SUCCESSFUL UPGRADE OF THE PULVERISED COAL INJECTION FACILITY AT ARCELORMITTAL GENT, BELGIUM[1]

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Abstract

ArcelorMittal Gent is a maritime steel production facility and the furthermost integrated plant in the ArcelorMittal Group. Located in Belgium, Western Europe, AM Gent is employing 4.700 people with an annual production of 5 million tonnes of flat steel products for the automotive sector and for high-quality applications. Since June 2006 the steel production facility has been part of ArcelorMittal, the world's leading steel and mining company. ArcelorMittal is active in 60 countries and employs about 245.000 people worldwide. Nowadays AM Gent operates two Blast Furnaces providing a yearly hot metal production of 2.13 million tons for BF A and 1.95 million tons for BF B in 2012. These results have been achieved in combination with pulverised coal injection rates of up to 235 kg/t_{HM} resulting in coarse coke rates of down to 210 kg/t_{HM}. The technology to inject pulverised coal into both Blast Furnaces at Gent was initially introduced in 1987. The original design capacity of the grinding and drying plants as well as of the two pulverised coal injection facilities were determined to 30 t/h each. Nevertheless, pulverised coal preparation and injection capacities have continuously been upgraded ever since. Between 2008 and 2012 a third GAD plant was installed while implementing significant upgrades to the PCI system, thus aiming for injection rates up to 70 t/h for each Blast Furnace. This was achieved by upgrading the existing conveying hoppers, adding new conveying lines, replacing the injection lines and finally upgrading the complete system from static to dynamic distribution.

Key words: Pulverised coal injection; Dynamic distribution; Plant upgrade; Individual flow control.

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1 INTRODUCTION

Aiming for a continuous improvement in Blast furnace operation and efficiency, permanent considerations have been made in order to upgrade and modernise the pulverised coal injection (PCI) systems installed at ArcelorMittal Gent. The most previous upgrade provided by Paul Wurth S.A. included state-of-the-art technology allowing injection rates of about 235 kg/t_{HM} on both Blast Furnaces. One of the key factors resulting in this success was the replacement of the existing static distribution system in favour to a dynamic distribution comprising a Cabloc flow meter in combination with a GRITZKO® coal flow control valve in each individual injection line. The entire set of upgrades was executed during blast furnace operation which consequently led to a very tight time schedule.

1.1 History of PCI at AM Gent

AM Gent initially introduced PCI technology on BF A and BF B in 1987 in collaboration with Paul Wurth. Frequent upgrades and modernisation of the entire plants did finally lead to actual injection rates of more than 235 kg/t_{HM} on both Blast Furnaces. The table below briefly summarizes the major milestones of PCI history at AM Gent.

Table 1. Historical overview of the PCI installation

1986	Installation of two Paul Wurth PCI plants with two grinding and drying (GAD) facilities - Design capacity: 30 t/h each
1987	Start of PCI on BF A and BF B
1995-2003	Capacity upgrade of the GAD installations towards 56 t/h by increasing motor power and modifying the louvre rings of the vertical roller mills (Loesche) Increase of storage capacity by installing a third pulverised coal storage bin feeding the existing storage bins for BF A and BF B
2008	Installation of a second raw coal storage bin to allow coal blending
2008-2012	Capacity upgrade of conveying and injection rates to 70 t/h on both Blast Furnaces by - installing a second, larger conveying line - installing new injection lines - upgrading the PCI facilities from static to dynamic distribution - upgrading the existing conveying hoppers by installing new fluidising compartments - upgrading the global flow control by installing Cabloc flow meters and a GRITZKO® flow control valve in the conveying lines - installation of a third GAD plant

1.2 Blast Furnace Key Data

Table 2. Design features of BF A & BF B

	BF A	**BF B**
Relining	June 2003	Dec 2001
Hearth diameter (m)	11,1	10,5
Inner volume (m³)	2.931	2.634
Working volume (m³)	2.550	2.347
Hearth volume (m³)	715	508
Hearth volume / Working volume	0,28	0,22
Number of tuyeres	28	27
Tapholes / Taphole angle	2 / 15°	
Max. blast temperature (°C)	1.200	
Charging equipment	Skip / Paul Wurth Bell-Less Top®	
Injection medium	Pulverised coal	
Hot blast pressure / Top pressure	max. 3,2 bar g / 1,6 bar g	

2 MATERIALS AND METHODS: DESCRIPTION OF THE MOST RECENT MODIFICATIONS

The time schedule below shows the major upgrades with the corresponding commissioning periods carried out during the most recent PCI upgrade phase from 2008 to 2012.

Table 3. Time schedule

	Realisation of commissioning
Second Conveying Line PCI BF A	April 2008
Second Conveying Line PCI BF B	January 2008
New Injection Lines New Distribution tower on PCI BF A	September 2010 – November 2010 December 2010
New Injection Lines New Distribution tower on PCI BF B	October 2010 – January 2011 February 2011
Upgrade of Conveying Hoppers for PCI BF A	April 2012
Upgrade of Conveying Hoppers for PCI BF B	February 2012

The principle flow sheet below shows the actual plant configuration for raw coal handling, GAD as well as the PCI facilities.

