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Increased Plant Safety and Plant Availability by Cleaning with Dosed Gas Explosions

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Kurzfassung

Erhöhte Sicherheit und Anlageneffizienz dank Reinigung mit dosierten Gasexplosionen

Einen Kessel einer thermischen Abfallverwertungsanlage für einen problemlosen Betrieb bezüglich Kesselverschmutzung auszulegen ist eine Kunst. Eine der Problematiken für eine korrekte Auslegung liegt darin, dass die Müllzusammensetzung oder die Umweltvorschriften sich ebenso schnell ändern wie die Anlagenbauer ihre Erfahrungen der letzten Anlagen in die neuesten Auslegungsrichtlinien einbinden können. Jede neu gebaute Anlage ist somit vor Überraschungen bezüglich Reisezeit aufgrund der Kessel-Verschmutzung nicht gefeit. Speziell bei bestehenden Anlagen, bei welchen sich die Müllzusammensetzung im Laufe der Zeit stark verändert hat, sehen wir heute grosse Probleme mit Kesselverschmutzungen. Es gibt für diese Probleme wiederum technische Lösungen. Der Betreiber bevorzugt natürlich Lösungen bzw. Technologien, welche fest am Kessel angebaut sind. Dazu zählen verbesserte mechanische Klopfung, Druckluft-Pulsentladung, Beschallung, Dampf- oder Wassereindüsung.

Trotz neuer oder verbesserter Technologien können aber auch diese Lösungen geringere Reinigungswirkung oder andere Nachteile aufweisen:

Es werden nicht alle gewünschten Bereiche erreicht, der Betrieb ist nicht zuverlässig genug oder es gibt negative Auswirkungen für nachgeschaltete Bereiche.

Eine steigende Nachfrage bezüglich Reinigungen mit der "bang & clean Methode" ist daher feststellbar.

In dem vorliegenden Beitrag wird erläutert, wie in über 100 Anlagen diese erprobten Reinigungs-Technologien angewendet werden und dies auch anhand von praktischen Anwendungsfällen. Jede dieser Methoden lässt sich online anwenden und somit kann die Anlage während der Reinigung in Betrieb bleiben.

Das Grundprinzip der Reinigungstechnologien basiert auf einem explosionsfähigen Gasgemisch welches wohl dosiert und geordnet an der gewünschten Stelle zur Explosion gebracht wird.

Dazu wird mittels einer gekühlten Lanze ein hitzebeständiger Sack in die Nähe der zu reinigenden Heizfläche gebracht, dort mit dem Gasgemisch gefüllt und gezündet.

Durch diese kontrollierte, dosierte Gasexplosion wird eine Druckwelle erzeugt und die Kesselrohre und -wände werden in Schwingung versetzt. Beide Aktionen bewirken die Abreinigung der Kesseloberflächen.

Bei sehr harten Anbackungen kommt das "high-energy-Verfahren" zur Anwendung, welches sehr lokal und mit höherer spezifischer Energiedichte arbeitet.

Bei sehr harten stationären Anbackungen wird das CARDOX-Verfahren eingesetzt. Dieses Verfahren basiert auf der 600-fachen Volumenvergrösserung bei der Umwandlung von flüssigem CO_2 in die Gasphase. Mittels dieser Volumenvergrösserung werden Drücke bis 3.000 bar erzeugt, die zur Beseitigung der Anbackungen eingesetzt werden.

Alle die oben beschriebenen Verfahren inklusive unserer Video-Inspektionskamera werden in Feuerräumen, Kesseln und Behältern von Müllverbrennungsanlagen und Kraftwerken erfolgreich angewendet.

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Introduction

It is not an easy task to design a waste-to-energy boiler and to guarantee trouble-free operation i.e to avoid boiler fouling, deposits etc. One of the main difficulties is the fluctuating waste composition and the environmental regulations that are changing so fast that it is almost impossible for the suppliers to incorporate their latest experience. For every new built plant the availability is therefore a non-predictable factor which is mainly influenced by the fouling of the furnace and boiler. Also existing plants are fighting with boiler fouling mainly caused by the changing composition of waste flows. Technical solutions to these problems like improved mechanical rapping, air pulsation, ultra-sonic sound and water- or steam blowers are available. All these solutions are characterised by the following features:

— they do not produce the expected cleaning efficiency or

— they incorporate negative side-effect to the equipment to be cleaned.

