REDUCTION IN THE COKE-RATE AT CSN´S BLAST FURNACES BY DECREASING THE PULVERISED COAL MOISTURE CONTENT[1]

Ricardo Sebastião Nadur Motta [2]
Carlos Hilton Zanetti [3]
José de Souza Filho [4]
Alcides José Lucena Silva [5]
Valmir Soares de Carvalho [6]
Leandro Nonato Vianna [6]

Abstract

The Pulverised Coal Injection System – CSN´s PCI – comprises two grinding plants of indirect drying mineral coal, which utilise recirculation gases from the plant itself, aiming at better energy efficiency. Every coal grinding plant grinds about 66 t/h of raw material to produce around 60 t/h of pulverised coal with maximum of 2.2 % of final moisture. The raw coal moisture varies from 8 to 12 % in average, and the final product moisture varies from 1.5 to 2.2 %, depending on the season of the year, inherent moisture, coal hygroscope, amongst other factors. The hot gas generator, HGG, supplies gases for drying and grinding the coal in the roll mill. The less the moist is, the less the water introduction in the Blast Furnace will be, and better the coal combustion efficiency in lance will be. The introduction of the automatic control system for oxygen content in the plant carried out by Flap 5, and motorised positioning for the recirculation flow control valve, Flap 13, has improved both coal grinding plants. These two new loop controls along with its equipment, instruments and interlocks allowed the controlled suction of fresh air from the atmosphere, as well as the remote control of recirculation gas flow. The Flap 5 has got an intelligent pneumatic positioner, position transducer and new pressure transmitter, allowed the controlled introduction of fresh air in the grinding plants. The function of such fresh air is to dilute the steam contained in the recirculation gases, which are recycled for the grinding processes. Besides, a latest generation on-line pulverised coal moisture meter has been installed to adjust the grinding plant in order to obtain their best parameters for minimum moisture, complying with the granulometry. The two grinding loop controls made new operating functions possible, as well as a new knowledge for grinding parameterisation to obtain the lowest on-line moisture content for coal injection. The results obtained reduced the pulverised coal moisture down to the range of 0.6 to 1.2%, even during rain seasons. This meant the reduction of water introduction in Blast Furnaces 2 and 3 via pulverised coal injection, from around 3000 l/h down to 1000 l/h, making possible the decrease in coke-rate in approximately 3 kg/ton of pig iron.

Key words: Coal grinding plant; Pulverized coal; Moisture

[1] *Technical contribution to the 3rd International Meeting on Ironmaking, September 22 – 26, 2008, São Luís City – Maranhão State – Brazil*
[2] *Senior Development Engineer - GGAF/GMG;*
[3] *Specialist Engineer – GGAF/GMG*
[4] *Process Control Supervisor – GGAF/GMG;*
[5] *Development Technician - GGAF/GMG; and*
[6] *Process Control Technician - GGAF/GMG.*

1 INTRODUCTION

The coal grinding plant oxygen interlocking and the action over the auxiliary equipments is shown in the Bar graph 1. The Oxygen content acts in the grinding function and equipments as Figure 1 shows:

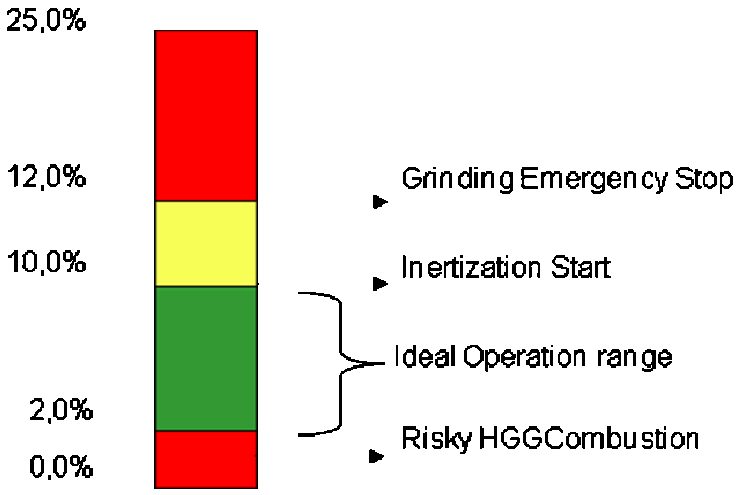


Figure 1 - Coal grinding plant interlocks as a function of its oxygen content

The coal grinding plant is composted of three main equipments: Roller Mill, Hot Gas Generator and the Bag Filter. The pulverised coal roll mill is one of the main equipment in a coal grinding plant is shown in the Figure 2:

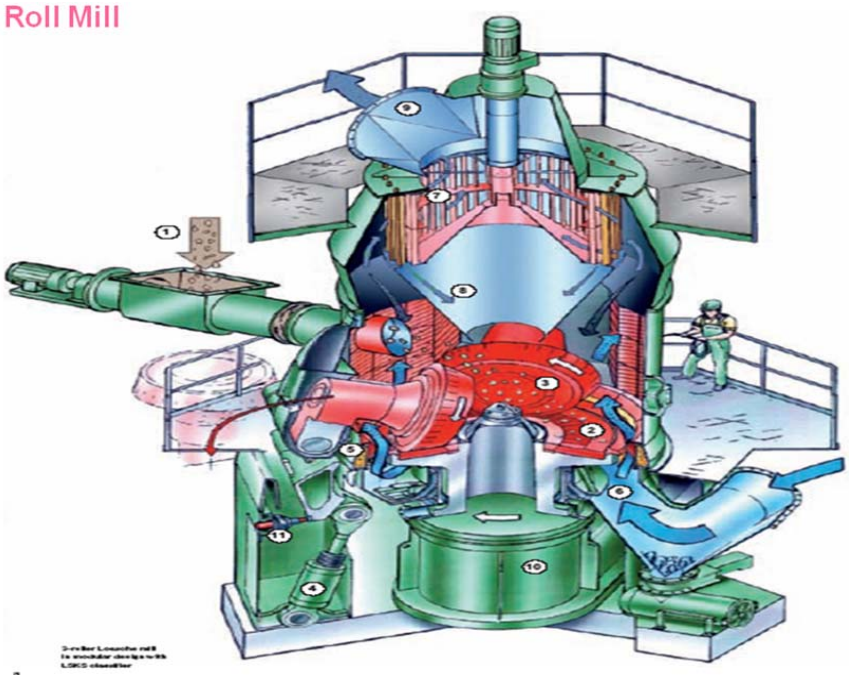


Figure 2 - Roller mill of a coal grinding plant

Figure 3 illustrates the screen of the coal grinding plant control process number 2 at CSN´s PCI. The two coal grinding plants are indirect firing plants with roller mills.

The roller mill is fed by two chain conveyors where you can mix low volatile with high volatile coals. In [1], there is a better description of this fed systems. The mill has got 3 rollers that are pressed against a rotary table. Its maker is Pfeiffer,

model MKS 2900, with grinding nominal capacity of 60 t/h (pulverised coal). This means that the mill can mill from 66 up to 75 t/h of raw coal depending on the Hardgrove index, coal humidity, Hot Gas Generator capacity, and Bag Filter removal capacity.

The HGG supplies the inertia hot gases for coal drying inside the mill. He burns Blast furnace gas and it possesses pilot flame of natural gas. In its exit, the mixture chamber allows the mix of recirculation gases with burned gases in way the homogenise the flow of the hot gases. In [2] has got larger information on its function and operation.

The Bag Filter located at the top of the grinding plant filters the powder of dusty gases that decays into the coal removal conveyors. The gases are sucks by the main fan main located after the bag filters. The main gas flow is controlled by a valve, Flap 2. Part of these gases goes to the main chimney and part is recirculated. That's why this kind of coal grinding plant is called indirect firing.

The recirculated flow part is controlled by Flap 13. As closer as better, because lower will be the pulverised coal humidity. However, more Blast furnace gas and electrical energy will be necessary and the energetic efficiency of the plant will decrease becoming the process very expensive and impossible to run.

The oxygen analyser measures the content after the bag filter in a range of 0 to 25%. The fresh air suction valve, Flap 5, allows the controlled entrance of air before the mill providing the decrease the humidity content after the mill by dilution of the steam after the mill. This reduces the pulverised coal humidity from about 2 to 1%.