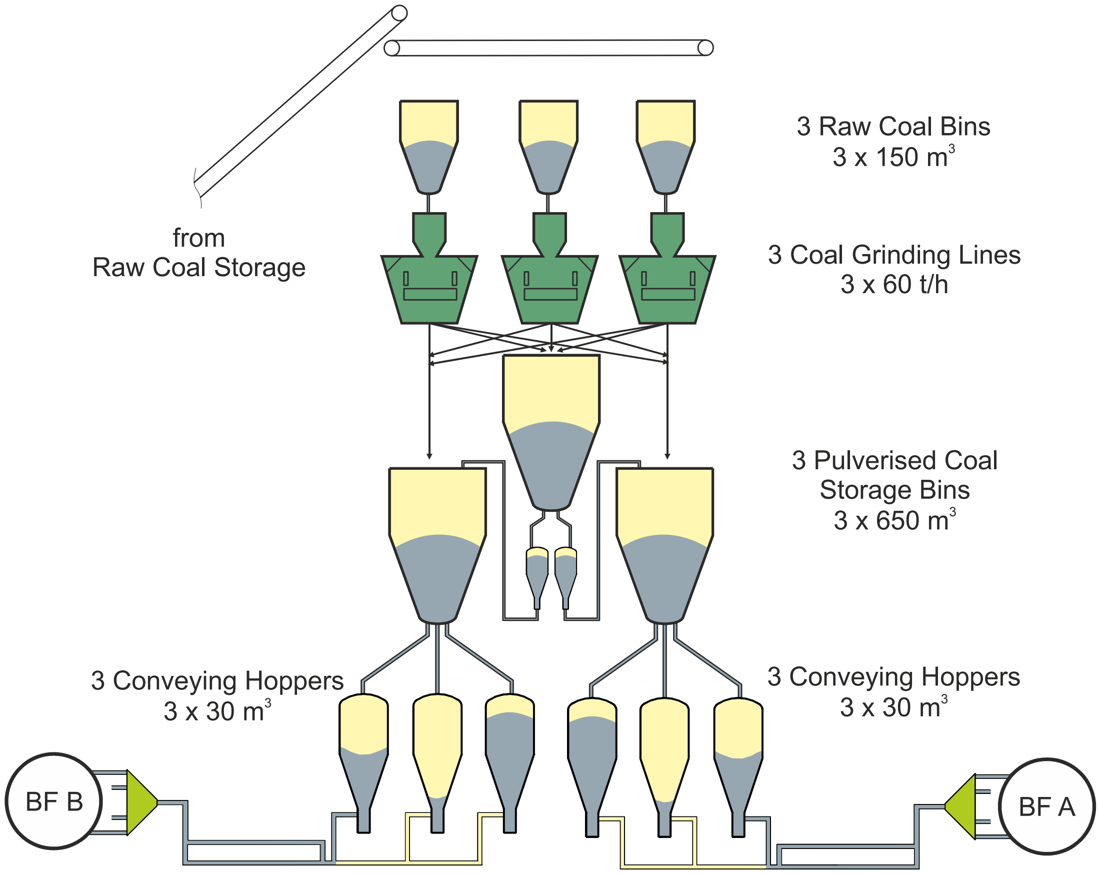

Figure 1. System Overview.

Table 4. Key Data of PCI for BF A & BF B

	BF A	**BF B**
Design Capacity	70 t/h	70 t/h
Conveying Hoppers	3	3
Special Features	Nitrogen recovery Scalping devices Dynamic distribution	
Transport gas	Nitrogen	
Fluidising chambers	DN 700	DN 700
Conveying lines	DN 80 DN 125	DN 80 DN 125
Global Injection flow rate control	Control is performed by means of Cabloc flow meter and a GRITZKO® flow control valve	
Injection lines	DN25 / 32	DN25 / 32
Distribution principle	Static splitter with dynamic distribution: Equal distribution is obtained by means of a Cabloc flow meter and a GRITZKO® flow control valve in serial installation in combination with a closed loop control in each injection line	
Accuracy of equal distribution of the global injection flow rate onto the injection lines	± 2,5 %	
Injection capacity	DN 80 => 45 t/h DN 125 => 70 t/h	DN 80 => 45 t/h DN 125 => 70 t/h
Nitrogen consumption [Nm³ / t_{PCI}] (with nitrogen recovery)	50-55	50-55

