



NEW ENHANCED PROVEN® A SNEAK PEEK INTO PRESSURE REGULATION OF COKE OVEN CHAMBERS FOR EMISSION CONTROL*

Wolfgang Kern¹
Philipp Dreis²
Martin Kirchmeier³
Natalie Hain⁴

Abstract

More and more coke oven plants worldwide face the task to improve their emission reduction at their coke oven batteries. In the 90's PROven® was invented and developed by DMT to regulate the inner pressure of a single coke oven chamber. Generally, most of the coke oven chambers can only close and open their connection to the collecting main but without the possibility to regulate the pressure during the carbonization time. Through the installation of PROven® the load on the coke oven door sealing system and the charging lids will be decreased and so does the emissions of crude COG as well. The current PROven® system, installed in the collecting main, does not only regulate the chamber pressure, it replaces the valve between the goose neck and the collecting main, too. This variable pressure control allows decreasing the leakages at the emissions sources to a minimum and allows operating the collecting main under optimum pressure. Subsequently, this will lead to enhanced emission reduction. PROven® proved its value with more than 2,100 units installed by licensee worldwide. Nevertheless, DMT is always focused on its client's needs and therefore enhance PROven® to provide the Best Available Technique (BAT). Among the main features of the now available system is the plain arrangement with a higher reliability and the possibility to install the system outside of the collecting main without modifying it. Hence, upgrading coke oven plants during operation is possible without any noticeable impact on the plant operation.

Keywords: Emission control; best available technique; coke oven chamber pressure; upgrading coke ovens

¹ Head of Sales at DMT GmbH & Co. KG, Essen, Germany.

² Sales Engineer at DMT GmbH & Co. KG, Essen, Germany.

³ M.Sc. (Mechanical Engineering) at DMT GmbH & Co. KG, Essen, Germany.

⁴ PhD Candidate (Fluid Mechanics) at DMT GmbH & Co. KG, Essen, Germany.

* Technical contribution to the 44th Ironmaking and Raw Materials Seminar, 15th Brazilian Symposium on Iron Ore and 2nd Brazilian Symposium on Agglomeration of Iron Ore, September 15th to 18th, 2014, Belo Horizonte, MG, Brazil.

Redução de Minério de Ferro & Tecnologia Mineral

Ironmaking and Mineral Technology

44th Seminário de Mineração em Minério de Ferro e Matéria-prima
15th Simpósio Brasileiro de Minério de Ferro
2nd Simpósio Brasileiro de Aglomeração de Minério de Ferro
44th Ironmaking and Raw Materials Seminar
15th Brazilian Symposium on Iron Ore
2nd Brazilian Symposium on Agglomeration of Iron Ore

Tema Central: Desafios para a mineração e siderurgia frente à nova realidade dos recursos de minério de ferro e carvão
Main Theme: Challenges for mining and steel making facing the current and future quality of the reserves of iron ore and coal



1 INTRODUCTION

Emission reduction at coke ovens is a task which is faced by most coke oven plants worldwide. Figure 1 shows emissions of a coke oven battery without improvements for emission reduction. Not only consistently stricter environmental rules force coke oven operators to minimize their emissions at their batteries, the awareness of their social and environmental responsibility leads to improvements by choice.

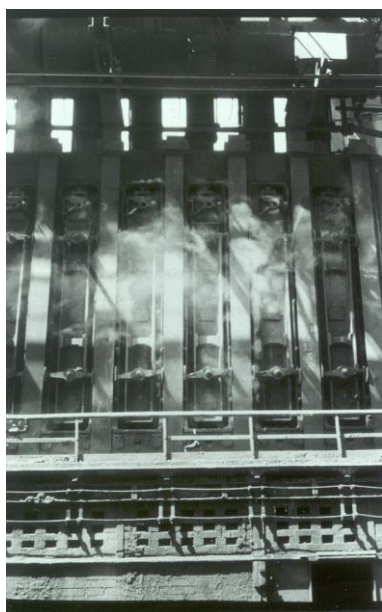


Figure 1 - Emissions without PROven



Figure 2 – Significant reduction of Emissions with PROven.

