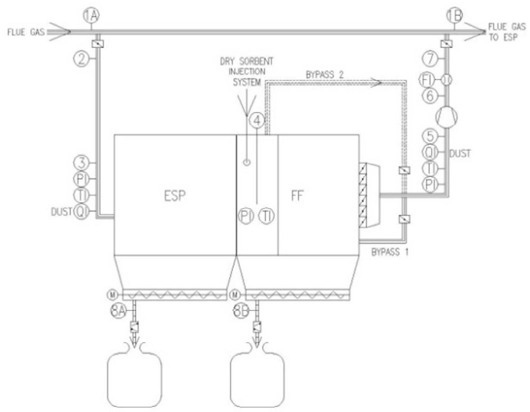

Figure 1. Flowsheet of pilot filter

As shown in the flowsheet (Figure 1) and drawing (Figure 2) it is possible to separate collected dust from the fumes in two stages. The first stage is an ESP part which may collect a certain part of the dust. The second stage is a FF part which collects the remaining part of the dust. After the FF part there is a very low emission. Process values such as static pressure, temperature, dust concentration at inlet, dust concentration at outlet and flow are all measured continuously. Dampers at certain locations provide the ability to bypass the FF section. The fan is able to operate at variable frequency which allows for testing at different flow values.

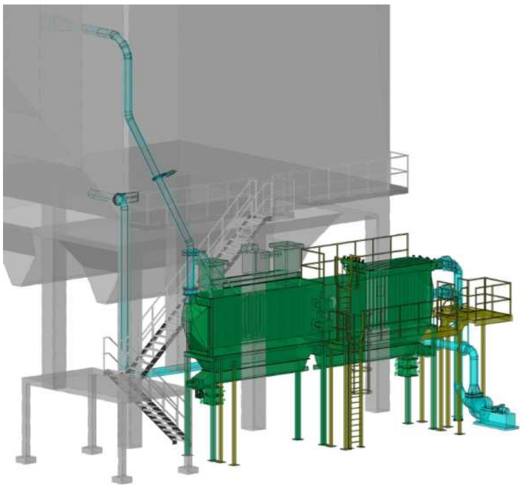

Figure 2. Pilot filter installation – 3D model

In order to use the HF for multipollutant abatement purpose several injection points are established at appropriate locations of the pilot filter installation.

3. Results

In early 2013 the pilot filter was designed to meet the different scenarios that can happen with sinter plant process fumes. Construction began in June 2013 and the partners inaugurated the pilot filter by September 2013.

The pilot filter treats up to 5000 Nm^3/h and can work in three different modes which are ESP, FF or HF. Bypass is installed at various locations in order to operate the pilot filter in each mode.

The pilot filter is connected to the sinter plant main duct and all the tests were done with realistic concentrations of sinter dust. Dust monitors measured the concentration before and after the pilot filter giving the efficiency of the process online at any time. The monitors were calibrated periodically by carrying out gravimetrical sampling (EPA-17). The concentrations on the inlet side varied from 500 mg/Nm^3 up to 5 g/Nm^3 but were typically in the range of 1 to 2 g/Nm^3.

A summary of the gravimetrical samplings can be seen in Table 1. The ESP mode gave the highest emission of nearly 90 mg/Nm^3. The FF and HF mode was below the detection limits < 1 mg/Nm^3. One of the FF samples showed 4 mg/Nm^3 which may be due to released dust from the duct.

Table 1. Dust concentrations measured gravimetrically at the pilot filter. Each value is based on the average of 3 measurements carried out on the same day

	Dust mg/Nm^3, wet
Inlet	1,872 ; 2,189
ESP	78 ; 88 ; 89
FF	~ 1 ; 4
HF	~ 0 ; ~ 0 ; ~ 0

During the tests current and voltage of the ESP part was modified in order to improve the filtration performance. The tests verified how much dust leaves the ESP part and which levels of dust may be appropriate for the FF part to receive. Topics such as flammable ash and the impact on the sinter process were considered in order to perform the optimization.

The nature of the dust from the sinter process fumes demanded careful consideration of the bag material and the cleaning method. With the submicron dust of the sinter process fumes it was observed that the differential pressure of the FF part became high (above 15 mbar) even for a filtration velocity of 1.0 m/min and lower. A solution was found and it was possible to keep the differential pressure below 15 mbar at 1.0 m/min and also with good values at 1.2 m/min.