This may be the reason why the demand on cleanings with the "bang & clean"-method is increasing. It is our top priority to fulfil the operators´ needs, and we are continuously developing our systems in order to assure the best cleaning efficiency with the safest technology. In the following the technologies that have been proved in more than 100 plants will be introduced. Each of these technologies can be applied during plant shutdown or online.

Technologies

KRR bang & clean Cleaning Technology for Boilers, Vessels and Hoppers

A lance with forced cooling is introduced into the boiler near the area to be cleaned. At the end of the lance a heat-resistant bag is inflated by an explosive gas mixture that is brought to explosion via remote control ignition. The explosion results in a shock wave which is transferred as vibrations to the boiler walls and -tubes. The shock wave plus the vibrations will make the fouling, like ashes and slag, off the boiler surface (Figure 1).

KRR high energy To Remove Hard and Huge Slag Build-ups

Similar to the "bang & clean" technology, the high energy method works with an explosive gas mixture but with a multi-usable vessel which is filled to over-pressure and therefore results in a higher specific explosion strength (Figure 2).

KRR CARDOX system For Real Hard Build-ups that always Accumulate at the Same Location

Build-ups and had deposits are cleared off in vessels and hoppers from the outside with the original CARDOX system that works as follows:
The"sealing plug" is removed from the "socket"; a hole is drilled into the build-up where the CARDOX tube is inserted through the socket into the build-up. The tube is activated, i.e. a small electrical charge starts the chemical heater which converts the liquid CO_2 into gas. This in turn creates a 600-fold increase of volume and leads to inside tube pressures of up to 3000 bar. The desired pressure is determined by a shear disc which will release the gas via the nozzles at the discharge head (Figure 3).

KRR view Video Inspection System for Furnaces, Boilers etc.

The video monitoring system "KRR view" is specially designed for applications in hot

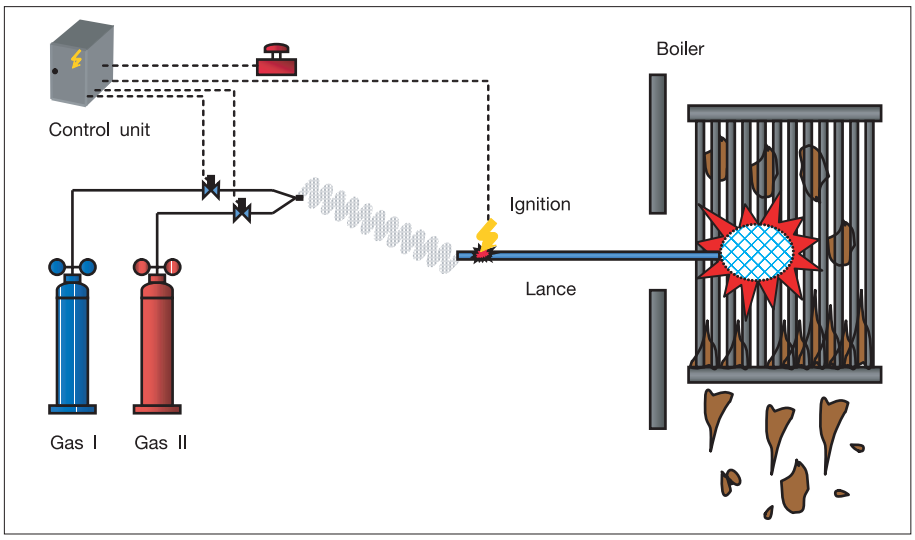


Figure 1. Set up of the "bang&clean"-method.

