DUST EMISSION MINIMAZING, MEASURING AND MONITORING IN FeCr-PRODUCTION IN TORNIO WORKS

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ABSTRACT

Environmental pressure from authorities and local people on the Tornio Works FeCr production has being constantly increased. FeCr plant in Tornio has invested more than 60 million euros in the environmental area in the last five years. All dust emissions of the processes and material handling are measured or calculated and reported to authorities. Most of the measuring systems of dust emission are continuous-time.

Hot and explosive process gases are typically cleaned with wet scrubbers. In the sintering process, off-gases are cleaned with cascade scrubbers, and dust emission and SO_2*-content are measured and monitored on-line. In the smelting furnace and preheat shaft kiln, off-gases are cleaned with venturi scrubbers. In addition, furnace CO-gases are also cleaned with CO-filters. The cleaned CO-gas is utilized in the FeCr plant and in the neighboring stainless steel plant. In practice, 95 % of the CO-gas produced in the three FeCr furnaces is utilized. The utilization of the CO-gas is an important environmental aspect considering* CO_2 *and* SO_2 *emissions.*

Dry and cold process dusts are cleaned with bag filter units. Bag filters are typically used for material handling processes and general de-dusting of buildings. Different types of dust can be collected into different bins and recycled back to the process.

In the future, the biggest challenge for decreasing environmental load is diffuse emissions. For example, diffuse emissions are generated in transporting, by conveyors and by casting area operations. Most of this kind of work is done in large areas or outdoors, and de-dusting systems can be very complicated and expensive.

Keywords: *Dust emission, bag filters, SAF, BAT*

1 INTRODUCTION

Outokumpu Tornio Works is the largest ferrochrome (FeCr) producer in Europe. Annual production capacity is 530 000 tons. The production is based on chromium ore from the company's chromite mine. The closed furnace smelting technology used in Tornio is developed in Finland. Today, the closed furnace technology is the most used and sold in the world due to energy and environmental benefits compared to other furnace types. For example, the energy consumption and emissions of hazardous compounds are the lowest. In closed furnace, it is possible to gather the generated CO gas, and to clean and sell it as fuel for other plants instead of oil and natural gas.

Environmental permits (licenses) are granted by the Regional State Administrative Agencies in Finland. The permit terms are supervised by local Centre for Economic Development, Transport and the Environment. Because the plant is situated just by the Swedish border, the Swedish authorities are also involved in licensing process [1].

Current environmental permit was granted in August 2012. It includes all the operations on the site: ferrochrome, steel melting and rolling and most of the sub-contractors. Majority on the limits were taken from the EU Iron& Steel and Non-Ferrous metal BREF documents (BAT conclusions) [1].

In Tornio, more than EUR 60 million was invested in environmental applications during construction of the new ferrochrome sintering and smelting line that was ramped up during 2013 and 2014. The largest individual investments were dust-filtering units, gas scrubbers and a new unit for process water handling [2].

2 DUST EMISSION MEASURING AND MONITORING

Outokumpu continuously monitors and evaluates legislative initiatives and estimates their impact on the factories' operations. Different types of dusts have traditionally formed the most significant source of emissions resulting from the operations by the metal industry.

Continuous improvements in the monitoring of factories' production operations reduce the environmental risks. Ferrochrome sintering and smelting plants are equipped with continuous-time on-line dust measurement units. The detailed daily emissions data obtained from the monitoring system allow potential filter leakages to be rapidly identified so the immediate remedial action can be taken. In Figure 1, a typical monthly report from continuous-time dust measurement system is shown. This data is also documented and reported to Finnish authorities.

