DEDUSTING SYSTEM FOR ARCELORMITTAL MONLEVADE SINTERING PLANT'S PRIMARY MIXER – JOÃO MONLEVADE PLANT: A PIONEER APPLICATION[1]

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Abstract

This article presents the results obtained with the dedusting system of the primary mixer's stack, existing in ArcelorMittal Monlevade's Sintering Plant – João Monlevade Plant. The dust is collected by means of a recently installed ElectroStatic Precipitator (ESP). The primary mixer's wet gas is heated with gases from the sinter cooler and, then, introduced in the precipitator inlet duct. The innovation here is the use of hot gases from the cooler to achieve this objective and to adapt the mixture for collection in the ESP.

Key words: Sintering; Primary mixer; Electrostatic precipitator (ESP).

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1 INTRODUCTION

The Sinter Plant of ArcelorMittal Monlevade started his operation in 1978. In 2002, aiming the utilization of 100% of sinter feed, was designed the HPS process (Hydrib Pelletized Sinter). In this process, the bonding is the lime. After the started operation with HPS process, the outlet dust emission from primary mixer was increased. ArcelorMittal signed the agreement with Environmental Control Agency to solve this problem. And, the secondary ElectroStatic Precipitator (ESP) had a not good performance, below than expected. The original ESP had been upgraded.
ArcelorMittal Monlevade had the need to dedust its primary mixer's stack.
In its sinter production process – sinter is one of the raw materials for the production of pig iron – ArcelorMittal introduces lime as one of the components of this process, which is mixed in a large horizontal rotary cylinder mixer.
During the bidding process to solve this problem, ENFIL S.A. proposed this stack's dedusting as an additional point for the dust collection to be introduced in an electrostatic precipitator, without performance loss and with the promise of totally eliminating the presented problem. The proposed system must be guaranteed the maximum outlet dust emission of 50 mg/Nm^3-dry.
The installed electrostatic precipitator had the objective of collecting the particulate matter (PM) generated in dozens of dust emission points, such as transfers of belt conveyors, end of the sintering machine, screening area, top of the silos, sinter cooler etc. And, additionally, the collection of gases from the primary mixer.
The objective of this article is to present the implantation of this new system of secondary dedusting of ArcelorMittal's Sinter Plant.

2 MATERIALS AND METHODS

The solution proposed by ENFIL anticipated the complete dedusting of the sinter handling area (commonly named secondary sintering dedusting) besides the addition of this point of the primary mixer's stack.
Concentrating on the primary mixer problem, the primary mixer and the sinter cooler conditions are as below:

Table 1- Input data

Plant Data		
Altitude	m	**650**
Local atmospheric pressure	Pa	**93,386**
Sinter Cooler		
Flow	m³/hr*wet	**16,000**
Gas temperature	°C	**340**
Gas pressure	mmAq	**-18**
Dust concentration	g/Nm³	**0.20**
Duct diameter	mm	**550**
Dust density	kg/m³	**1,500**
Primary Mixer		
Fow	m³/hr*wet	**48,634**
Gas temperature	°C	**48**
Duct diameter (outlet)	mm	**1.150**
Gas pressure	mmAq	**-2**
Dust density	kg/m³	**2,000**
Dust concentration	g/Nm³	**0.50**

The premises considered for the project were:

a.) primary mixer's dedusting: collection of the total gas flow (wet gas, 26% moisture, containing dust and lime);

b.) use of the heat generated by the sinter cooler for heating the primary mixer's gas;

c.) calculating of pressure drop and adaptation of the available negative pressure in the gases suction system.

The mass and thermal balance was elaborated.

When mixing the sinter cooler flow with the one from the mixer's outlet, the total mass flow is the sum of the two mass flows.

From these data, one may calculate the temperature of the mixture of the gas flows from the sinter cooler and from the mixer:

$$T_3 = \frac{\dot{m}_{ar1} T_1 c_{pcooler} + \dot{m}_{ar2} T_2 c_{pmix} + \dot{m}_{pó1} T_1 c_{p\,sinter} + \dot{m}_{pó2} T_2 c_{pcal}}{\dot{m}_{ar3} c_{p3} + \dot{m}_{pó1} c_{p\,sinter} + \dot{m}_{pó2} c_{pcal}} \quad [K] \qquad (1)$$

where:

T : temperature in K;

m: processing gas mass flow kg/h;

Cp: specific heat coefficient KJ/Kg. K;

From this mass and thermal balance, one may calculate the mixed gases final flow rate and its outlet temperature, as shown below.