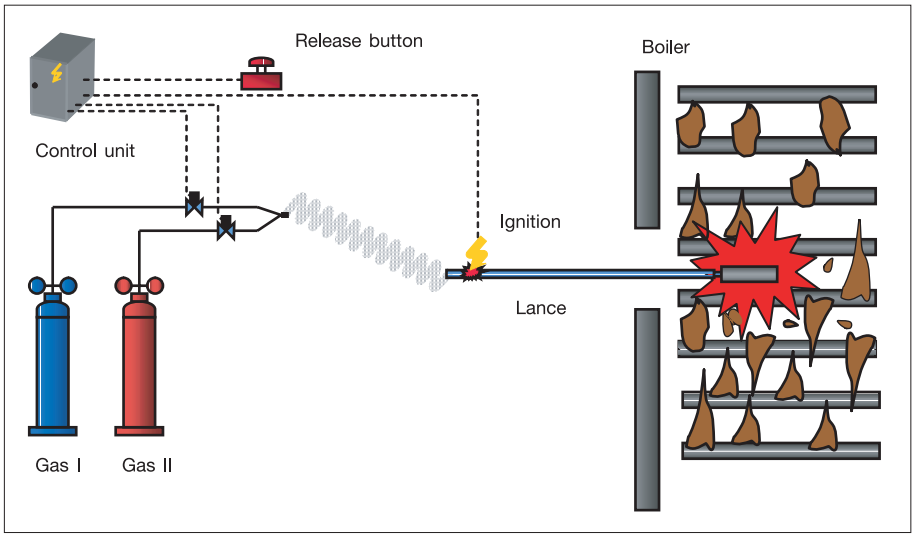


Figure 2. Set up of the "high-energy"-method.

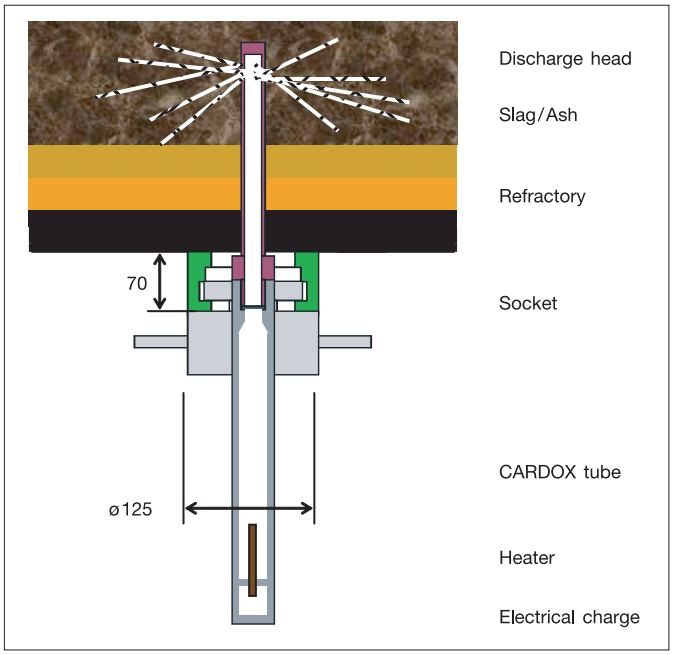


Figure 3. Set up of CARDOX system.

environment. Furnaces, boiler -banks and -walls, flue gas treatment systems can be inspected during operation (Figure 4).

Applications

Furnace Cleaning

There are two reasons for cleaning intervention:

a) Build-ups are disturbing the process, mostly by closing the secondary air nozzles resulting in inefficient combustion or waste transport on the grate is stopped when deposits are hanging on the side walls.

b) Huge slag build-ups in the furnace are a risk for inspection and maintenance personnel.

We have solved the problem with the following technologies:

The secondary air nozzles are to be cleaned by the "bang & clean" or "high energy" method. For a cleaning intervention during operation the air nozzles need to be accessible via openings in the furnace walls.

During shut-downs systems are mostly cleaned via openings at the waste feeding system or via access doors at the bottom ash discharge side (Figure 5). Build-ups on the side walls need an opening nearby for good access. Special process conditions are required for online cleaning. Build-ups which are local stationary can be treated with the KRR CARDOX system. This involves the installation of sockets on the walls and in most cases an additional boiler wall modification at the area of intervention.