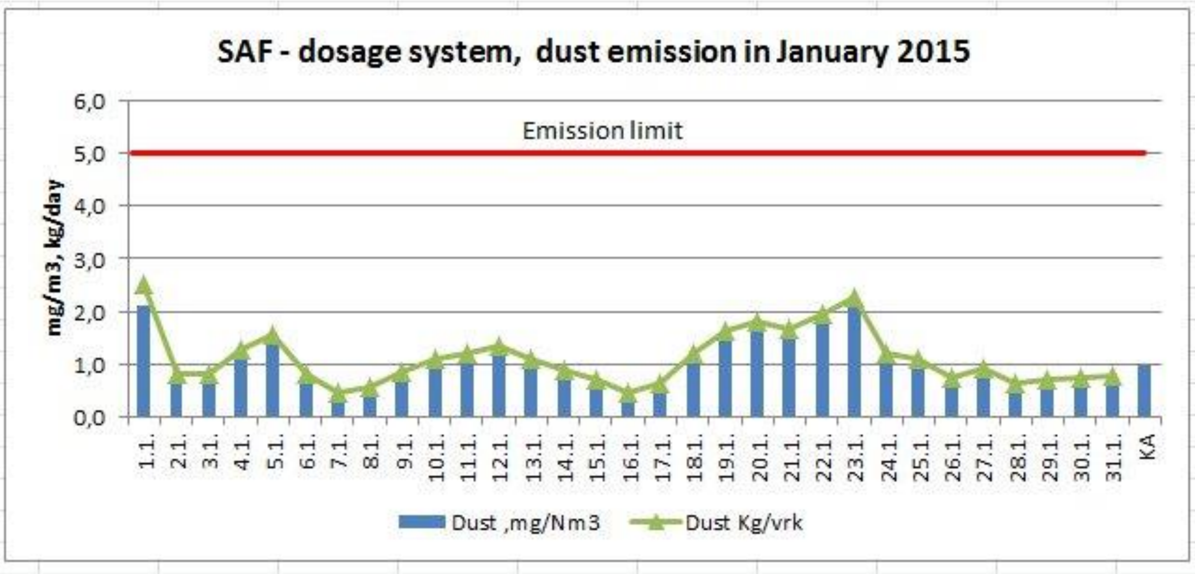

Figure 1. Dust emission data from continuous-time measurement reporting system (daily average).

Dust emission limits are 5 mg/m^3 (STP) for bag and cassette filter units and 10 mg/m^3 for wet scrubber off-gas. Emissions are reported in daily averages but measurement systems are continuous-time with typical sampling interval of one second for data recording. Most of the results from continuous-time measurement systems can also be calculated as emissions, e.g. kg per day.

All continuous-time measurement systems can send automatic alarm to control room for operators and a txt-message for shift foreman if the dust emission level is too high. In the case of an alarm (emission comes near the limit), de-dusting unit will be checked and corrective actions will be made as soon as possible. In some cases, it might mean that the process will be ramped or shut down for a while.

Typical installation place for continuous-time measurement unit in the off-gas stack is shown in Figure 2. All de-dusting and gas cleaning facilities in Tornio FeCr plant are presented in Table 1.

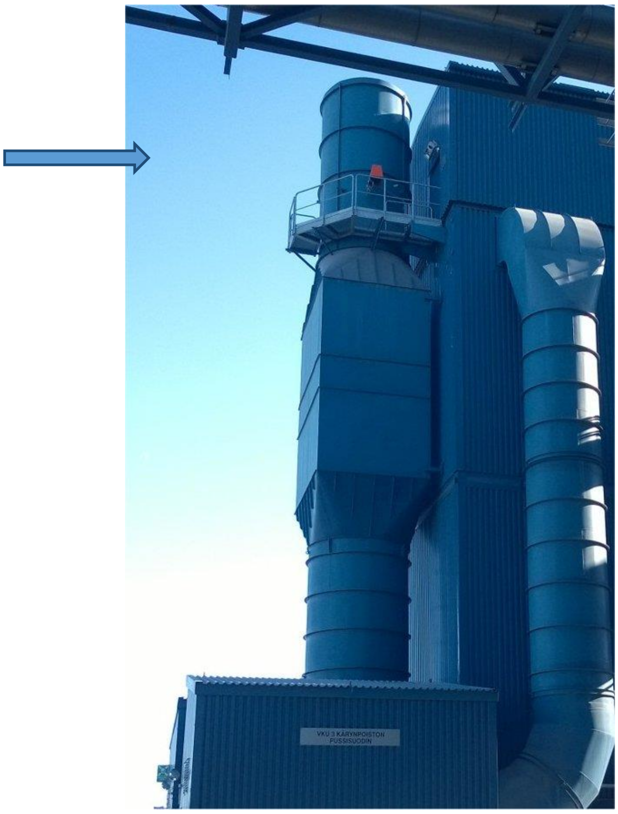

Figure 2. Sampling point on off-gas stack fora continuous-time measurement.

