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SINGLE OVEN PRESSURE CONTROL FOR COKE OVEN BATTERIES[1]

Luca Parodi [2]
Antonio Esposito [2]
Helênio Resende Silva Junior [3]

Abstract
The new Sopreco™ system (Single Oven PREssure COntrol system) significantly contributes to decrease emissions from coke oven batteries. Sopreco™ system has been designed and developed by Paul Wurth as a flexible item to be installed in TOP as well as Stamp charging batteries. In order to reduce emissions during the charging phase, for top charging batteries the traditional system which uses vapour or high pressure ammonia water can be replaced by a single oven pressure control system. Sopreco™ system maintains a depression in the collecting main of -350 Pa and more, which is what is needed for the suction of raw gas and dusts during first distillation and the charging phases.
Key words: Environment; Emissions; Pressure control.

CONTROLE INDIVIDUAL DE PRESSÃO PARA FORNOS DE COQUERIA

Resumo
O novo sistema Sopreco™ (sistema de controle de pressão individual em forno de coque) contribui significativamente para a redução das emissões poluentes em baterias de coque. O sistema Sopreco™ foi projetado e desenvolvido pela Paul Wurth com flexibilidade para ser instalado tanto em baterias com enfornamento pelo topo *(top charging)* quanto em baterias com enfonamento do tipo *Stamp charging*. Em baterias com enfornamento pelo topo, visando reduzir as emissões durante a etapa de carregamento dos fornos, o sistema tradicional que utiliza vapor ou licor amoniacal de alta pressão pode ser eliminado com a instalação do SOPRECO™. O sistema Sopreco™ mantém a depressão no tubo coletor em torno de -35 mm H_2O (-350 Pa) ou menos, suficiente para a sucção de todo o gás bruto e paticulados gerados durante o enfornamento e a fase inicial da destilação.
Palavras-chave: Meio ambiente; Emissões; Controle de pressão.

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[2] *Paul Wurth Italia S.p.A., Genova, Italy.*
[3] *Paul Wurth do Brasil, Belo Horizonte, MG, Brazil.*

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1 INTRODUCTION

The new Sopreco system (Single Oven PREssure COntrol system) significantly contributes to decrease emissions from coke oven batteries.
Sopreco system has been designed and developed by Paul Wurth as a flexible item to be installed in TOP as well as Stamp charging batteries.
In order to reduce emissions during the charging phase, for top charging batteries the traditional system which uses vapour or high pressure ammonia water can be replaced by a single oven pressure control system; Sopreco system maintains a depression in the collecting main of -350 Pa and more, which is what is needed for the suction of raw gas and dusts during first distillation and the charging phases.
Sopreco was lately tested by an independent certifying society which encapsulated a door and measured the quantity of pollutants for several distillation cycles; thus comparing emissions results when Sopreco was in function to when it wasn't.
Percentages of emissions decrease are reported here below:

- Benzo(a)pirene 95%;
- PM 90%.

On the other hand, Sopreco is particularly suitable to be installed on stamp charging batteries, where requested depression for gases suction during charging is higher: -600 Pa (-60 mm H_2O).
The Sopreco system here described is already installed at the Zentralkokerei Saar (ZKS, Germany), on the new Battery N°3 (50 ovens, 16.4 x 6.25 x 0.5) and will soon be on the future Battery N°1 (40 ovens, 16.4 x 6.25 x 0.5) in order to fulfil the ongoing modern environmental regulations (Figure 1).

Figure 1. New coke oven Battery N° 3 of ZKS.

2 SINGLE OVEN PRESSURE CONTROL SYSTEM IN A STAMP CHARGING BATTERY

During the charging process of a stamp charging battery, the coal cake charging takes place through the pusher side door (Figure 2).
This procedure causes high emissions; with the aim of decreasing emissions several systems have been experimented during coal cake charging, especially through the

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use of sealing frames, nevertheless this intervention only partially reduced emissions sources, without completely eliminating the problem.

Figure 2. Charging a coal cake with stamp charging technology.

In order to decrease emissions sources during the oven charging process, ZKS performed measurements and tests, thus developing a concept useful to eliminate emissions when doors are open (pusher side) during this phase.
This concept basically foresees the suction of charging gas creating a strong depression in the collecting main during the charging phase in oven number “n” then, thanks to the jumper pipe connections the charging gas is transferred from the same oven “n” to the ovens “n+2” and “n+4” (pushing schedule being 2,-1) (Figure 3).
Finally, through the ascension pipes, charging gas goes to the collecting main.
The technology developed by ZKS therefore consists in the simultaneous suction of the oven “n” charging gases on three ovens. Specially designed machines have been used for the charging gases transfer to the nearby ovens (service machines with a bypass gas system) (Figure 4).