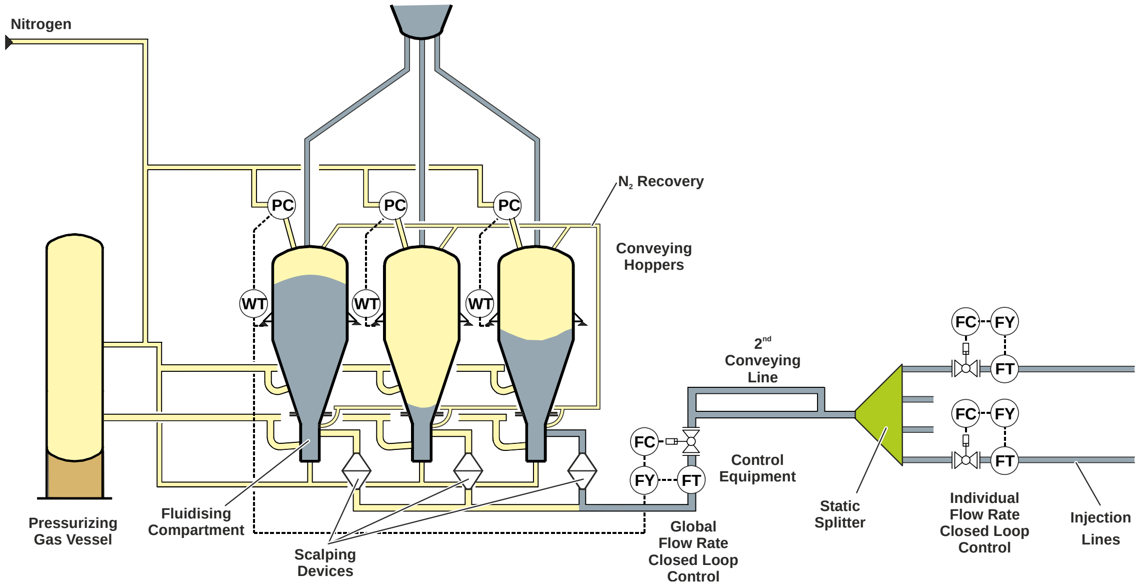

Figure 2. Conveying and Injection Plant.

The following chapter describes the different upgrades.

2.1 Second Conveying Line from the Conveying Hoppers to the Distribution Area

A new, bigger diameter conveying line from the conveying hoppers to the distribution tower has been installed in parallel to the existing conveying line, thus in order to increase conveying flow rate capacity.

2.2 New Injection Lines from the Distribution Area to the Blast Furnace

The entire set of injection lines has been replaced to provide for higher injection rates requiring injection piping of larger inner diameter. Using the dynamic distribution principle the design of the injection lines is essentially simplified since the need for injection lines of equal lengths is not existent anymore. Flow resistances inside the injection lines are roughly equalised by increasing the inner pipe diameter at different locations. The quality requirements related to the injection line design, routing, fabrication and installation are comparable to those applicable for common piping.

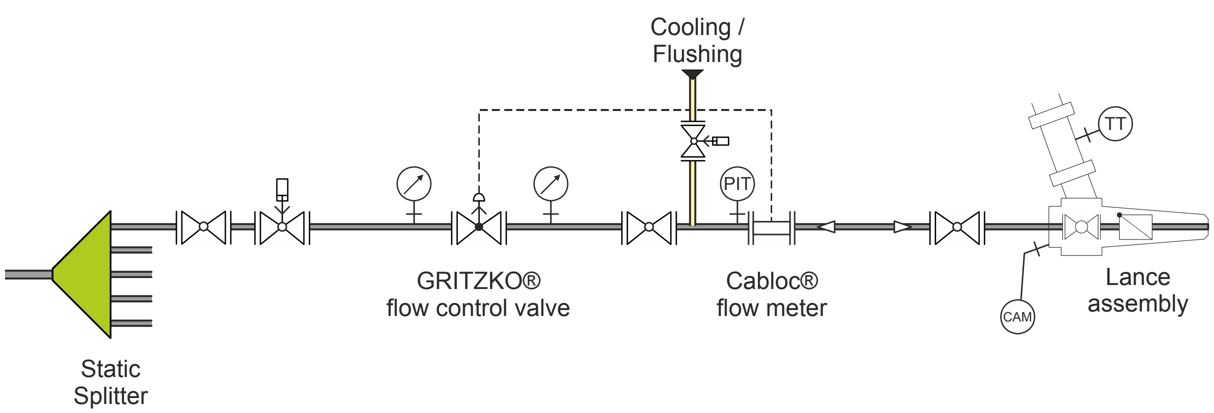

Figure 3. Injection Lines.

The injection lines have been replaced one by one during regular blast furnace operation.

2.3 New Distribution Device

A completely pre-assembled rack with the static splitter, the GRITZKO® flow control valves, the Cabloc flow meters and other process valves was shipped to the site by truck. Prior to that, the rack was completely assembled and tested in the workshop to avoid unexpected problems during commissioning, thus since time schedule for the complete transformation was tight. Due to the fact that the transition phase from the old to the new coal injection system asked for 'All coke blast furnace operation', the aim was to achieve the shortest possible shutdown time of the Pulverised Coal Injection Plant, thus resulting in an initial schedule for changeover of less than one week. Tasks to be executed included the entire removal of the former distribution equipment as well as the installation and connection of the new distribution rack, pressure testing and electrical commissioning of the new installation.
Re-commissioning of the BF A PCI distribution system took 150 hours in total. Fast subsequent progress in hot commissioning activities resulted in injection rates of 160 kg_{PCI}/t_{HM} after only 3 days. Based on the experience gained at BF A, the total downtime of the BF B PCI was reduced to 93 hours and allowed an injection rate of 180 kg_{PCI}/t_{HM} only 3 days later.

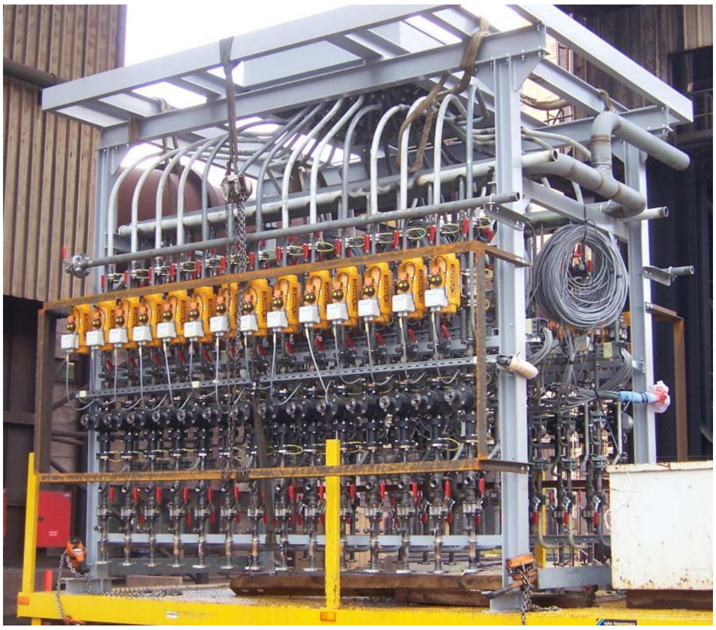

Figure 4. Pre-assembled rack.