Table 1. De-dusting and gas cleaning facilities in Tornio FeCr plant

De-dusting type	Number of units in Tornio FeCr plant	Typical application	Max capacity per unit [m^3(STP)/h]	Measurement system	Measured component
Bag or cassette filter	17	Dosage system, Furnace tapping, Material handling	300 000	on-line	Dust
Venturi Scrubber	12	Smelter gas cleaning, Preheating off-gas cleaning	15 000	periodic	Dust
Cascade Scrubber	7	Sintering plant off-gas gleaning	100 000	on-line	Dust, SO_2 and NO_x
CO-gas filter	9	CO-gas cleaning	15 000	on-line gas analyzer	CO, CO_2, H_2
Slag granulation Hood	5	Slag granulation	1 000 000	periodic	Dust

3 PROCESS EMISSION CONTROL

3.1 Wet Scrubbing

In general, wet scrubbing is used in Tornio FeCr plant for hot gases in the temperature range of 100°C to over 1000°C. Wet scrubbing is especially safe and suitable method to rapidly clean and cool off the large volume of hot and explosive CO-gas formed in SAF (submerged arc furnace) [3]. There are two kinds of wet scrubbers in Tornio: the venturi scrubbers used for SAFs' CO-gas and preheating kiln off-gas, and the cascade scrubbers for SBS (steel belt sintering) furnaces' off-gases. Typical dust emissions after wet scrubbing per produced metric ton of ferrochrome or chromite pellets are presented in Table 2.

Table 2. Residual emissions after different wet scrubbing processes

Process	Dust emissions	
	kg/t	mg/m^3(STP)
Closed SAF: venturi scrubber + CO-filtering	$< 0.01 / t_{FeCr}$	< 5
Preheating: venturi scrubber	$0.002 / t_{FeCr}$	10
SBS: cascade scrubber	$0.01 - 0.02/ t_{pellets}$	10 - 15

The scrubbers used by SAFs are of two-stage, ejector-venturi type with integrated droplet removal. Water is sprayed through a nozzle at very high pressure. This creates a jet of very small water droplets that collects dust effectively and also sucks the gas from the furnace. Dust particles are removed as slurry from the bottom of the scrubber. The remaining small dust particles are removed from the CO-gas with sintered plate filters after the scrubber. The separation degree of the ejector-venturi scrubber is nearly 99.9 % with the cleaned gas containing dust particles around 50 mg/m^3(STP) [4]. After the sintered plate filtering, the residual dust level is only 1-5 mg/m^3 (STP). The SAF CO-gas cleaning with scrubbing and backwashed plate filtering is demonstrated in Figure 3. Preheating kiln off-gases are cleaned with scrubbing only. The residual off-gas dust level is under 10 mgm^3 (STP).

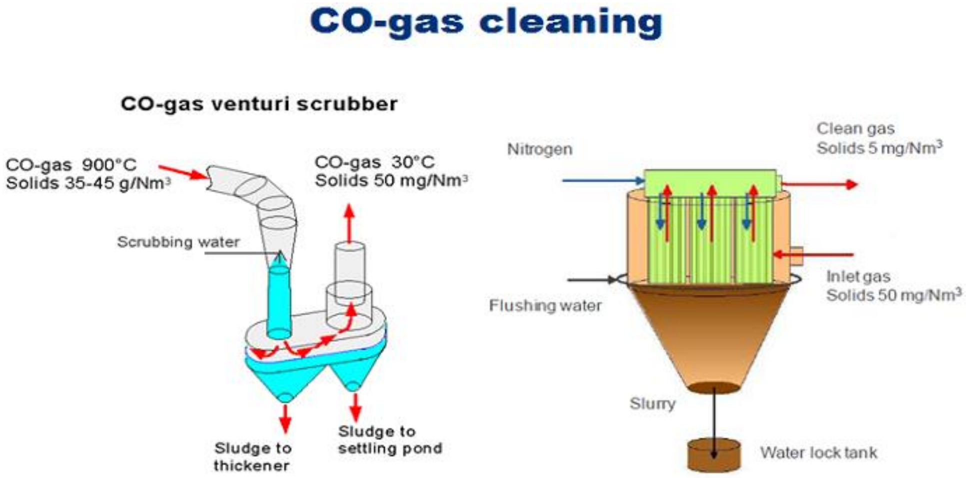

Figure 3. CO-gas cleaning with scrubbing and filtering

The cascade scrubbers used in SBS-plants utilize off-gases' kinetic energy to form small water droplets which collect dust particles. The off-gases are sucked through nozzles at high velocity and impacted into a water bath. The induced droplets are redirected to form a thin water film through which the gas travels while exiting the cascade nozzle. As a final stage, the cleaned gases are run through a droplet separator to remove entrained water. Dust particles settle to the bottom of the scrubber and are removed as slurry.