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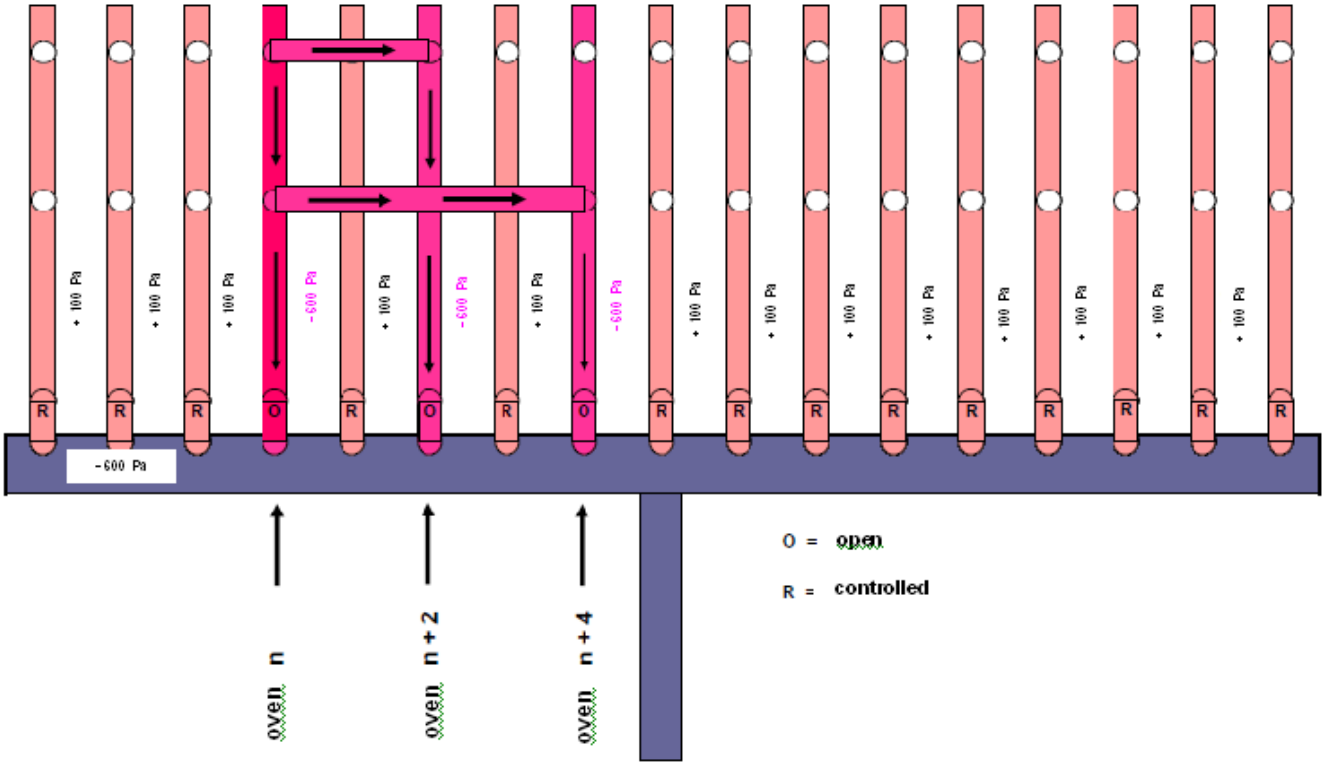

Figure 3. Charging gas suction scheme.

In the tests executed by ZKS in old existing batteries it has been calculated that the pressure to be maintained in the collecting main, during charging phase, is -600 Pa (-60 mmH2O). In order to minimize emissions during the distillation process a negative pressure in the collecting main of -200 Pa (-20 mmH2O) has been determined. This means that when no charging process is ongoing, the collecting main will have to work with only about -200 Pa (-20 mmH2O), on the other hand, when the charging phase is ongoing, it must operate with a value of about -600 Pa (-60 mmH2O). Therefore, before starting the relevant pushing series, the pressure in the collecting main will have to be set at a lower value (-600 Pa = -60 mmH2O) as per table here below (Figure 5).