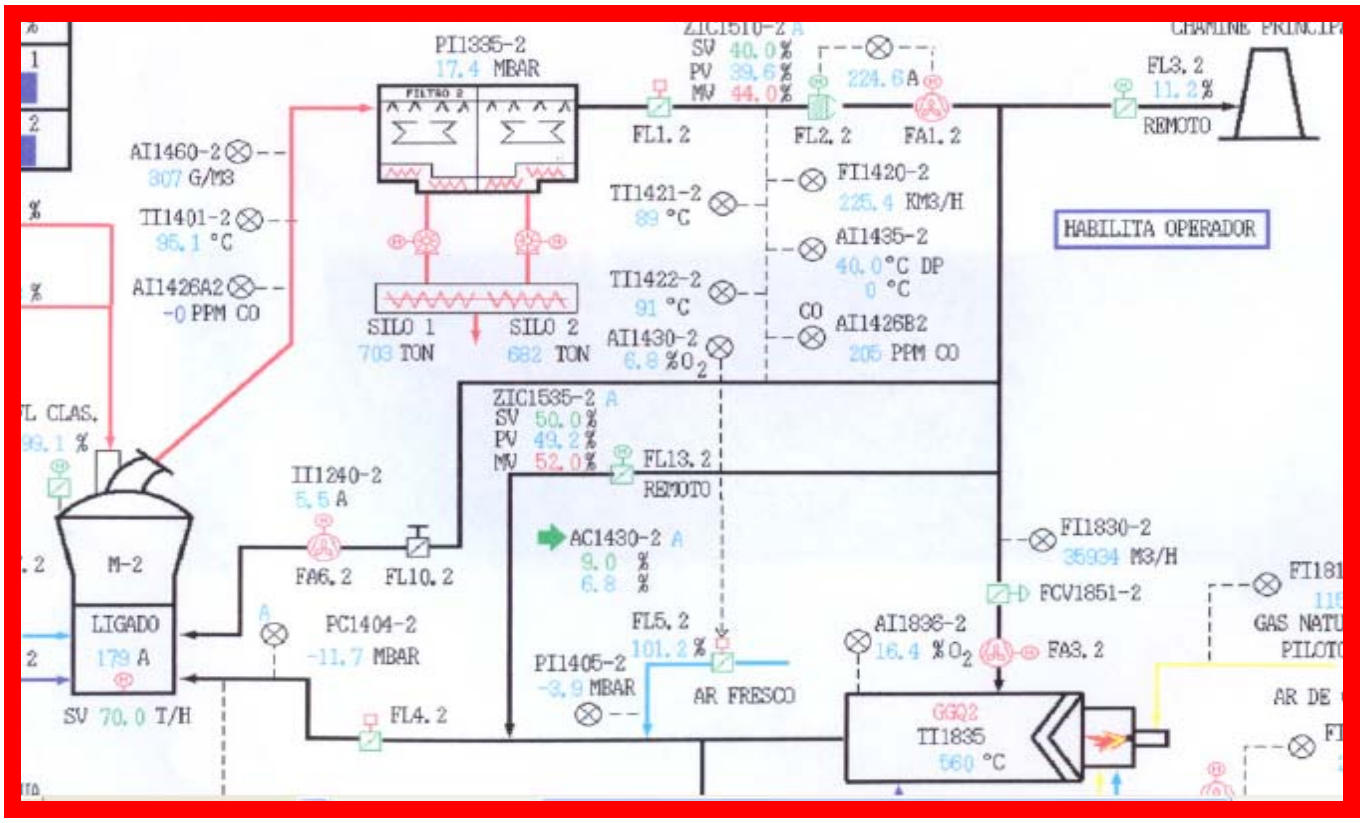


Figure 3 - Coal grinding plant 2 at CSN´s PCI

2 OBSERVATION OF THE PROBLEM

The data from the problem are:

- Coal Moisture content produced: from 1.8% to 2.2% above the coal grinding plant specification **(<1%);**
- High standard deviation of the coal moisture content produced;
- Fresh air Flap 5 not commissioned;
- Motorised actuator of Flap 13 for recirculation flow control not operating;
- Unawareness of the grinding settings and parameters as well as their effect in the pulverised coal moisture and granulometry produced.

2.1 Suction Fresh Air Control Flow Valve – Flap 5

The main gain and the advantages of the suction fresh air valve, Flap 5, are:

- Decrease of the roll mill temperature gradient;
- Decrease of the pulverised coal moisture produced, improving the final quality of the grinding product and diminishing the introduction of water into the blast furnace;
- Extension of the useful life of the pipelines and equipment due to the moisture and corrosion decrease.

The difficulties found to implantation the Flap 5 were:

- Lack of oxygen control, leading to grinding drops;
- Positive pressure at the suction point of fresh air by Flap 5.

2.2 Recirculation Control Flow Valve – Flap 13

The Recirculation control flow valve, Flap 13, controls the recirculation flow from 1/3 to 2/3 of the total flow though the bag filter. It controls whether the grinding is direct or indirect, i.e., whether the burn/drying is direct by the HGG or receives recirculation gas flow after the bag filter.

The more closed the Flap 13 is, the less moisture. However, there will be less ratio of kWh/t of coal produced, which means the reduction of the grinding process energetic efficiency, that is to say, more energy is spent to for production of the same amount of coal.

3 ANALYSIS OF THE PROBLEM

- High gas recirculation flow (Flap 13 totally open);
- Flap 13 motorised actuator under-dimensioned;
- Fresh air Flap 5 always closed and without defined control;
- Lack of suction pressure transmitter for safety interlocking and operation of Flap 5;
- Determination of the influence of the grinding settings and parameters in the pulverised coal moisture and granulometry produced.

4 COAL GRINDING PLANT PARAMETERS

The Table 1 shows the main coal grinding plant parameters and set-points and theirs influence in granulometry (Size distribution) and Pulverised coal moisture content.

Table 1 - Grinding plant parameters and theirs influence in granulometry and moisture.

Parameters	Setting Range	Granulometry	Moisture
Outlet mill temperature	95 to 100°C		x
Recirculation flow control Opening of Flap 13	30 to 60%		X
Oxygen control Opening of Flap5	7 to 9%		X
Opening of the classifier	0 to 100%	X	
Hydraulic mill pressure	70 bar	X	
Inlet mill pressure	-8 to -15 mBar	X	X
Main gas flow controller Opening of Flap 2	35 to 60%	X	X

5 MOISTURE CONTROL DEVELOPMENTS

The main actions to perfume the reduction in the moisture were:

- To position oxygen positioned and controller to perform fresh air gradual intake;
- To install suction pressure transmitter for safety interlocking of Flap 5;
- To implant remote control system for Flap 13;
- To reduce gas re-circulation, partially closing Flap 13;
- Specify, acquire and install last generation Rotork motorised actuator for Flap 13;
- Generate tables with moisture and granulometry results of the pulverised coal produced, due to grinding settings and parameters.

The main developments made in the two grinding plants to reduce the moisture content of pulverised coal were:

A - Installation of an oxygen Loop control with SP in 9%, allowing the maximum opening of suction fresh air, Flap 5. A PID controller has been implemented in the DCS, in which the PV is the gas analyser measurement and the MV is 4 to 20 mA to the Flap 5 pneumatic positioned;

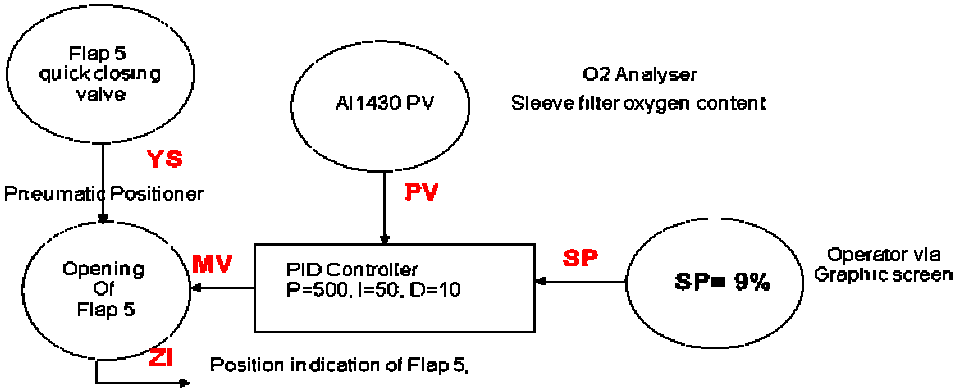
B - Installation of suction transmitter on Flap 5 entry to guarantee that there will not be expulsion of hot gases to the environment. Insertion of interlocking in the new control logics;

C - Lower of the roll mill inlet pressure from -5 to -12 mBar. That guaranteed the decrease of Flap 5 pressure from 0 mBar to -4 mBar, allowing the entry of fresh air;

D - Positioner Loop control for recirculation gas flow valve, Flap 13.