In addition to solid particles, the cascade scrubbing also removes gaseous emissions effectively. This is particularly practical while reducing sulfur dioxide emissions. Outokumpu takes advantage of alkaline water produced at stainless steel slag handling process to control the sulfur dioxide absorption through altering the scrubbing water's pH–level. Control of both dust and gaseous emissions is precise with online-monitoring of dust, SO_2 and NO_X in the SBS process' flue-gas stack. Corrective actions can be done based on process' real-time response in order to minimize emissions. Dust emission levels with cascade scrubbers are typically below 10 mg/m^3 (STP).

The sludge from venturi scrubbers is processed with thickening and centrifugal decentering, while the solids from cascade scrubbers are separated with sedimentation. Remaining moisture is removed by air drying in both cases.

3.2 Dry Gas Cleaning

For dry process gases close to ambient temperature, filtering is a feasible method to reduce dust emissions. Depending on process, Outokumpu uses either bag or cassette type filters. Applications vary from single spot dust collection to building de-dusting. The size of the filter unit depends on gas flow volume and the type of solids.

During tapping, fumes can escape from the furnace tap-hole area into the surrounding atmosphere. These fumes can be collected with hooding system and then cleaned with bag filters. Outokumpu has recently invested in equipment for every SAF to collect and clean tapping hole fumes. This application requires gas temperature dilution with excess air. A filter unit for tapping fumes de-dusting is shown in Figure 4.

Figure 4. Bag filter unit for SAF3 tapping area fumes handling

In every location, the operating principle is the same: residual dust level is monitored on-line by direct measurements from the stack. In case the dust level increases above a threshold, preventative maintenance operations are performed on the filter unit in order to minimize emissions before the environmental limits are reached. The separated dust is collected for re-usage in appropriate processes.

3.3 Dust Recirculation

Different dusts collected with dry cleaning techniques are stored separately and re-used as they are, i.e., mostly by feeding them back into the processes. Fine coke particles and dust are used as chemical energy. After drying, the sludge from wet scrubbers is used in land grading, e.g. instead of bentonite.

Dust emissions from Outokumpu's operations typically contain small quantities of metals (etc. Fe, Cr, Zn), most of which are present in harmless form. Chromium is usually found in its trivalent form and not in the hazardous hexavalent form.

3.4 Diffuse emission reduction

The main sources of diffuse emissions in Tornio plant are materials conveying, furnace tapping, FeCr casting and ingots handling, products crushing and screening.

After tapping fumes de-dusting, the next big challenge is to avoid diffuse emissions produced by FeCr casting. The casting operations happen within large areas outdoors and de-dusting systems can be very complicated and expensive to implement. Best way the minimize emissions is to avoid casting. In Tornio, liquid FeCr can be sent to stainless steel mill nearby, and only some part of the produced ferrochrome must be cast into ingots.

The cast material is fed into an integrated crushing and screening plant to produce the wide range of product sizes. These operations are a potential source of diffuse emissions and require consequent covering. Extraction and bag filters are used and the collected dusts are reused [3].

Other methods to reduce diffuse emission are water spraying (see Figure 5), walls and buildings and optimized working order, i.e., for example, handling and moving cast ingots as little as possible before crushing.

During tapping and casting, slag also creates a lot of fumes and dust. Most of the slag in Tornio is granulated with water. The vaporized water from slag granulation is exhausted through collecting hoods and stacks.

Figure 5. Water spraying with a “snow cannon”.

4 CONLUSION

One of the Outokumpu’s operating principles is to use best available techniques (BAT) to reduce emissions and minimize harmful environmental impacts which could result from factories operations. BAT means the best available pollution prevention technology from technical and economic perspective.

Employing BAT means that the latest technology will be used to keep emissions from Outokumpu’s operations at the lowest achievable level. Outokumpu continuously develops processes and pollution prevention techniques to maintain high levels of emissions control also in the future. Outokumpu is also an active participant in the process of updating the reference documents (BREF) which specify related technologies, helping to set the high standards applicable within the European Union [2].

5 REFERENCES

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