Boiler Cleaning

Cleaning of boilers of different design types like: horizontal or vertical boilers, two drum boilers, power plant boilers including all areas of the boiler like: radiation part with or without baffle wall, superheaters, evaporators and economizers that are basically successfully cleaned by the "bang & clean" method. For very hard build-ups or totally closed tube bundles the "high-energy method" should be applied.

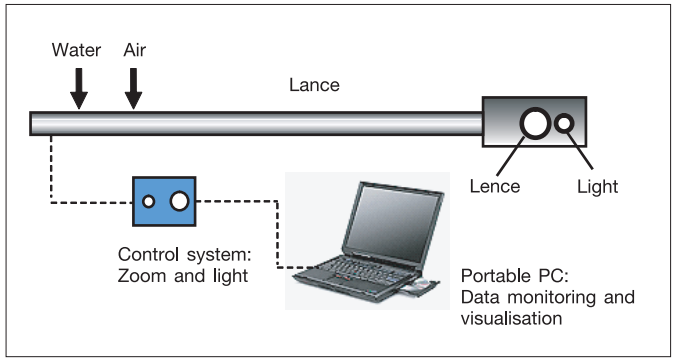


Figure 4. Set up of KRR view system.

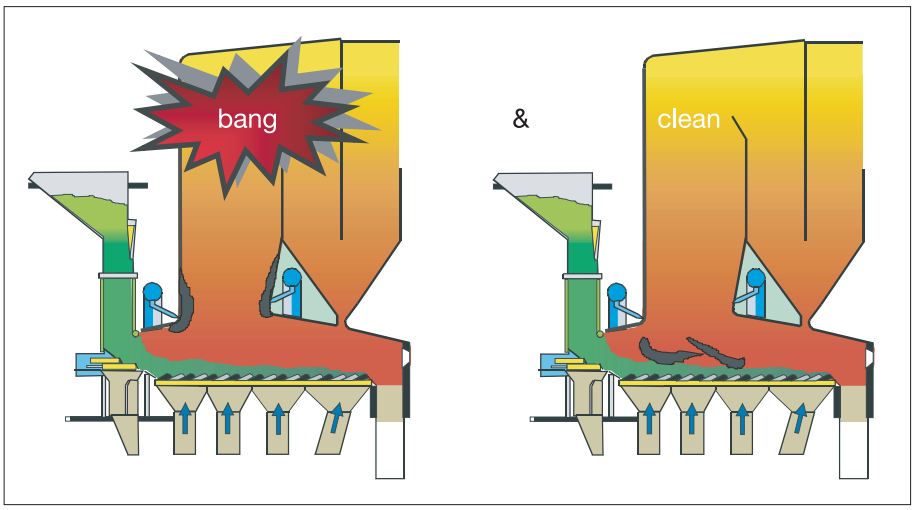
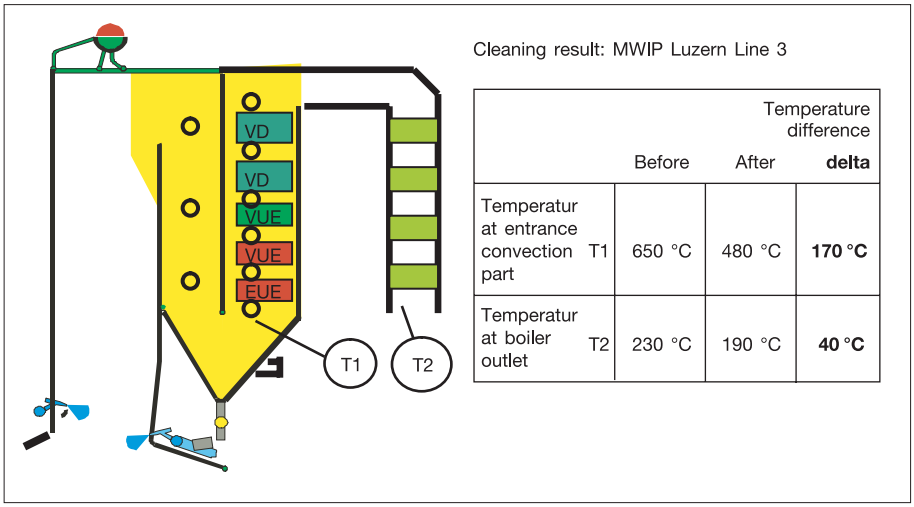


Figure 5. Principle of furnace cleaning.