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Figure 4. Service machine with a bypass gas system.

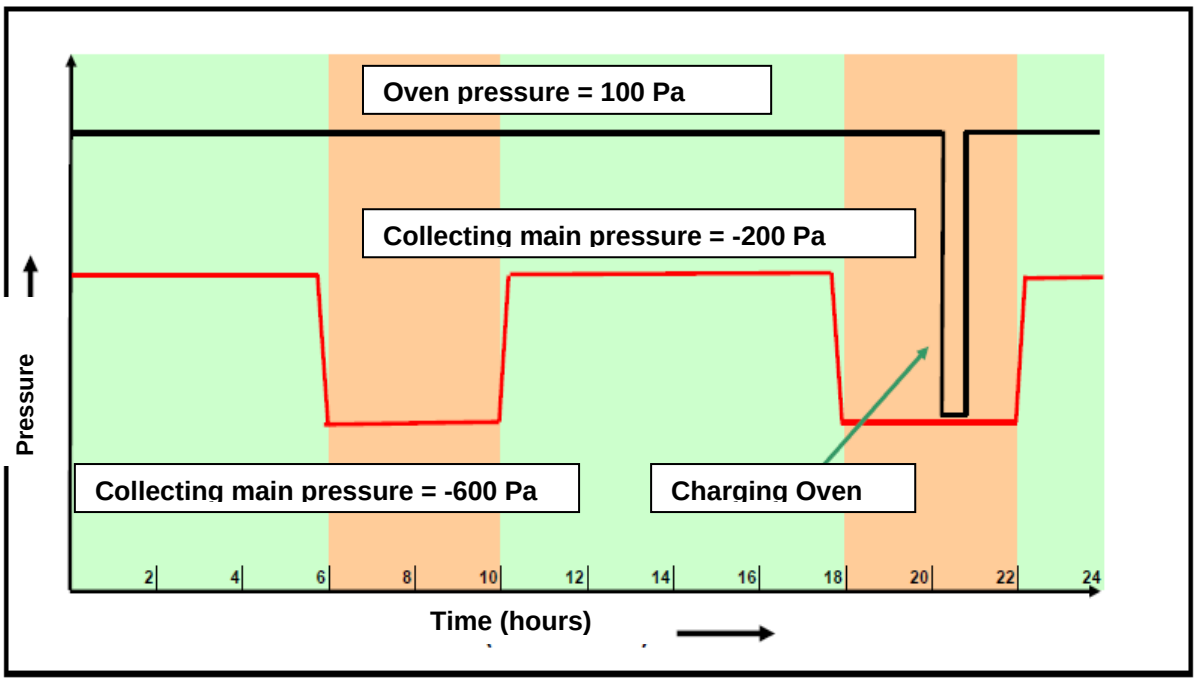

Figure 5. Pressure regulations in the oven and in the collecting main during the distillation and the charging phases.

3 DESIGN REALIZATION OF THE REGULATING VALVE – SOPRECO VALVE

On the basis of past experiences, PW realized the single oven pressure regulation system, which is a special regulating valve essentially composed by a funnel which, thanks to a spherical valve, can be opened or closed in order to regulate the pressure (Figure 6). The valve is fixed to two supports and started by the relative actuator.

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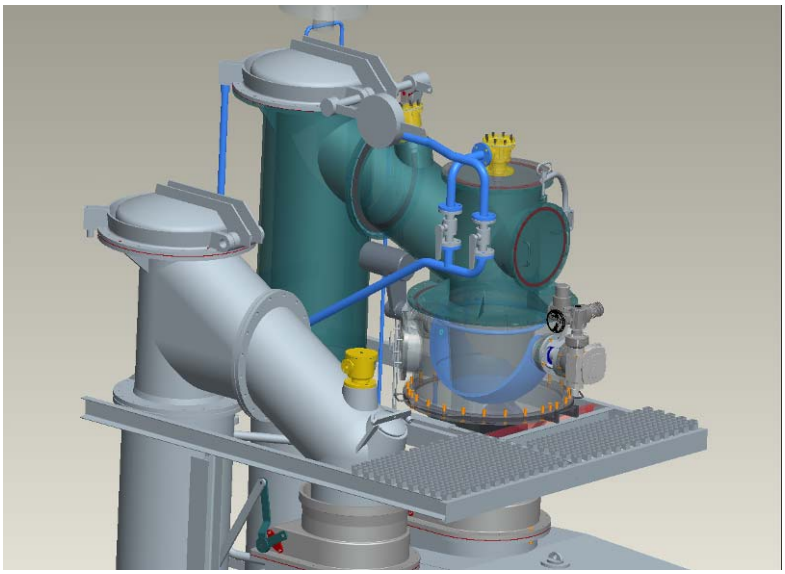

Figure 6. Sopreco valve.