Since the 90's DMT is developing systems to support their clients to tackle those problems. One of these inventions is the PROven[®] (Pressure Regulated Oven) system. This PROven[®] system assures an adjustable but constant inner pressure of the coke oven chamber during the carbonization process. Via an adjustable water sealing system (installed inside the collecting main), the inner chamber pressure is controlled and will be maintained on a required level. Controlling the inner chamber pressure leads to a lower load on the emission sources (coke oven door sealing system and the charging lids) of an oven. Hence, leakages at those sources will be reduced to a minimum, which is shown in Figure 2. As can be seen, emissions of poly-aromatic hydrocarbons (PAH) will be significant lowered by installing PROven[®].

* Technical contribution to the 44th Ironmaking and Raw Materials Seminar, 15th Brazilian Symposium on Iron Ore and 2nd Brazilian Symposium on Agglomeration of Iron Ore, September 15th to 18th, 2014, Belo Horizonte, MG, Brazil.

Redução de Minério de Ferro & Tecnologia Mineral

Ironmaking and Mineral Technology

44th Ironmaking and Raw Materials Seminar
 15th Brazilian Symposium on Iron Ore
 2nd Brazilian Symposium on Agglomeration of Iron Ore

44th Ironmaking and Raw Materials Seminar
 15th Brazilian Symposium on Iron Ore
 2nd Brazilian Symposium on Agglomeration of Iron Ore

Theme Central: Desafios para a mineração e siderurgia frente à nova realidade dos recursos de minério de ferro e coque
 Main Theme: Challenges for mining and steel making facing the current and future quality of the reserves of iron ore and coal

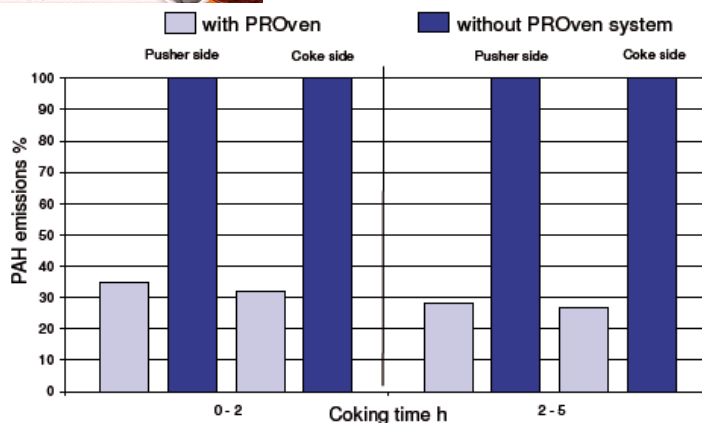


Figure 3 - PAH emissions at coke ovens with and without PROven.

As one of the main goals of DMT to provide Best Available Technique (BAT) to its customers, PROven[®] is enhanced in a steady process. The outcome of this enhancement is PROven[®] NG (PROven[®] Next Generation). The next generation of PROven[®] will be installed outside of the collecting main; hence, upgrading of existing coke ovens is possible during operation without modifying the collecting main. Another benefit of installing the system outside of the collecting main is the better accessibility for maintenance reasons. In addition the next generation is self-cleaning which leads to a reliable operation and decreasing maintenance efforts to a certain level.

2 PROven[®] - FIRST GENERATION

In the 90's DMT investigated emissions sources at coke ovens. As can be seen in Figure 4 the majority of emissions occur at the coke oven doors (~45-60%) and the charging lids (~10-20%). To reduce those emissions, DMT started a research program to develop a technical solution to individually regulate the pressure in a coke oven chamber. This development was named PROven[®] and allowed to successfully lower the load on the coke oven door sealing system and the charging lids to minimize the emissions at those sources.