2.4 Upgrade from Static to Dynamic Distribution

A static distribution system usually guarantees an equal distribution to an extent of maximum ± 5 %. Meanwhile the dynamic distribution system provides a guaranteed distribution accuracy of ± 2,5%.
The dynamic distribution system can also intentionally be set up to a non-uniform and non-equal distribution of coal to the blast furnace tuyeres. This effect can be useful for injection lances in the proximity of a tap hole, which might ask for a different heat input in this area. This can be achieved by applying different multiplication factors to the individual injection line set points.
A dynamic distribution system permanently monitors the coal flow distribution accuracy. An active closed-loop control balances any deviation (e.g. due to coal

deposits in the injection lines) and automatically adjusts the position of the GRITZKO® coal flow control valve.
Another benefit of the dynamic distribution system is the possible reduction of nitrogen consumption which is based on the reduced pressure drop over the GRITZKO® valve versus the otherwise installed coal tuyere. The GRITZKO® opening position is always adapted to the actual coal flow rate providing a constant pressure drop, which cannot be realised by means of static coal tuyeres.

2.5 GRITZKO® Flow Control Valves

The effectiveness of the control system largely depends on the installed flow control valves. In this project, Paul Wurth provided the heavy duty GRITZKO® valve design which has already been used in many other PCI facilities around the world. These special application valves with hard metal inserts are designed to withstand the abrasive pulverised coal flow. The opening position of the flow control valve can be varied by the control system in a large range. By rotating the metering segment, the opening position of the valve can be set from nearly closed to fully open. The conveying hopper pressure is automatically adapted in order to operate all the GRITZKO® valves (in the conveying line and the injection lines) in their optimal control range.

Figure 5. GRITZKO® flow control valve installed in the Conveying Line.

In case of eventual plugging of a GRITZKO® flow control valve installed in an individual injection line, the plug will simply be removed by completely opening the valve for a few seconds. The subsequently increased coal flow will convey the particle causing the plug to the Blast Furnace without interrupting coal injection in the concerned injection line. This consequently reduces the down times of the individual injection lines and thus the nitrogen consumption required for flushing and cooling the injection lances during these down times.

2.6 Global Injection Flow Rate Control in the PCI Plant

The control of the global pulverised coal flow rate transported to the Blast Furnace is performed by means of a Cabloc flow meter and a GRITZKO® flow control valve installed in the first section of the conveying line. The flow meter and the flow control valve are backed up by the weighing systems and the pressure control equipment of the conveying hoppers.

2.7 Upgraded Fluidising Compartments

When increasing the injection rates, the injection time per conveying hopper batch will automatically be reduced. Thus the preparation time (sum of depressurising, filling and pressurising sequences) of the hoppers has also to be reduced accordingly in order to match the injection time. Therefore, new fluidising compartments were installed with additional pressurising gas nozzles in order to reduce the conveying hopper pressurising time.
Furthermore, the new design improves fluidisation of the pulverised coal and thus guarantees a smooth and stable pneumatic transport. An additional benefit is the improved changeover from one conveying hopper to the next one with nearly no fluctuations in the conveying line.

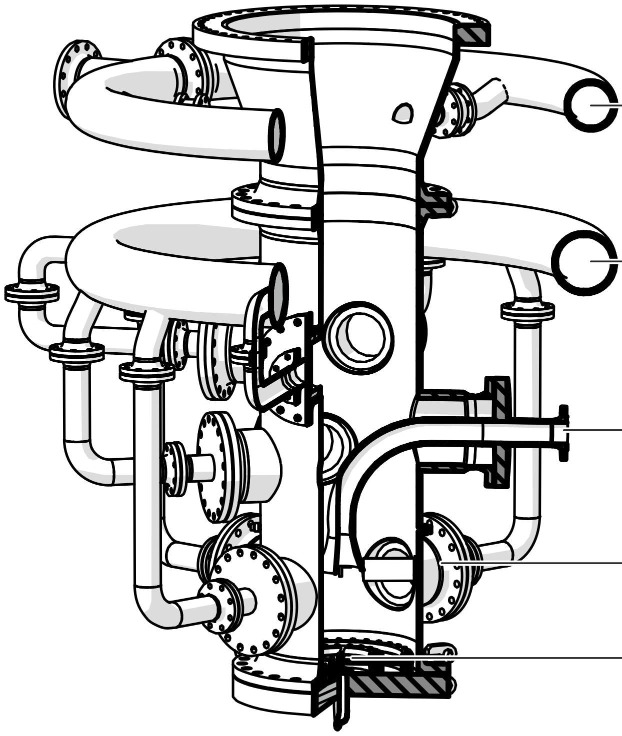

Figure 6. New Fluidising Compartment.