One of the key tests was to measure the difference between the FF and the HF. It was performed by measuring the change in differential pressure over time and compared both technologies. The change in differential pressure over time is related to the cleaning frequency of individual bags and thereby related to the lifetime of the bags. Testing the pilot filter in FF and HF mode at same air to cloths ratios showed that the cleaning frequency of FF was 3 to 4 times higher that of HF (see Figure 3).

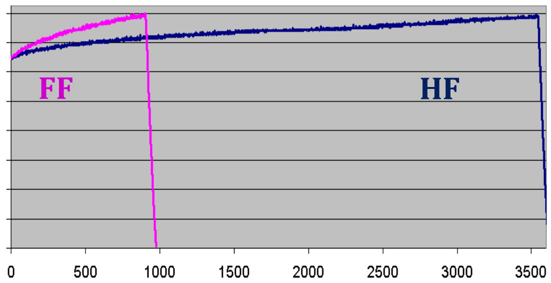

Figure 3. Comparing differential pressure over time [s] for HF and FF modes of the pilot filter

During the tests the pilot filter experienced several extreme situations such as start up with low temperature and wet fumes. High temperatures were also checked during stops or special situations. The pilot filter continued to perform well despite several cycles of low temperature wet fumes and high temperatures. The pilot filter operated in the order of 4000 hours with the same set of bags.

As a final test the bags were analysed in the laboratories of FLSmidth. Microscopy and differential pressure tests verified that the material was in good conditions. The features of the material were still intact and the differential pressure had risen to a level which is considered normal for reference processes.

4. Industrial implementation

After completing the trials at the pilot filter all results and experiences were verified by the expert teams of both partners. In ArcelorMittal it was proposed to go ahead with the upscaling of the HF technology in a sinter plant with a volume flow of 500 000 m^3/h (see Figure 4).

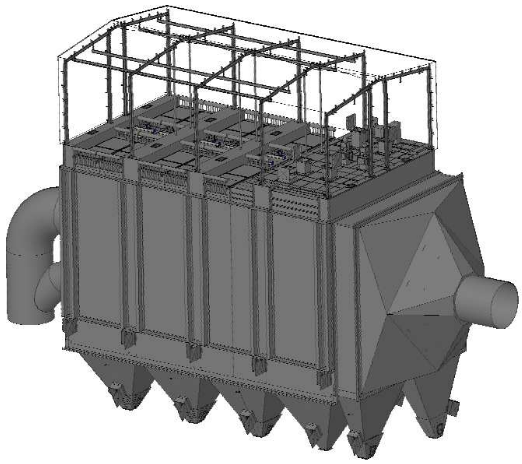

Figure 4. Industrial implementation of HF at ArcelorMittal sinter plant – 3D model

This first industrial scale HF will benefit of the lessons learned during the pilot filter trials and thus minimizing any side effects that can arise with the sinter process. The HF has been designed with reliability as a priority in order to guarantee stable emission levels during all sinter conditions and over long operation time. Further is has been designed with the aim of minimizing the impact on the sinter plant operation.

This first HF is a promising technology, which is aiming to minimize the dust emission levels of the existing sinter plants. In addition to minimizing the dust emission also the energy required is reduced. The HF also solves the problem of footprint otherwise required to do the filtration with conventional technologies.

Further the solution by FLSmidth will allow those plants to be prepared to do multipollutant abatement for different chemical compounds, aiming to minimize the environmental impact of the sinter process.

5. Conclusion

The HF technology has proven able to meet all the process conditions and give a solution to all type of operation modes in a sinter plant. Further the same filter is prepared for multipollutant purpose and can easily be converted in the future. It is one of the important barriers that the present partnership has broken: the HF is able to treat dust and other pollutants in a single step that only require few modifications between flanges of existing equipment.

ArcelorMittal highlight that the HF technology will imply savings in terms of energy and CO_2 footprint thanks to the satisfying differential pressure observed in the trials done in the pilot filter connected to the sinter plant. The operational cost of the HF technology, compared with the existing state of the art technologies, will decrease also thanks to one casing technology, which means less maintenance costs. Cost-wise for sinter plants it is a significant opportunity that meets the best filtration performance with more benefits than existing alternatives.

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