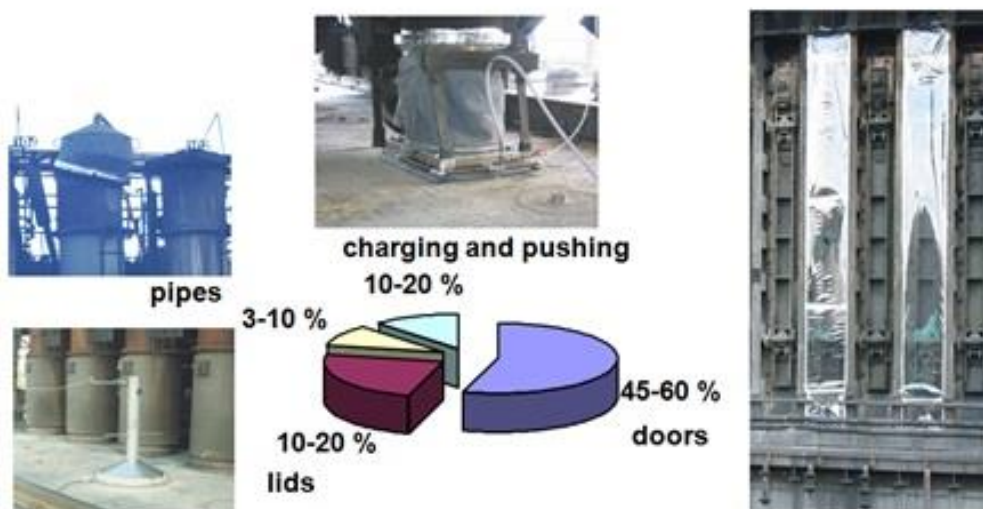


Figure 4 - Emissions at Coke Ovens

* Technical contribution to the 44th Ironmaking and Raw Materials Seminar, 15th Brazilian Symposium on Iron Ore and 2nd Brazilian Symposium on Agglomeration of Iron Ore, September 15th to 18th, 2014, Belo Horizonte, MG, Brazil.

Redução de Minério de Ferro & Tecnologia Mineral Ironmaking and Mineral Technology

44th Ironmaking and Raw Materials Seminar
15th Brazilian Symposium on Iron Ore
2nd Brazilian Symposium on Agglomeration of Iron Ore

44th Ironmaking and Raw Materials Seminar
15th Brazilian Symposium on Iron Ore
2nd Brazilian Symposium on Agglomeration of Iron Ore



The so called PROven[®] is working via an adjustable water seal. Compared to common systems, which can only connect and disconnect the oven to the collecting main, PROven[®] is able to regulate the pressure/gas flow during the whole coking process. Figure 5 shows the working principle of the control loop, which was successfully installed and tested at DMT's own laboratory (see Figure 6). Additionally the inner chamber pressure and the pressure of the collecting main are independent to each other and will be controlled separately. Hence, both systems, the oven chamber and the collecting main, can be operated under ideal pressure conditions.

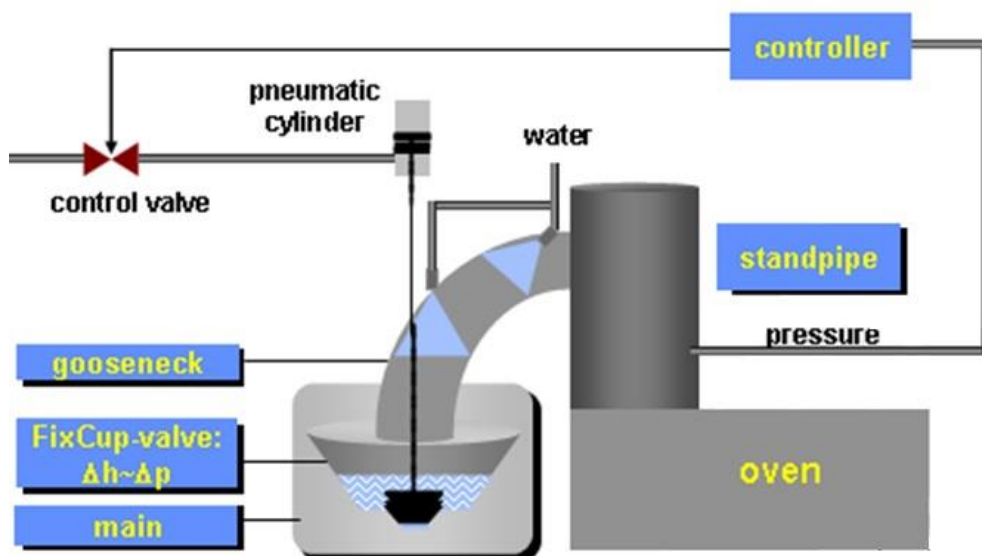


Figure 5 - Working principle of the control loop



Figure 6 - DMT Laboratory

The following figure (Figure 7) is showing the PROven[®] system under its workloads: charging, carbonization time and pushing.

* Technical contribution to the 44th Ironmaking and Raw Materials Seminar, 15th Brazilian Symposium on Iron Ore and 2nd Brazilian Symposium on Agglomeration of Iron Ore, September 15th to 18th, 2014, Belo Horizonte, MG, Brazil.