Sopreco valve is therefore designed as a control valve and placed between the isolating valve and the elbow of the ascension pipe, thanks to the isolating valve the oven can be completely isolated from the collecting main.
The system is then completed by a pressure measuring device of the oven placed at the bottom of the ascension pipe and by a regulation device through a junction box (Figure 7).

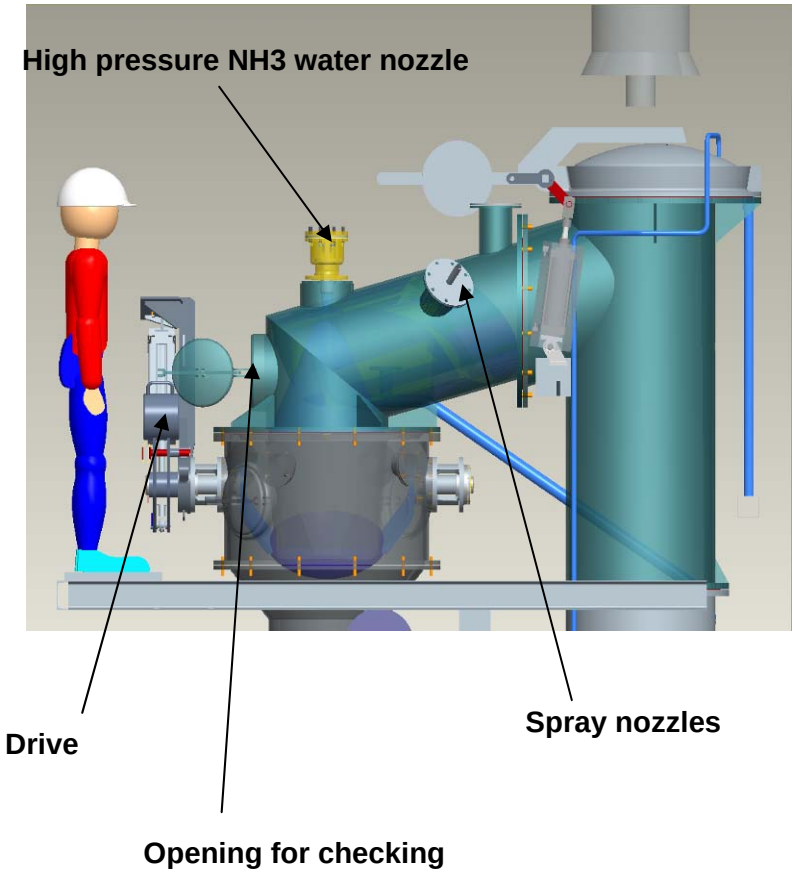

Figure 7. Sopreco regulation system.

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4 DEVELOPMENT OF THE SOPRECO VALVE

The development and realization of the valve took about two years and was finally tested with three Sopreco valves installed on Battery N° 2 of ZKS (Figure 8).
During the development process great efforts were made to be sure all possible influences on the valve, typically caused by the operation of a coke oven battery, were taken into consideration.
In particular:

- high temperatures from the collecting main, flares and open ascension pipes;
- dusts;
- tar inside the valve;
- ammonia water flow for gas cooling.

Even the dangerous deposits on the valve and on the external part of the funnel did not take place, even after long testing periods.

Figure 8. Realization of a Sopreco unit in the existing Battery N° 2 of ZKS.

5 INDUSTRIAL APPLICATION

In 2009 new coke oven Battery N° 3 of ZKS was equipped with 50 Sopreco regulating valves (Figure 9).

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Figure 9. 50 Sopreco valves in the new Battery N° 3 of ZKS.

The experience gained with the ascension pipes tests of Battery N° 2 on all components has therefore been extremely helpful and Sopreco never needed further modifications. Only the realization of the shell and gooseneck was further optimized for what encumbrance is concerned in order to improve operative accessibility (Figure 10).