2.8 Modified Scalping Devices

To increase the availability of the injection lines, so called scalping devices have been installed downstream of each fluidising compartment and upstream of the common section of the conveying line. The pulverised coal leaving the fluidising compartment passes a scalping plate where the coarse material is trapped and removed from the pulverised coal. The scalping device’s aperture is defined by the smallest section in the injection line in order to reduce the risk of clogging.
The scalping devices are equipped with differential pressure measurements to monitor the level of possible clogging. If requested by the control system or the operator, the automatic back-flushing sequence will be launched after the completion of the injection cycle of a particular conveying hopper. The flushing gas is directed into a cyclone where it is separated from the coarse material. The coarse material

falls by gravity into a container, whereas the nitrogen will be returned to the pulverised coal storage bin.

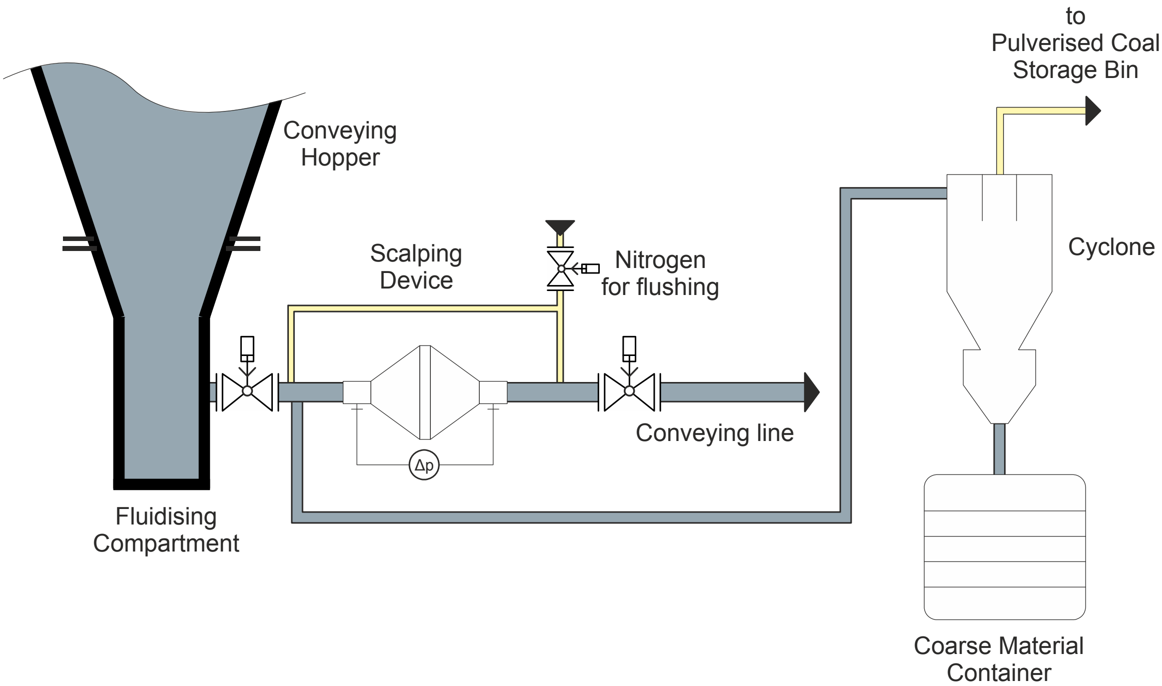

Figure 7. Scalping device.

This simple, cost-effective and proven system significantly reduces the risk of clogging phenomena in the injection lines. Compared to vibrating screens, scalping devices only require reduced space for installation, lower investment costs and significantly less maintenance. Furthermore, considerably smaller amounts of oversize material are to be expected due to the openings in a scalping device being significantly larger than the mesh of vibrating screens.

3 RESULTS AND DISCUSSION

By upgrading the plant from static to dynamic distribution, three major improvements have been achieved.

3.1 Higher Availability of the Injection Lines

Due to the fact that the GRITZKO® flow control valves show a significantly lower risk of clogging compared to static distribution devices, availability of the individual Injection Lines has considerably been improved. Figure 8 and 9 illustrate the differences in injection line availability.
Figure 8 shows the comparison between the upgraded PCI of BF A with the former PCI system of BF B for a period of 4 days.