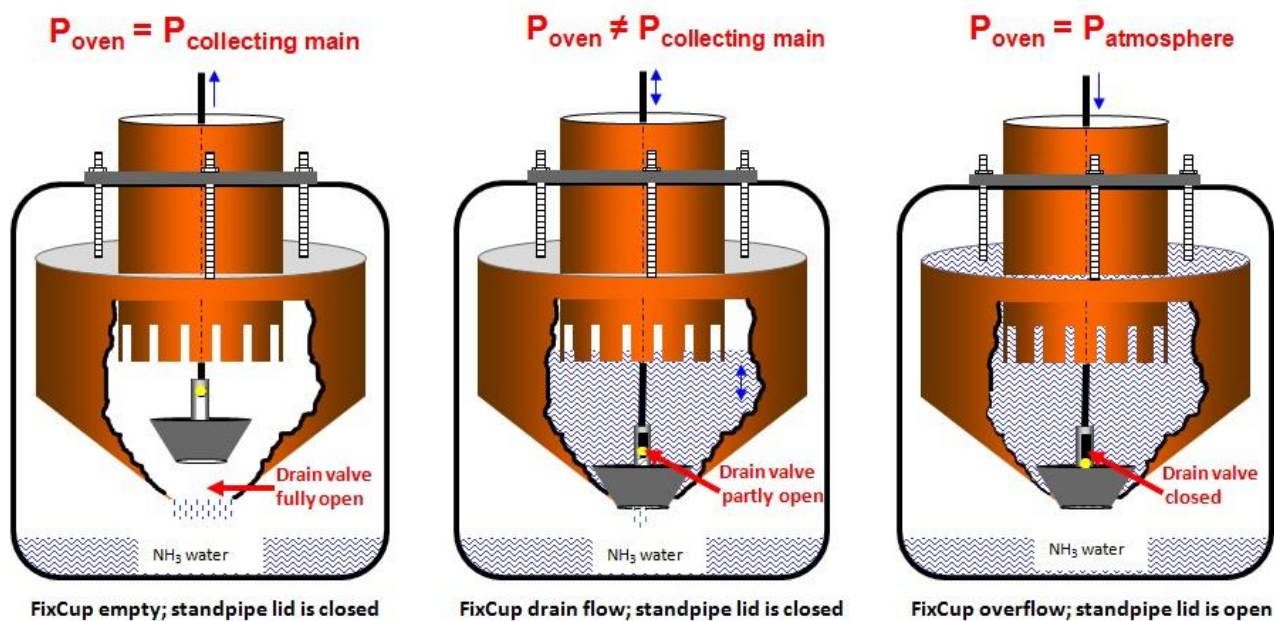
Redução de Minério de Ferro & Tecnologia Mineral

Ironmaking and Mineral Technology

44th Ironmaking and Raw Materials Seminar
 15th Brazilian Symposium on Iron Ore
 2nd Brazilian Symposium on Agglomeration of Iron Ore

44th Ironmaking and Raw Materials Seminar
 15th Brazilian Symposium on Iron Ore
 2nd Brazilian Symposium on Agglomeration of Iron Ore

Theme: Challenges for mining and steel making facing the current and future quality of the reserves of iron ore and coal



1. Charging (figure left hand side)

As can be seen in the figure above the drain valve of PROven[®] is fully open and not interfering, hence, all emissions during the charging process are directed into the collecting main.

2. Carbonization time (figure middle)

Whilst the carbonization time, PROven[®] is regulating the inner chamber pressure of the single coke oven. Controlling the pressure will be carried out via an adjustable water seal, which is controlled by the drain valve inside the fix cup. In this case the oven pressure is independent to the collecting main. Hence, over-/ low-pressure inside the oven will be avoided. This system allows controlling each coke oven chamber individually and independent from the collecting main.

3. Pushing (figure right hand side)

During the pushing procedure, PROven[®] will set the oven “off the main”. At this point the drain valve will be closed and the fix cup will be filled up to a maximum. The oven pressure is now equal to the atmospheric pressure and the crude COG goes through the standpipe.

3 PROven[®] NG – NEXT GENERATION

PROven[®] NG is the next generation of PROven[®] developed and enhanced by DMT. As like PROven[®] the main goal of PROven[®] NG is:

- To regulate the inner chamber pressure of each coke oven independently of the collecting main
 - To lower the load on coke oven doors and charging lids
 - Lowering emissions at coke ovens

In addition to those goals, PROven[®] NG also has the advantage and possibility to be installed outside of the collecting main, hence PROven[®] NG is better accessible and upgrading existing plants is possible during operation. Furthermore the plain design leads to a better availability of the system.