5.1 Oxygen Loop Control

The Oxygen Loop control for the opening of suction fresh air valve, Flap 5, is shown in the Figure 4 below:



***Legend: PV** = Process variable = oxygen content after the bag filter; **SP** = Aimed value for oxygen content in the coal grinding plant; **MV** = Manipulate variable = 4 to 20mA current value to Flap 5 pneumatic positioner; **ZI** = Flap 5 position transducer; **YS** = Flap 5 quick closing command.*

Figure 4 - Oxygen loop control for coal grinding plant

An Oxygen Loop control, tag **AC1430** (Figure 3), for the control of oxygen content in the coal grinding plant has been developed. The set-point choose for the oxygen controller was 9.0 % in order to allow the maximum entrance of fresh air. The control logics have been changed in order to action in the grinding plant, as Figure 5 shows below:

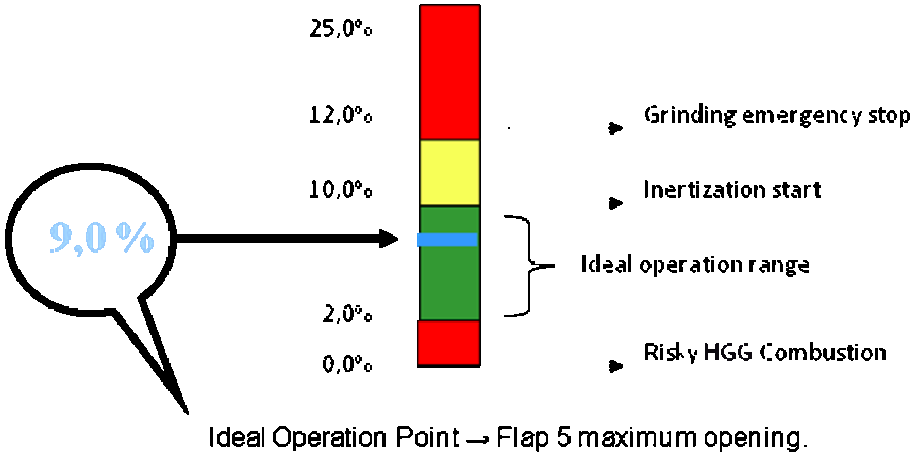


Figure 5 - Oxygen loop control for coal grinding plant

5.2 Suction Pressure Transmitter

A negative pressure transmitter, tag **PI-1405** (Figure 3), was installed in the inlet of the suction fresh air valve in order to avoid the hot gas flow going out of the grinding plant. Also, the mill inlet pressure had to be decreased from - 5 down to -12 mBar. The Figure 6 shows the installation:

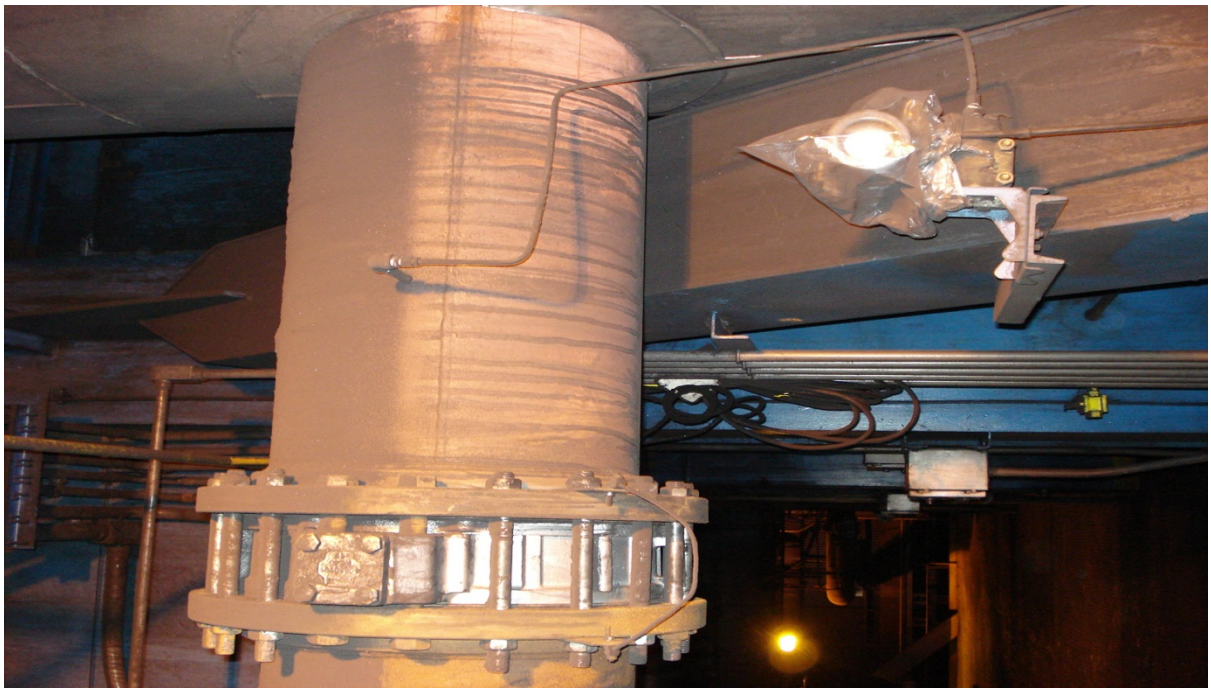


Figure 6 - Inlet suction pressure transmitter

The interlocks were made to maximise the security and to allow the safety operation of suction fresh air valve in action to the new negative pressure transmitter signal.