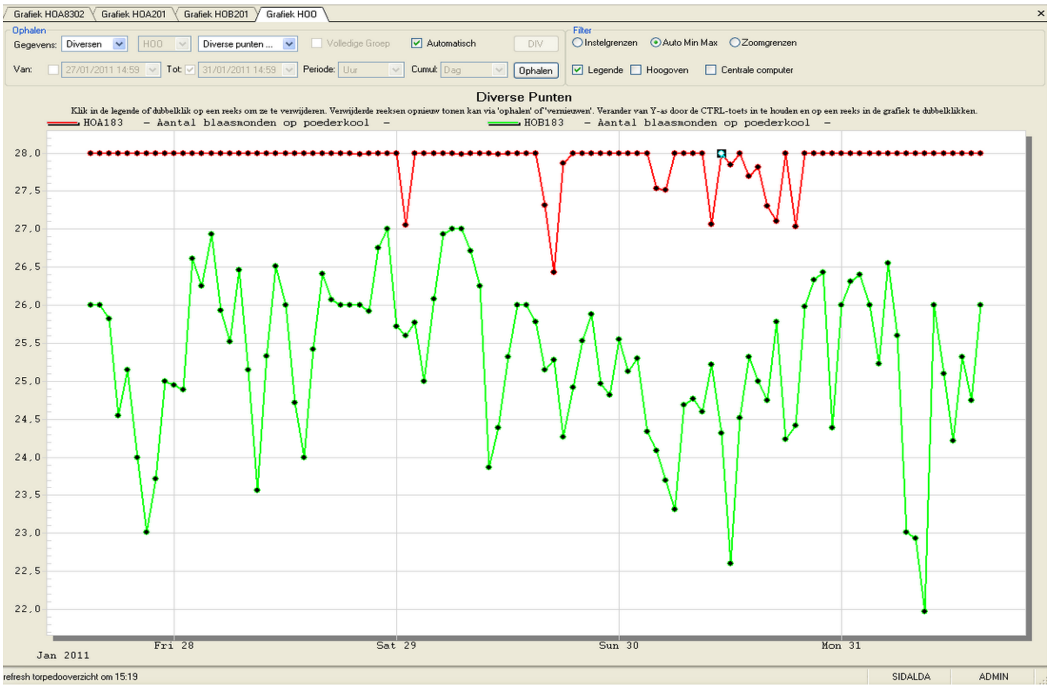

Figure 8. Comparison of lances in services between BF A (red line - new installation) and BF B (green line - old installation), number of lances on PCI hourly average.

The same phenomenon can be seen in figure 9, indicating the number of alarms generated by an injection line which switched from coal injection to nitrogen purging/cooling mode due to no coal flow detection. This number has considerably been reduced after the upgrades, especially when taking into account that the remaining alarms are mainly due to a preventive weekly change of all PCI lances or due to BF (maintenance) stops.

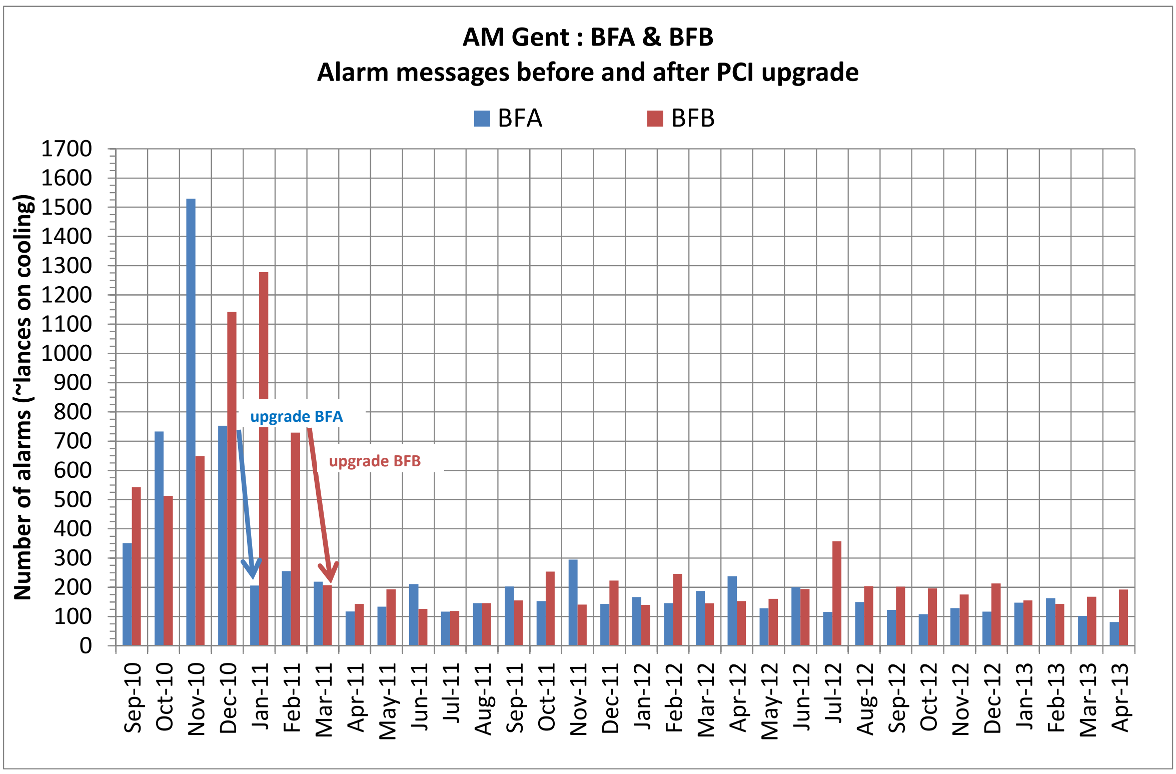

Figure 9. Number of Alarm messages before and after PCI upgrade (monthly total).

As a result, the operator of the installation benefits from:

- reduced down-times of the individual injection lines and virtually no interrupt of coal supply to the different hot blast tuyeres (positive influence on BF behaviour);
- reduced nitrogen consumption due to less purging / cooling;
- reduced manual intervention from operators.

3.2 Improved Accuracy on Equal Distribution and Global Flow

Figure 10 shows all injection lines in operation with the corresponding actual flow rates. The average deviation shows values virtually always below 1%, the guaranteed value being 2,5%. These results underline the perfect control characteristics of the GRITZKO® valves in combination with the Cabloc flow meters and the appropriate control loops implemented in the automation system.