The 50 Sopreco valves entered in service on 10th February 2010 together with Battery N° 3. After charging the ovens, the regulation of the Sopreco valve was started through electrical control; after an initial period of distillation equal to 32 hours it started working immediately in a stable way, reaching a distillation time of 22 hours.

The operating parameters were adapted to the real necessities of the stamped charged coke oven battery and the Sopreco valves are now operated with the following pressure:

- collecting main during charging: -400 Pa (planned -600 Pa);
- collecting main without charging: 0 Pa (planned -200 Pa);
- set point over pressure: 130 Pa (planned 100 Pa).

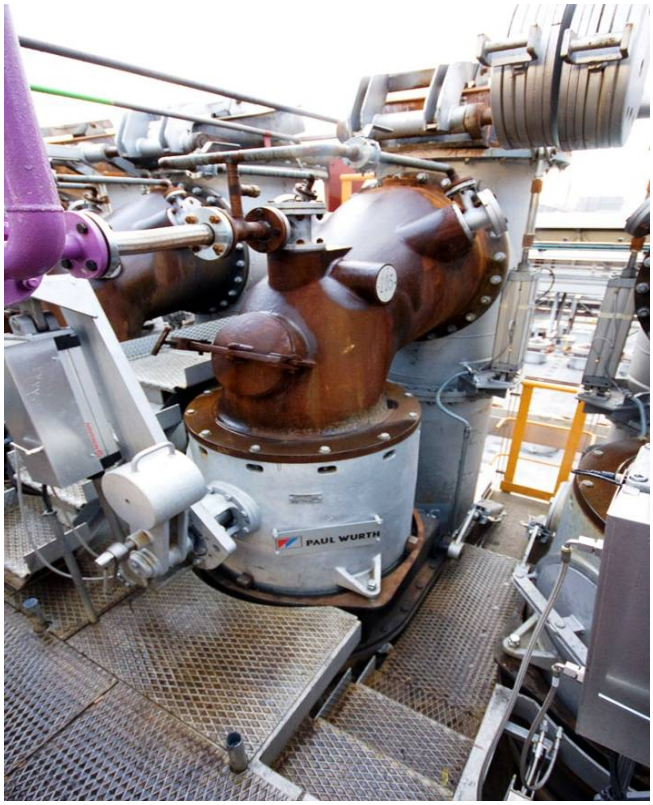

Figure 10. Sopreco valve with optimized dimensions in Battery N° 3 of ZKS.

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6 PRESSURE MEASUREMENT POINTS

Pressure probes are installed at the bottom of the ascension type and are continuously fluxed with nitrogen in order to avoid possible clogging, pressure measurement point was configured in a particularly easy way for cleaning. Anyhow up to today it wasn't necessary to proceed with manual cleaning.

7 RISK ANALYSIS - PROCESS SECURITY

During the project phase the operative suitability of the valve itself was taken into account, mainly focusing on the following aspects:

- the distribution of ammonia water;
- temperature peaks;
- good accessibility to inside components for inspection purposes.

Therefore, an accurate risk analysis took care of the security of the process in each single oven as well as in the whole battery, and the consequences of possible control failure of components of Sopreco valve were taken into high consideration as well.
In particular:

- lack of compressed air;
- lack of energy;
- malfunctioning of the regulation;
- failure of each component, such as pipes for compressed air etc.

In ZKS coke oven battery, Sopreco is started and monitored from the control room. The valve position and the oven pressure are continuously recorded. Before pushing the oven, Sopreco valves are completely open and the control regulation system is in pause. After charging the oven, the control system is operative again and the valves are working again. In ZKS these procedures are executed from the control room and are automated, thanks to the local control boxes though, if necessary, they can also be executed by personnel present on the oven top.

8 CONCLUSIONS AND PERSPECTIVES

Sopreco regulation system is based on the experience gained with tests on mechanical elements and PW multi-year experience in blast furnace technology design in areas particularly exposed to heat and fines.
The three valves installed as a test in the Battery N° 2 and the 50 valves installed in Battery N° 3 have been immediately accepted by operative personnel.
During all the pre-industrial phase, the testing period in an old battery and also during the industrial use in the 50 ovens of Battery N° 3 the system proved to be very stable and effective.
Sopreco system is designed to be installed as an autonomous system even on existing plants with a minimum effort for adaptation works, also thanks to its small dimensions.