The Figure 7 shows how the interlocks for Flap 5 were implement in the Yokogawa DCS.

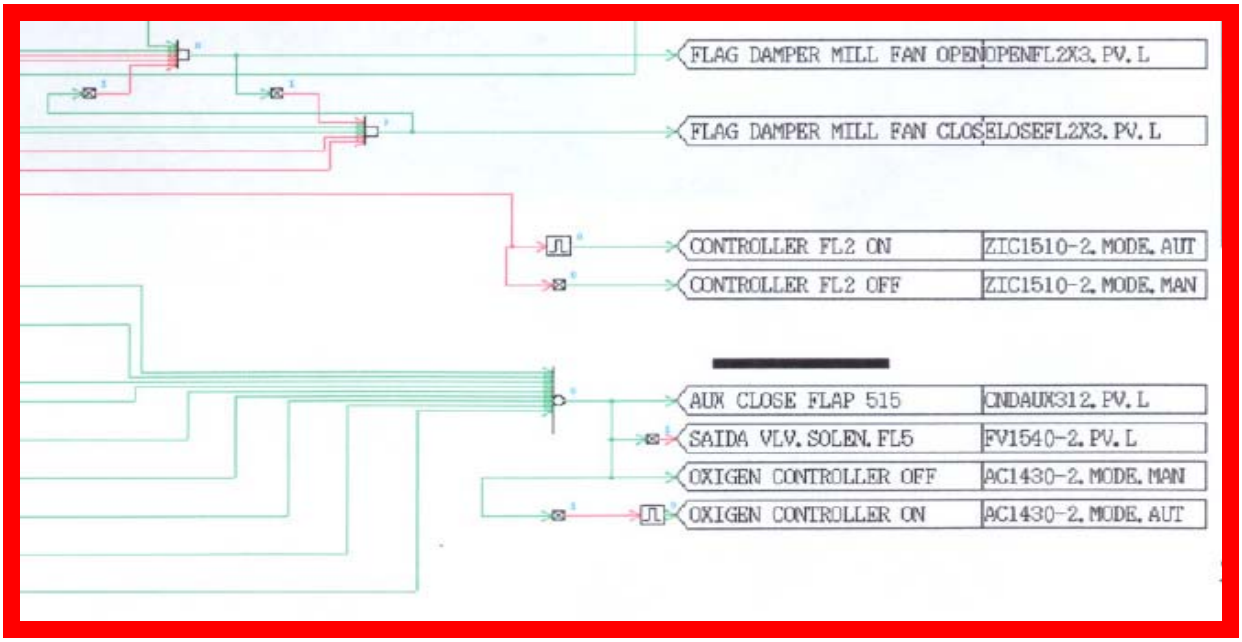
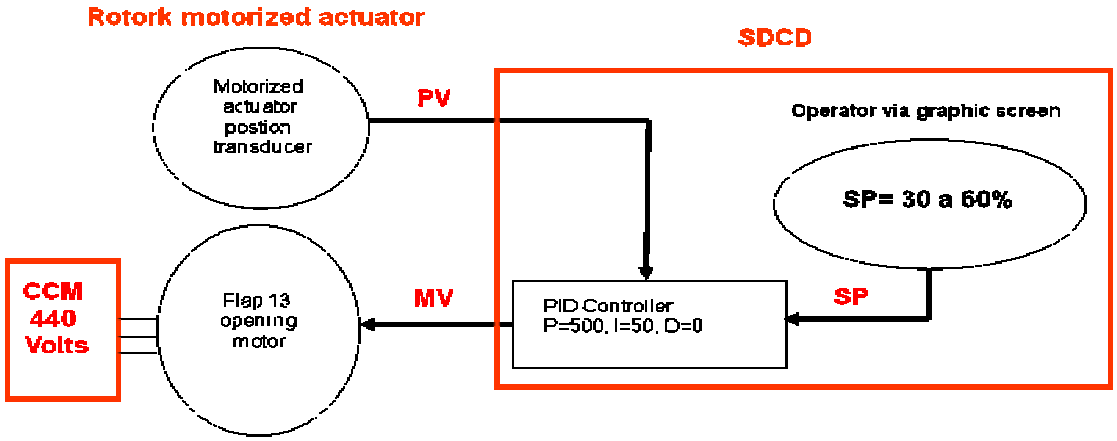


Figure 7 - Logics for suction fresh air valve safety operation

5.3 Recirculation Flow Control – Flap 13

- It was machined the bushing and the reducer for the new Rotork motorised actuator with appropriate opening torque for Flap 13;
- Installation of conduit and analogue cable route from control room to site, with 4 to 20mA command signal for adjustment of Flap 13 desired position;
- Implementation of PID Position Controller in the DCS to determine the operation position during grinding;
- Correction of #1 and 2 grinding control logics to close Flap 13 grinding stoppage, and open it during the start of the hot gas flow route.