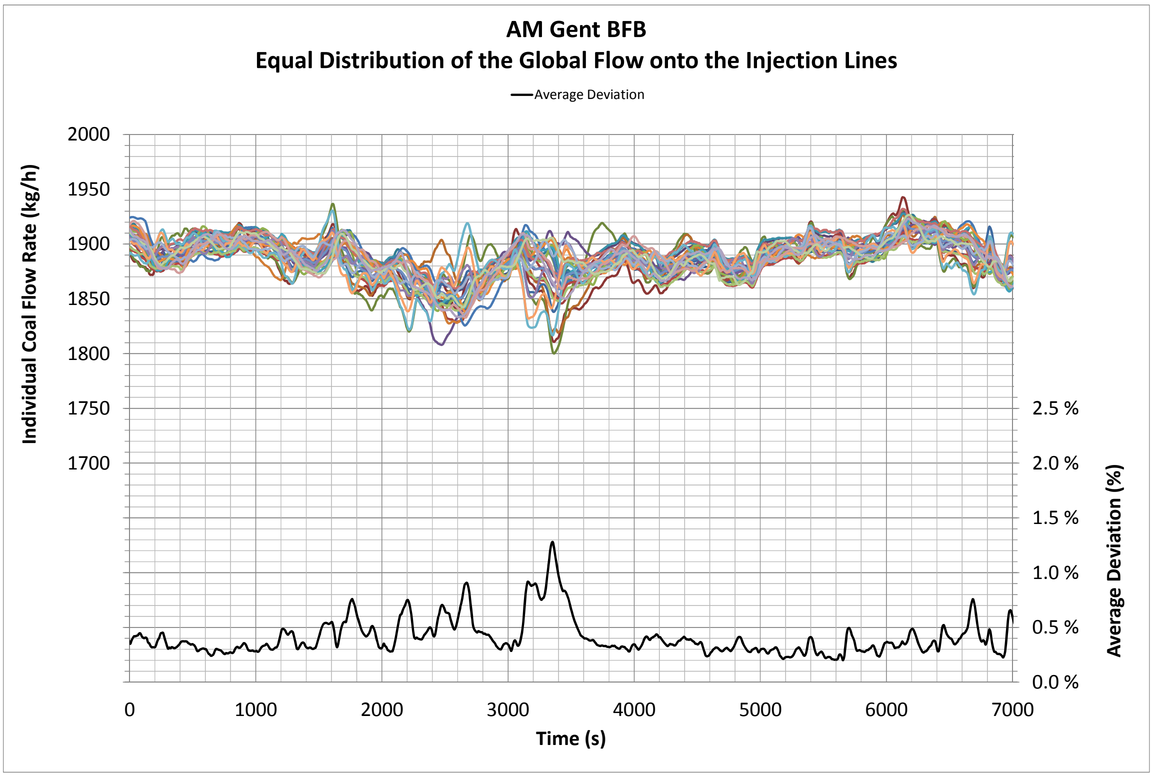

Figure 10. Equal Distribution of the Global Flow onto the Injection Lines.

The same can be stated for the comparison between the global coal flow rate set point and the related process value, as shown in Figure 11.

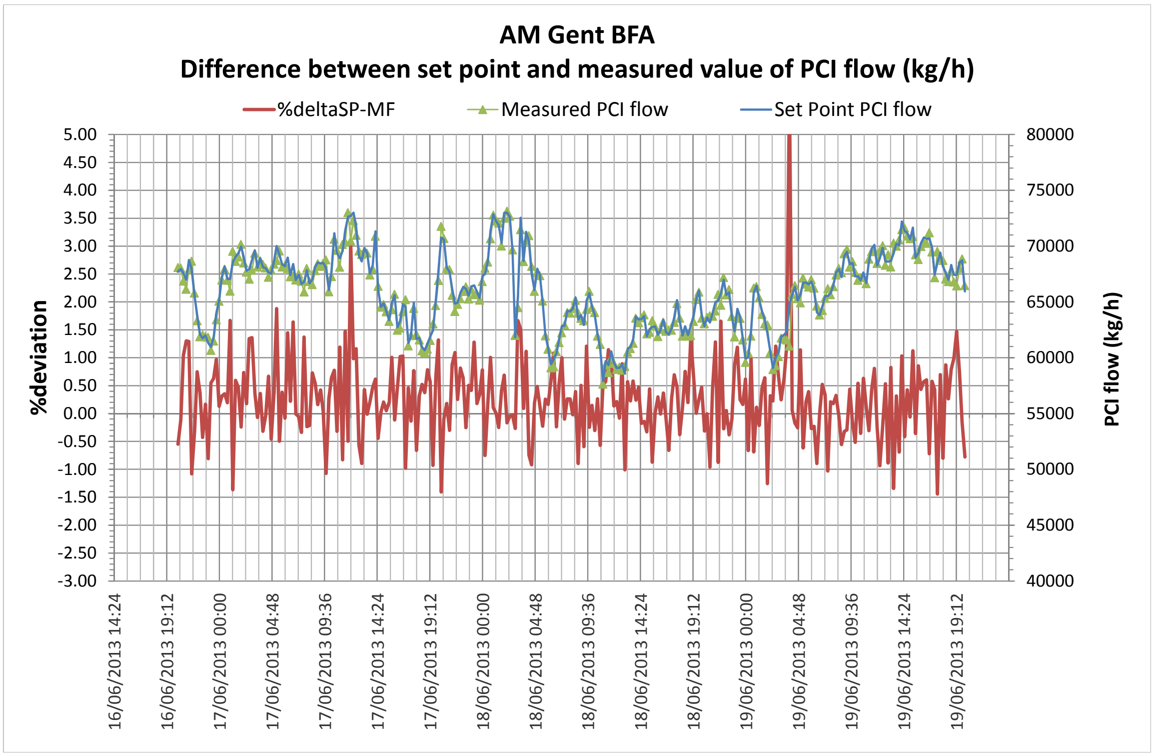

Figure 11. PCI flow comparison between set point and measured value.