* Technical contribution to the 44th Ironmaking and Raw Materials Seminar, 15th Brazilian Symposium on Iron Ore and 2nd Brazilian Symposium on Agglomeration of Iron Ore, September 15th to 18th, 2014, Belo Horizonte, MG, Brazil.

Redução de Minério de Ferro & Tecnologia Mineral

Ironmaking and Mineral Technology

44th Seminário de Redução de Minério de Ferro e Materiais-primos
 15th Simpósio Brasileiro de Minério de Ferro
 2nd Simpósio Brasileiro de Aglomeração de Minério de Ferro
 44th Ironmaking and Raw Materials Seminar
 15th Brazilian Symposium on Iron Ore
 2nd Brazilian Symposium on Agglomeration of Iron Ore

Tema Central: Desafios para a mineração e siderurgia frente à nova realidade dos recursos de minério de ferro e coque
 Main Theme: Challenges for mining and steel making facing the current and future quality of the reserves of iron ore and coal



Summarizing, those goals are archived by:

- Installing PROven® NG outside of the collecting main (Figure 8)
 - Upgrading has no impact on operation
- New design of the “cup” (Figure 9)
 - Self-cleaning
 - Lower maintenance efforts

As can be seen on Figure 8 the next generation of PROven®, PROven® NG can be installed outside of the collecting main, only a spool-piece is necessary to upgrade existing plants (beside the PROven® NG system). Hence, no modification of the collecting main is necessary and the system can be installed during operation in addition a better accessibility for maintenance is another advantage.

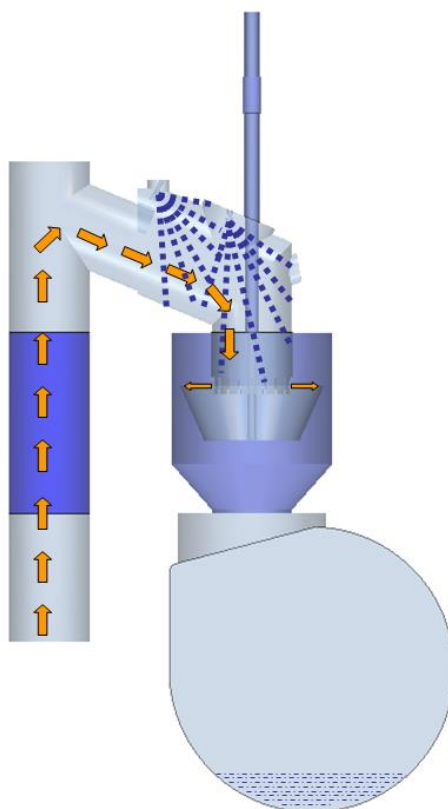


Figure 8 - PROven NG installed outside of the collecting main

Figure 9 shows the new design of the “cup”. This cup hasn’t got high sidewalls, which could deflect the coke oven gas, hence, no turbulences accrue. Another advantage of the new design is the rotatable cup (see Figure 10), which leads to:

- No drain valves necessary
- Self-cleaning (even with bigger particles)

* Technical contribution to the 44th Ironmaking and Raw Materials Seminar, 15th Brazilian Symposium on Iron Ore and 2nd Brazilian Symposium on Agglomeration of Iron Ore, September 15th to 18th, 2014, Belo Horizonte, MG, Brazil.

Redução de Minério de Ferro & Tecnologia Mineral

Ironmaking and Mineral Technology

44th Ironmaking and Raw Materials Seminar
 15th Brazilian Symposium on Iron Ore
 2nd Brazilian Symposium on Agglomeration of Iron Ore
 44th Ironmaking and Raw Materials Seminar
 15th Brazilian Symposium on Iron Ore
 2nd Brazilian Symposium on Agglomeration of Iron Ore

Tema Central: Desafios para a mineração e siderurgia frente à nova realidade dos recursos de minério de ferro e coque
 Main Theme: Challenges for mining and steel making facing the current and future quality of the reserves of iron ore and coal