The Flap 13 position Loop control, tag **ZIC1535-2** (Figure 3), works in order to control the coal grinding recirculation gases. The Figure 8 below show the block diagram for the Flap 13´s positioner controller implemented in the Yokogawa DCS (SDCD).



Legend: PV = *Process variable = current position of Flap 13;* ***SP =*** *Desired value for the position of Flap 13 (from 30 to 60%);* ***MV =*** *4 to 10mA current value to the Flap 13 positioner.*

Figure 8 - Position loop control for recirculation gas flow control valve

The mechanical installation of Flap 13 in the coal grinding plant is shown in the Figure 9:

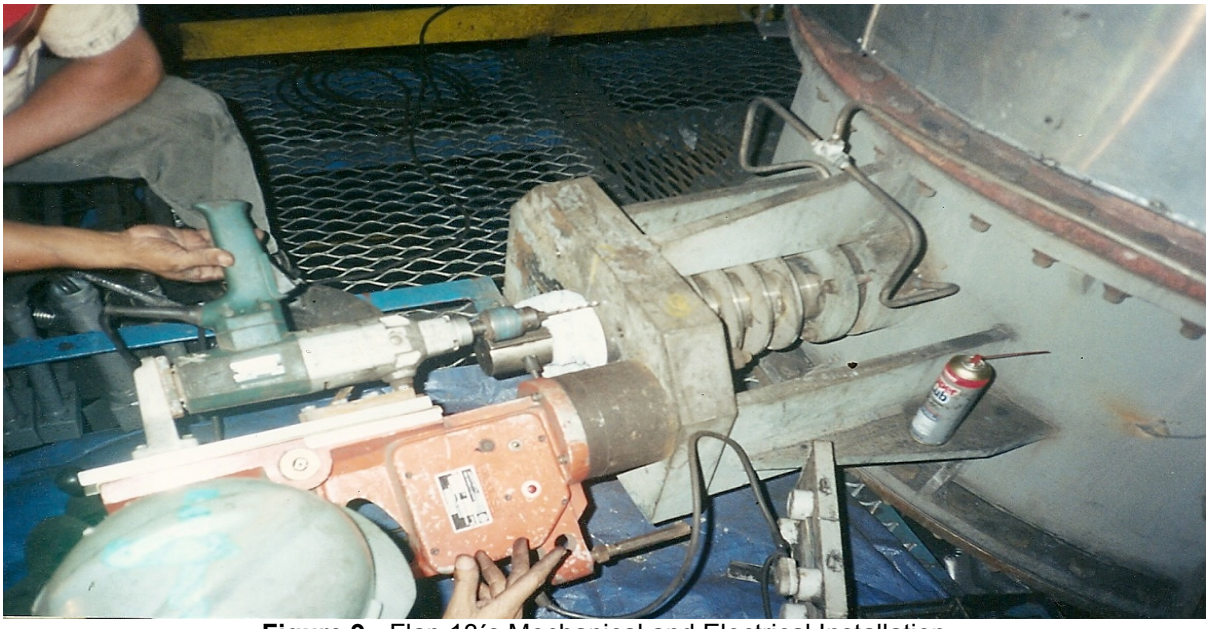


Figure 9 - Flap 13´s Mechanical and Electrical Installation

6 COAL MOISTURE ON-LINE CONTROL AND MEASUREMENT

The humidity depends on many grinding parameters. They have to be researched for the best set to produce the pulverised coal as drier as possible regarding also to the granulometry. It has to be as fine as possible with spending too much energy. Figure 10 shows a block diagram for the behaviour of the grinding plant in order to get a model. A new device to measure the humidity on-line at the outside of bag filter coal removal system is used for the validation.

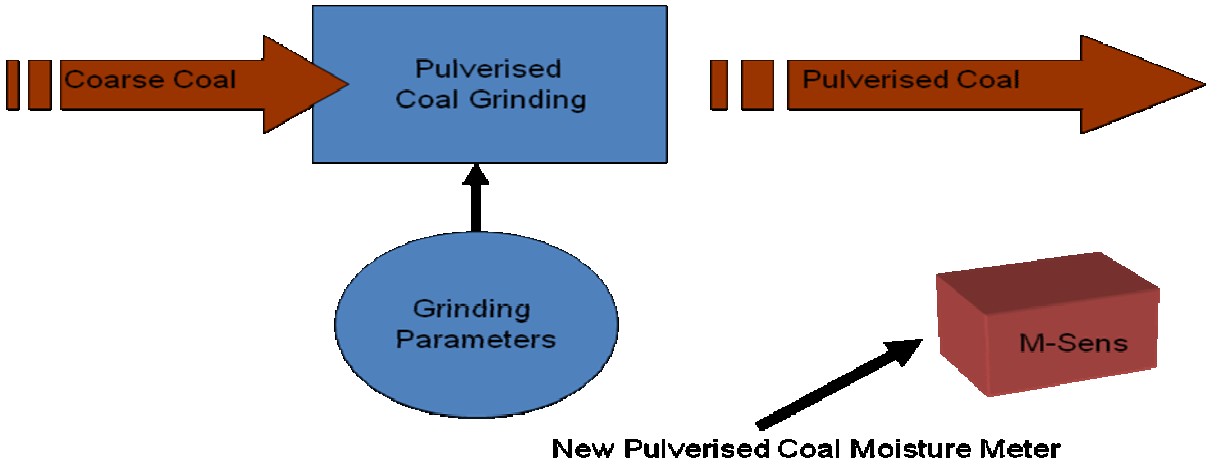


Figure 10 - Black box model for Humidity

Figure 11 below show the pulverised coal Moisture Measurement installed at the end of the coal grinding plant:

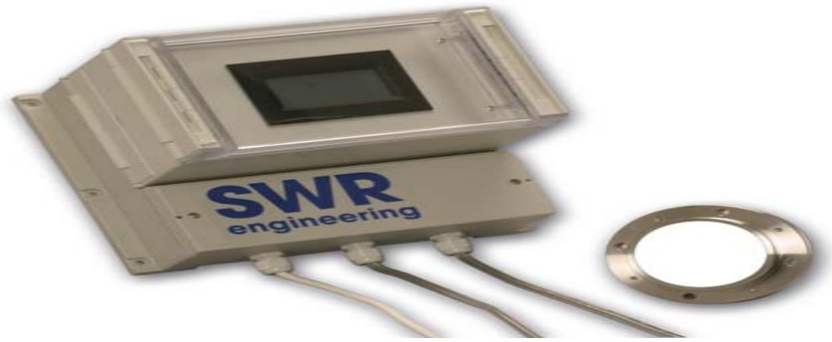


Figure 11 - Moisture measurement for pulverised coal

The model for the coal grinding plant can be obtained and the minimum humidity can be reached by the stochastic control and data measurement. Figure 12 shows the final knowledge obtained from the coal grinding plant parameters set model:

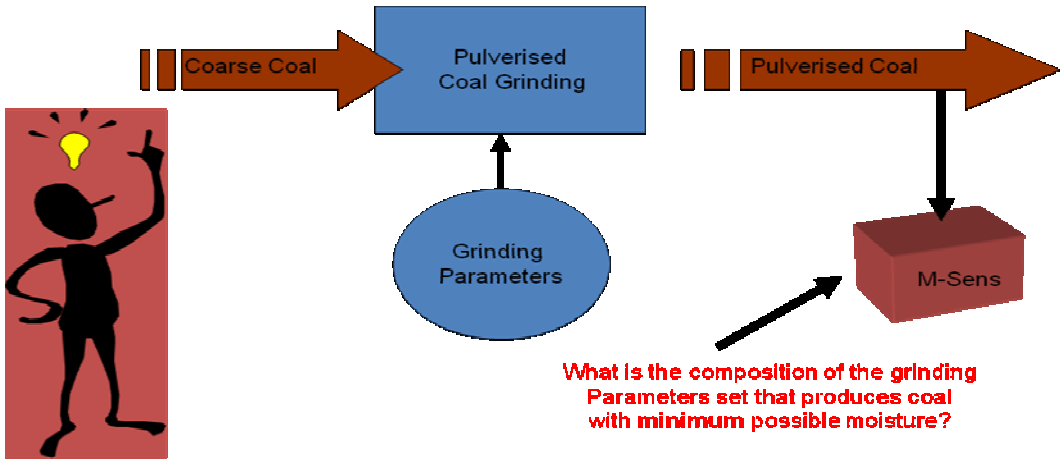


Figure 12 - Model for pulverised coal humidity and granulometry control

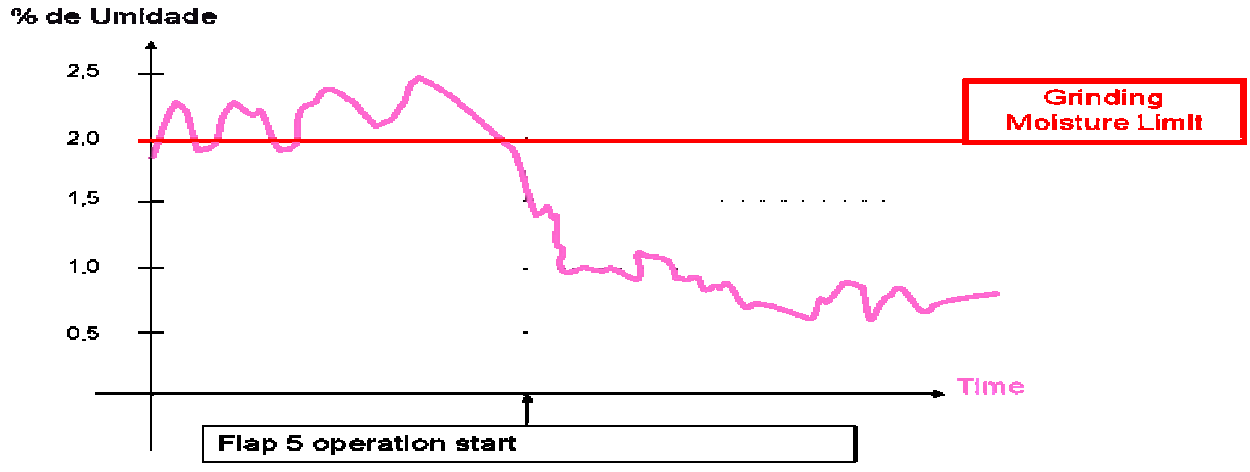
7 RESULTS

The main results of this work were:

- Reduction of moisture range from 1.8 ~ 2.2% down to 0.6 ~ 0.8%;
- Remote control and adjustment for Flap 13 via operator;
- Fresh air suction pressure measurement and interlocking < -2 mBar for Flap 5;
- Stable oxygen controller with fresh air Flap 5 totally open, i.e., at maximum dilution capacity;
- Development of operational or knowledge of grinding settings and parameters due to the on-line granulometry and moisture results.