3.3 Higher Injection Rates Due to Dynamic Distribution

Immediately after upgrading the PCI plants, AM Gent increased the pulverised coal injection rates on both Blast Furnaces towards the design capacities. As illustrated in figure 12, levels up to 234 kg/t_{HM} have been reached on monthly average, without giving in on total RAR.

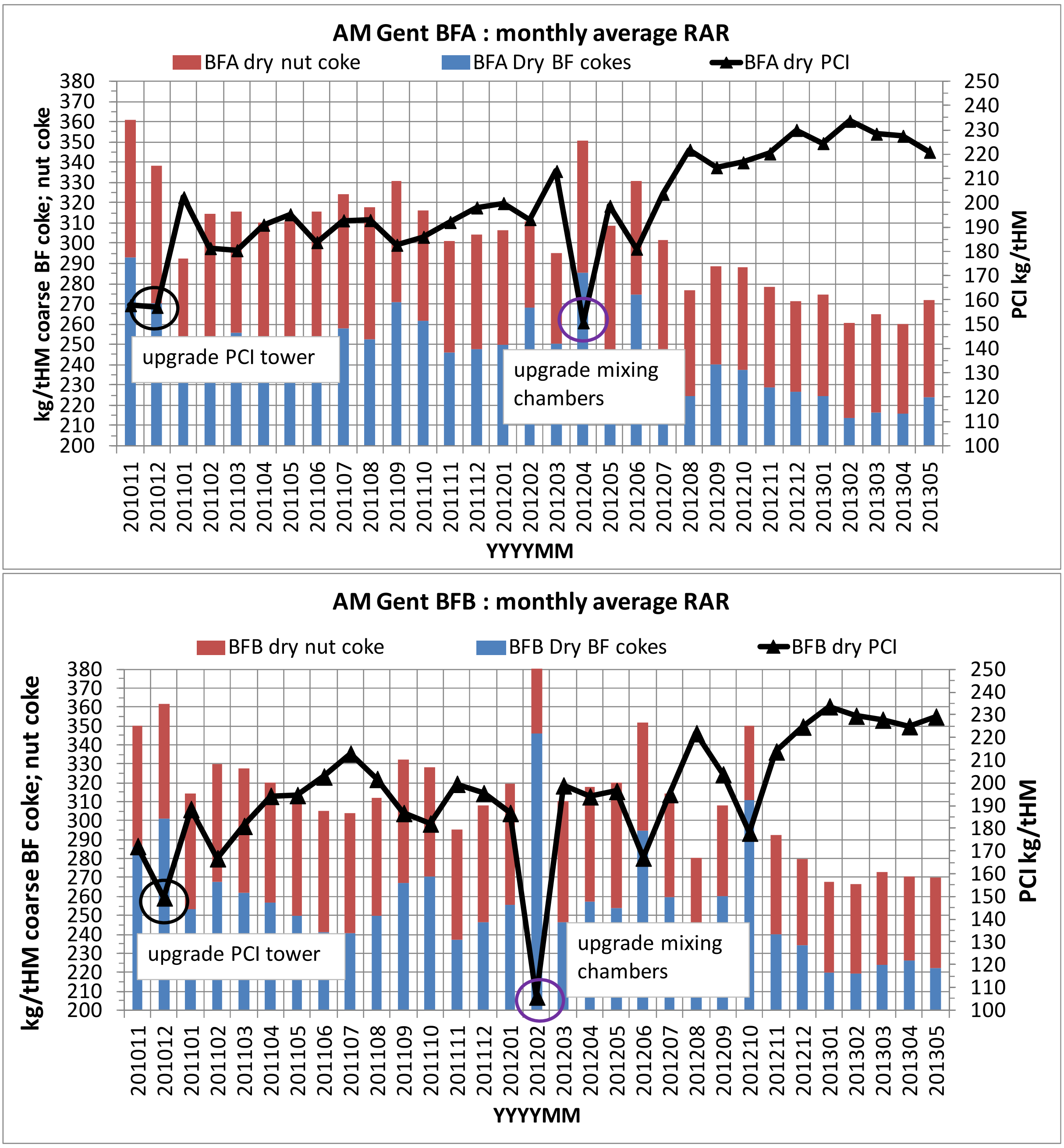

Figure 12. AM Gent BF A and BF B PCI rate, BF coke rate (monthly average).

4 CONCLUSION / SUMMARY

The dynamic distribution proved again to be one of the keys for high efficient blast furnace operation. High availability as well as accuracy on equal distribution below ± 2.5 % are only two of the advantages linked to the supplied Paul Wurth technology. In combination with dense phase conveying with low fluctuations and very accurate global flow control, high PCI injection rates above 220 kg/t_{HM} become state-of-the-art on new, as well as on existing Blast Furnaces.
Successfully upgrading PCI plants demand from the plant operators as well as from the technology supplier deep understanding of the technology, accurate time scheduling as well as a careful preparation of all the different project steps. At the end the operational and financial results easily justify the investment and confirm the decision for continuously improving PCI facilities.