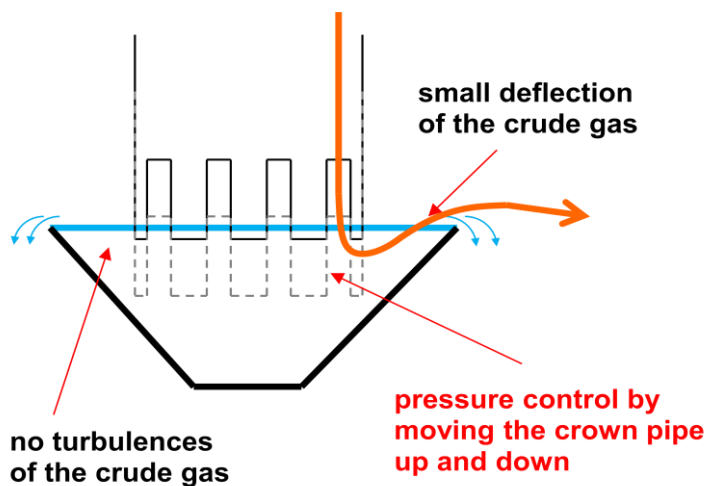


Figure 9 - New "Cup" design

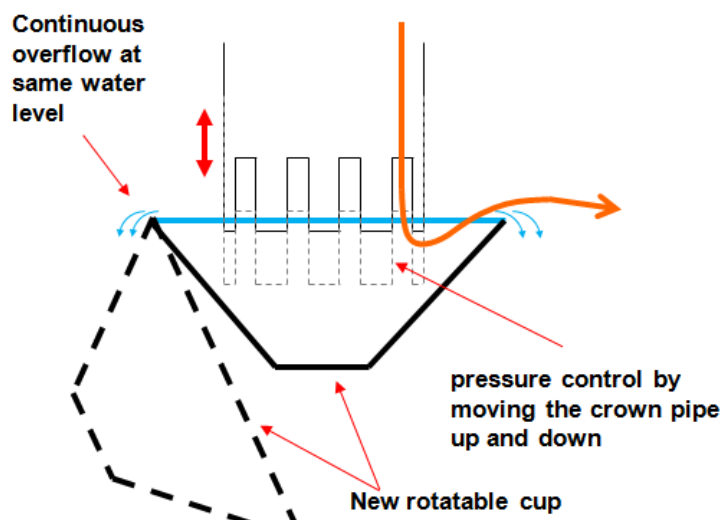


Figure 10 - Rotatable cup design

The following Figure 11 shows PROven[®] NG in its three different operating modes: charging, carbonization time and pushing.

* Technical contribution to the 44th Ironmaking and Raw Materials Seminar, 15th Brazilian Symposium on Iron Ore and 2nd Brazilian Symposium on Agglomeration of Iron Ore, September 15th to 18th, 2014, Belo Horizonte, MG, Brazil.

Redução de Minério de Ferro & Tecnologia Mineral

Ironmaking and Mineral Technology

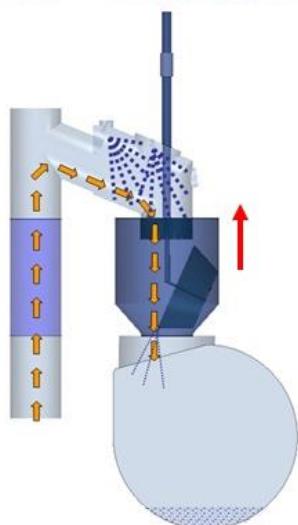
44th Ironmaking and Raw Materials Seminar
 15th Brazilian Symposium on Iron Ore
 2nd Brazilian Symposium on Agglomeration of Iron Ore

44th Ironmaking and Raw Materials Seminar
 15th Brazilian Symposium on Iron Ore
 2nd Brazilian Symposium on Agglomeration of Iron Ore

Theme Central: Desafios para a mineração e siderurgia frente à nova realidade dos recursos de minério de ferro e coque
 Main Theme: Challenges for mining and steel making facing the current and future quality of the reserves of iron ore and coal