7.1 Final Moisture Drop from 1.8 Down to 0.8%

The figure 13 shows how the humidity decreases after the commissioning of fresh air suction valve, Flap 5:

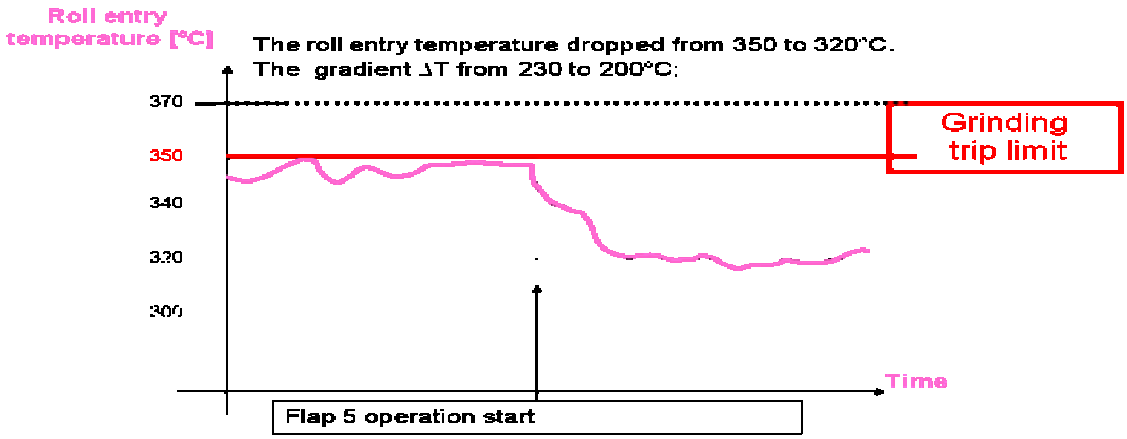


Graph 1 – Pulverized Coal Moisture with Flap 5.

Figure 13 - Humidity after fresh air suction valve opened

7.2 Gain in Safety Operation

The Figure 14 shows how the temperatures before the mill decrease after the commissioning of fresh air suction, Flap 5:



Graph 2 - Roll entry temperature with Flap 5.

Figure 14- Temperature before mill after fresh air suction valve opened

7.3 Graph of Coal Mix Moisture

The Figure 15 shows the actual values of the CSN´PCI coal grinding plants, lower than the 1% of the original specification. These results were obtained after the new two loop controls were commissioned: recirculation gas control for Flap 13 and the fresh air suction valve control via oxygen controller for Flap 5.

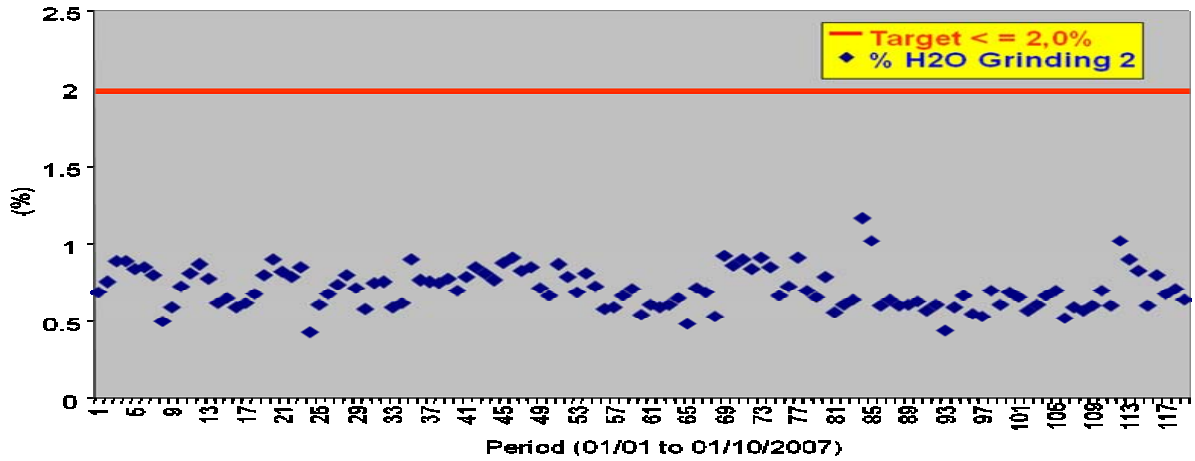


Figure 15 - Coal Humidity after loop control improvements

8 CONCLUSIONS

The Flaps 5 and 13 of Grindings 1 and 2 have been commissioned and the temperature at the roll mill inlet lowers 50°C, and kept away from the trip point of 350°C.

Increasing the temperature after the mill can reduce the pulverised coal moisture content but can also be dangerous for the bag filter.

The power to reduce the moisture by decreasing the gas recirculation flow and by the introduction of fresh air carried out by the grinding oxygen controller, has

shown to be efficient and functional lowering the humidity below 1%, and reducing the introduction of water into the Blast Furnaces.

REFERENCES

1 Motta R.S.N., Lopes S. J., Abrita, R. M., Silva A.J. L; “Malha de controle de moagem e dosagem de carvão pulverizado da CSN” 60° Congresso Anual da ABM – 25 a 28 de Julho de 2005 – Belo Horizonte - MG

2 Motta R.S.N., Figueira, R.B.; Silva A.J. L; “Desenvolvimento dos geradores de gás quente das moagens de carvão pulverizado da CSN” XXXVI Seminário de Redução de Minério de Ferro e Matérias Primas 12 a 15 de setembro de 2006 - Ouro Preto – MG