Table 2 - Values calculated in the mass balance.

Existing Sinter Cooler		
Processing Gas Volume	m³/hr*wet	16000
Processing Gas Volume	m³/s	*4.444*
Processing Gas Volume	Nm³/s	*1.821*
Gas Temperature	K	*613.15*
Gas Pressure	mmAq	-18
Gas Pressure (abs)	Pa	*93210*
Dust Concentration	g/Nm³	0.2
Air Density (Actual)	kg/m³	*0.532*
Dust Density	kg/m³	1500
Duct Diameter	mm	550
Duct Velocity	m/s	*18.71*
Reynolds	-	*182234*
Processing Gas Mass (Dust)	kg/s	*0.00036427*
Processing Gas Mass (Air)	kg/s	*2.362*
Processing Gas Mass (Dust+Air)	kg/s	*2.363*

Primary Mixer		
Processing Gas Volume	m³/hr*wet	48634.31
Processing Gas Volume	m³/s	*13.510*
Processing Gas Volume	Nm³/s	*10.578*
Gas Temperature	K	*321.45*
Gas Pressure	mmAq	-1.8
Gas Pressure (abs)	Pa	*93369*
Dust Concentration	g/Am³	0.5
Air Density (Actual)	kg/m³	*1.016*
Dust Density	kg/m³	2.000
Duct Diameter	mm	2.000

Duct Velocity	m/s	*4.30*
Processing Gas Mass (Dust)	kg/s	*0.007*
Processing Gas Mass (Air)	kg/s	*13.720*
Processing Gas Mass (Dust+Air)	kg/s	*13.727*

Mixer Outlet (1+2)		
Processing Gas Volume	m³/hr*wet	*65933*
Processing Gas Volume	m³/s	*18.315*
Processing Gas Volume	Nm³/s	*12.400*
Gas Temperature	K	***367.94***
Gas Temperature	°C	*94.79*
Gas Pressure	mmAq	**-100**
Gas Pressure (abs)	Pa	*92405*
Air Density (Actual)	kg/m³	*0.8781*
Dust Concentration	g/Am³	*0.39*
Dust Concentration	g/Nm³	*0.57*
Duct Diameter	mm	1150
Duct Velocity	m/s	*17.63*
Reynolds	-	*849528*
Processing Gas Mass (Dust)	kg/s	*0.0071*
Processing Gas Mass (Air)	kg/s	*16.0826*
Processing Gas Mass (Dust+Air)	kg/s	*16.0897*

The most important point for consistence of the mixture data was to define the outlet temperature and the moisture of the mixed gases that would not impair the performance of the ESP and, also, would not cause undesired fouling in the ducts and inside the ESP.
Once the process conditions were defined and the calculation of this mass balance was concluded, it was possible to proceed with the constructive design of the gases mixture in the top of the primary mixer's stack..
Using the experience of mixture of fluids executed in coal fines injection systems for blast furnaces (PCI – Pulverized Coal Injection), Eng. Hideo Kimura, from ENFIL, idealized the gas mixing device as shown below:

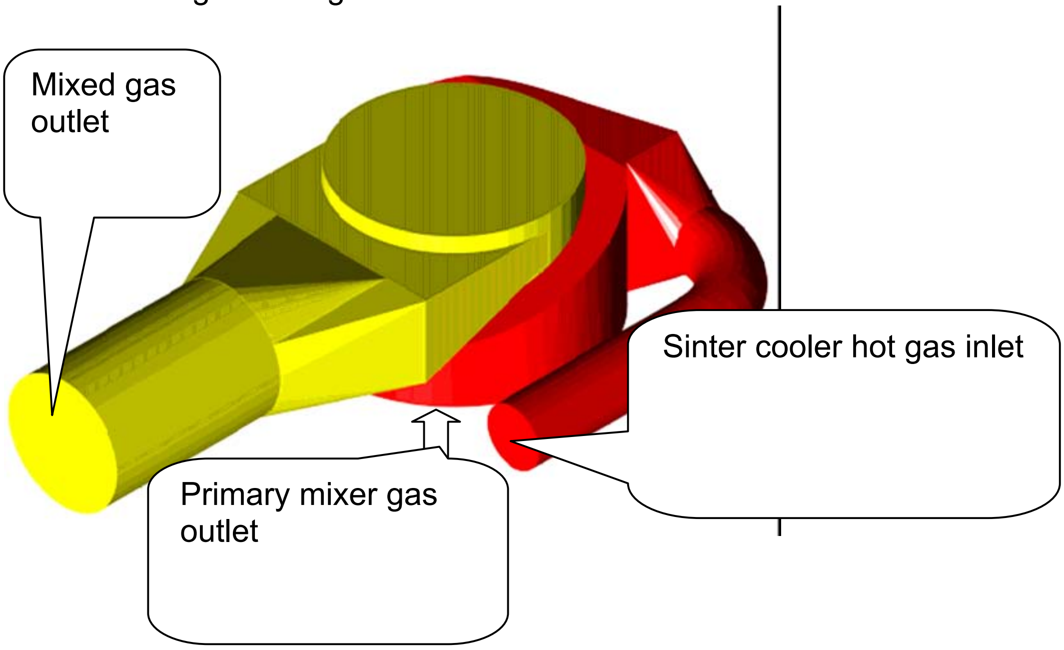


Figure 1: Gas mixing device

3 RESULTS AND DISCUSSION

The results achieved were the following:

a.) improvement of the area's environmental conditions: as the dedusting was performed, the total gas, originating from the primary mixer's stack was taken to the ESP's inlet duct that collected most of the particulate matter;

b.) cleaning work reduction in the stack's area: before the installation of the dedusting system, the mixer's stack had exhaustion by natural circulation and, therefore, the stack's top permanently demanded cleaning in its edge, access ladder and platform around,

c.) complete dedusting of the primary mixer's stack: This was the one of objectives and it was fully reached (Figure 2 shows the stack before the dedusting operation, figure 3 shows with dedusting device in operation and figure 4 shows the installation when it was finished);

Figure 2: Before the dedusting operation

Start-up information:

- ESP operation start-up date: Sept. 24, 2007.
- Mixer's stack and ESP interconnection date: Sept. 26, 2007.
- Interconnection time: 12:00 hs.
- Ambient temperature: 25°C.
- Weather: cloudy.
- Sintering production: normal load (5100t/day).

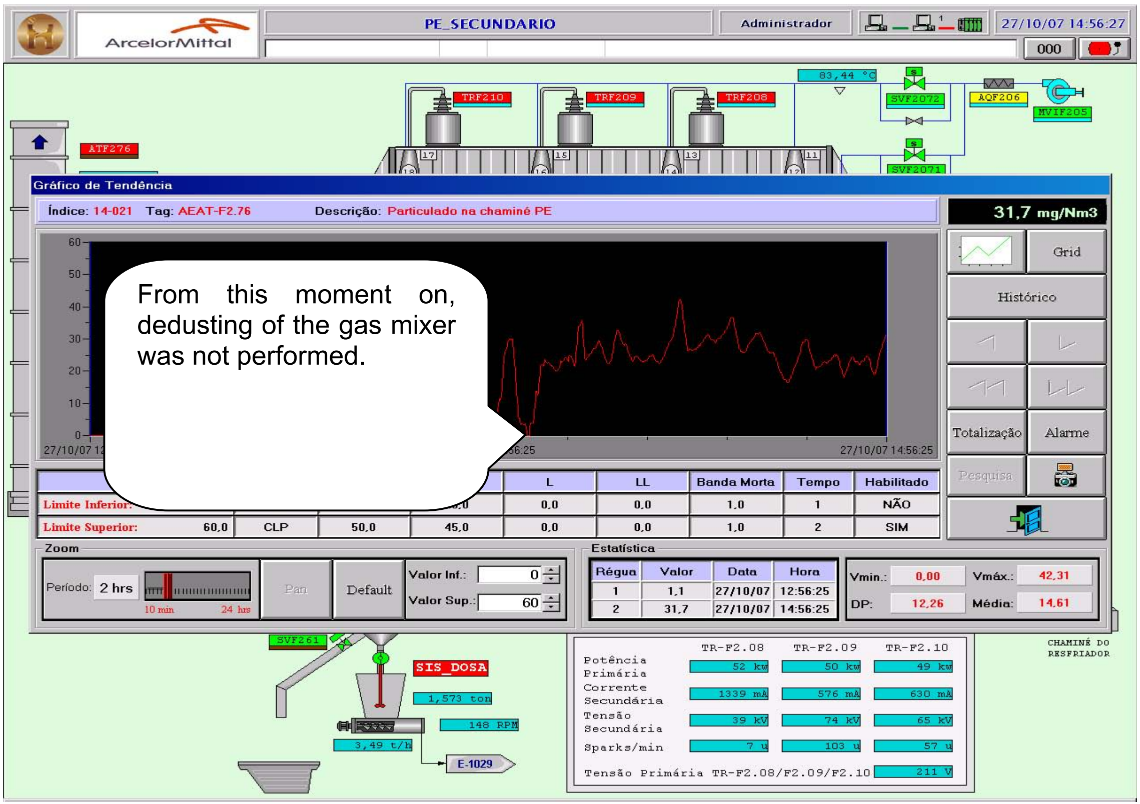
Figure 3: With dedusting device in operation