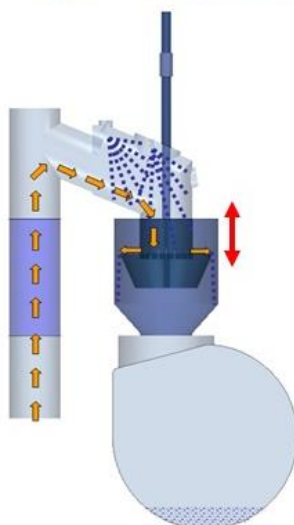


$$P_{\text{oven}} = P_{\text{collecting main}}$$



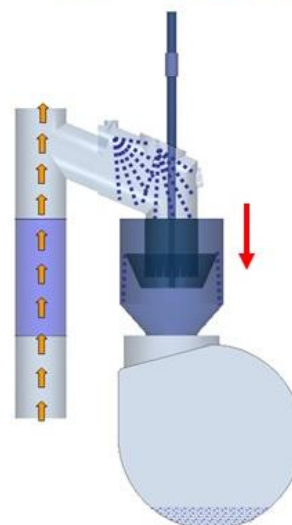
Crown pipe open;
standpipe lid is closed

$$P_{\text{oven}} \neq P_{\text{collecting main}}$$



Crown pipe moves in water;
standpipe lid is closed

$$P_{\text{oven}} = P_{\text{atmosphere}}$$



Crown pipe dipped in water;
standpipe lid is open

Figure 11 - PROven NG - Operating modes (charging; carbonization time; pushing)

1. Charging (figure left hand side)

As soon as the oven will be charged, PROven® NG opens the cup to assure, that all gases etc. will be sucked into the collecting main without being interfered by the cup. Additionally the cup itself is cleaned of solids by passing fluids.

2. Carbonization time (figure middle)

Whilst the carbonization time, the cup of PROven® NG is closed and the inner pressure of the oven will be regulated via the adjustable height of the crown pipe. Hence, the water seal level varies to assure the ideal pressure inside the coke oven chamber.

3. Pushing (figure right hand side)

During the pushing procedure, the cup of PROven® NG will be closed and the crown pipe dips into the water seal at its maximum position. In this position no gases will be sucked in by the collecting main and will be routed to the open standpipe.

Figure 12 shows three different positions of the crown-pipe, which is freely adjustable:

- Left hand side: crown pipe at maximum height (no water seal; chamber pressure = collecting main pressure)
- Middle: crown pipe dipped in water
- Right hand side: crown pipe at lowest level (maximum water seal; chamber pressure \neq collecting main pressure).

* Technical contribution to the 44th Ironmaking and Raw Materials Seminar, 15th Brazilian Symposium on Iron Ore and 2nd Brazilian Symposium on Agglomeration of Iron Ore, September 15th to 18th, 2014, Belo Horizonte, MG, Brazil.

Redução de Minério de Ferro & Tecnologia Mineral

Ironmaking and Mineral Technology

44th Seminário de Redução de Minério de Ferro e Materiais-primos
15th Simpósio Brasileiro de Minério de Ferro
2nd Simpósio Brasileiro de Aglomeração de Minério de Ferro
44th Ironmaking and Raw Materials Seminar
15th Brazilian Symposium on Iron Ore
2nd Brazilian Symposium on Agglomeration of Iron Ore

Tema Central: Desafios para a mineração e siderurgia frente à nova realidade dos recursos de minério de ferro e coque
Main Theme: Challenges for mining and steel making facing the current and future quality of the reserves of iron ore and coal



Figure 12 - Adjustable crown pipe

4 CONCLUSION

To provide Best Available Technique (BAT) to its customers, DMT is steadily enhancing its products e.g. PROven[®]. The enhanced PROven[®] system, called PROven[®] NG, combines the features of PROven[®] with certain advantages.

One of the main advantages of PROven[®] NG is the possibility to install it outside of the collecting main. Hence, upgrading existing plants is possible during operation and the maintenance effort is lower because of the better accessibility.

Additionally the new design of the “cup” has various advantages as well.

First, no drain valve is needed,

second, it is self-cleaning and

third, there are no turbulences of coke oven gas leaving PROven[®] NG.

To summarize, PROven[®] NG has the following advantages:

- Ideal pressure in each coke oven chamber and independent collecting main pressure
- Installation outside of the collecting main
 - Upgrading existing plants during operation is possible
 - Better accessible for maintenance
- New design of the “cup”
 - Self-cleaning through rotatable cup and continuous water overflow
 - No drain valve necessary
 - No turbulences of COG

SOURCE

PROven[®] and PROven[®] NG were invented and developed by DMT, all documentation regarding those systems, published in this paper, are internal documents of DMT GmbH & CO. KG.

* Technical contribution to the 44th Ironmaking and Raw Materials Seminar, 15th Brazilian Symposium on Iron Ore and 2nd Brazilian Symposium on Agglomeration of Iron Ore, September 15th to 18th, 2014, Belo Horizonte, MG, Brazil.