Figure 4: Concluded construction of the gas mixing device

d.) absence of leak emission close to the primary mixer: there were several slots, gaps close to the mixer, through which gas leak emission could be noticed. Due to the negative pressure of the system with the dedusting, the exhaustion was complete;

e.) use of the sinter heat (energy saving): usually, the sinter cooler gases are dissipated in the atmosphere. However, with the partial use of these hot gases (around 300°C), it was possible to use the heat to heat up and demoisture the mixer's gases;

f.) contribution for the improvement of the characteristics of dust collection, for the electrostatic precipitator: Despite the fact that the device's mixed gases flow represents only 10% of the total flow of the system, the increase of the gases moisture, combined with the introduction of lime dust, improved the characteristics of dust collection; in other words, the collected dust resistivity probably decreased and, hence, the electrostatic precipitator could collect the dust more easily.
It was possible to prove this fact during the performance test (measurement of particulate matter) in the electrostatic precipitator outlet, when introducing the primary mixer's gases and when removing them.
The particulate matter emission (indicated by the opacimeter) increased in the period in that the mixer was out of operation and returned to the normal levels, when the mixer operated again. Figure 5 shows the tendency during the tests.



g) the design data and the measured data of Mixer is shown below:

Table 3: Design data x measured data.

Data	Unit	Design	Measured after start of ESP
Mixed gas flow – duct conditions	m^3/h	65,933	30,201
Mixed gas flow	Nm^3/h	44,640	13,850
Mixed gas temperature	$^{\circ}C$	94.8	145.7
Particulate matter concentration in mixed gases	mg/Nm^3	570	2,328
Mixed gas moisture	% vol.	8	26.3

h.) the inlet and outlet dust concentration of ESP are shown in table 4 below:

Description	1st test	2nd test	3rd test	4th test	5th test
T (^{o}C)	77,4	70,6	71,5 (*)	66,3	67,5
Humidity (%)	3,25	2,41	4,05 (*)	2,18	3,01
Gás flow rate (m^3/h)	706.649	704.450	702.533 (*)	679.385	687.666
Inlet dust concentration (mg/Nm^3-dry)	**13.149,37**	**12.953,73**	**-----**	**12.712,96**	**10.721,80**
Outlet dust concentration (mg/Nm^3-dry)	**10,86**	**13,45**	**9,87**	**9,04**	**9,58**

4 CONCLUSION

Starting from ArcelorMittal Monlevade's need – the primary mixer's stack dedusting – it was proposed the unique possible solution, but without previous references in Brazil. There are technical reports, in Japan, of use of the heat generated from the sintering material cooling in heat recovery boilers, but, in Brazil, in most Steel plants, the sinter cooler heat is simply lost in the atmosphere.
Besides reaching the main objective (outlet dust emission < 50 mg/Nm^3-dry), the relevant facts of using the sinter cooler heat and improvement of precipitability conditions of the gaseous flow containing dust made this project to be a technical success of performance. It can contribute a lot to new applications that involve sintering plants in most of the steel plants.
The initial fear of the high moisture of the mixer's gases and the particulate matter generated in the mixture of water, lime and the primary mixer's dust did not come true and the project's results demonstrated that it was highly reliable, without risks and with excellent process and constructive performance. For such, studies and calculations were made necessary, allied to the dedusting systems experience of ENFIL.
And the most important resulted was achieved. The outlet dust concentration average was 11 mg/Nm^3-dry, below than 50 mg/Nm^3 (guaranteed value).
The new dedusting system is already operating for approximately seven months, with good efficiency since start-up of ESP.

With ArcelorMittal Monlevade's pioneer spirit of improving and respecting the environmental conditions, allied to the continuous improvement of its production process, it was possible to believe in the success of this project.

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REFERENCES

1 WHITE, F.M. Viscous fluid flow. New York: McGraw-Hill, 1991.
2 PATANKAR, S.V. Numerical heat transfer and fluid flow. New York: Hemisphere Pub. Corp.: McGraw-Hill, 1980.
3 Fluent v6.3.26 User´s Guide.