Cleaning result: MWIP Luzern Line 3

		Before	After	Temperature difference **delta**
Temperatur at entrance convection part	T1	650 °C	480 °C	**170 °C**
Temperatur at boiler outlet	T2	230 °C	190 °C	**40 °C**

Figure 6. Boiler cleaning: example of cleaning efficiency.

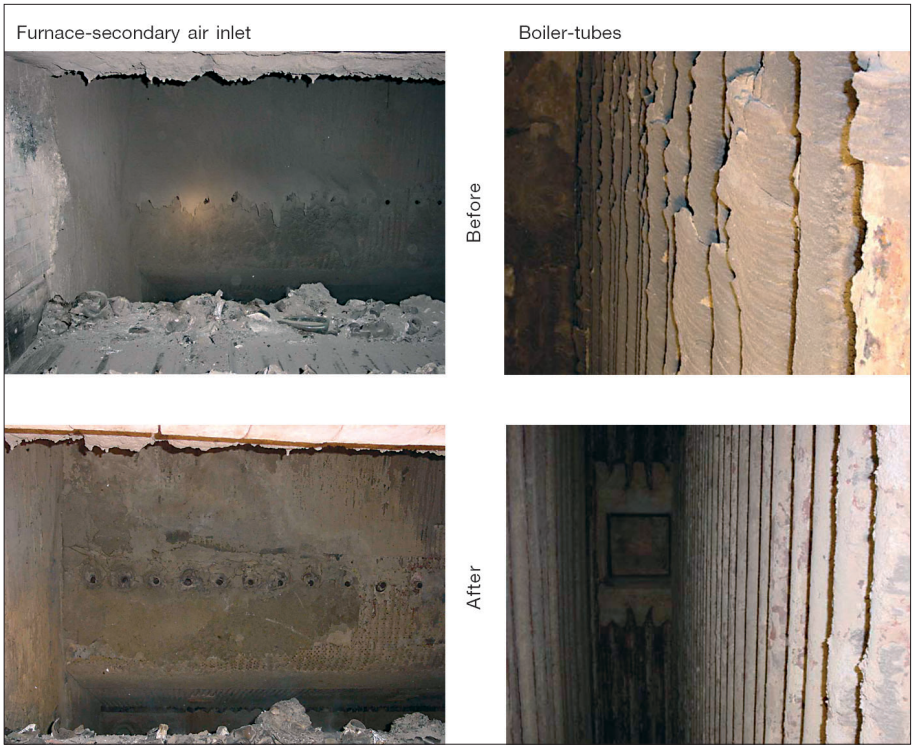


Figure 7. Boiler cleaning: example of cleaning efficiency.

Note: In an increasing number of power plants primary fuel is substituted by secondary fuel. Naturally this has an enormous influence on the fouling of the furnace and the boiler parts. However, cleanings with the above described systems have shown good results.

Cleaning results: example MWIP Luzern, Switzerland. The boiler configuration is shown in Figure 6.

Temperature difference "delta T" before and after cleaning

— adiation part 170 °C
— total boiler 40 °C

Typical values for all designs of waste-to-energy boilers:

Temperature difference "delta T" before and after cleaning

— radiation part 50 to 200 °C
— total boiler 15 to 45 °C

Visual cleaning results:

Typical pictures before and after the cleaning of furnace and boiler are shown in Figure 7.

Absorber

Absorber, spray dryer and spray cooler are tending to create build-ups along the walls. Regular interventions with the "bang & clean" method during the plant in operation are helping to avoid unforeseen shutdowns and are increasing plant availability (Figure 8).

Electrostatic Precipitators (ESP)

Electrostatic precipitators frequently need to be shut down due to a blocked ash hopper or due to an electrical short circuit caused by ash bridging. Both failures can be successfully counteracted with the "bang & clean" method.

Ash Hoppers of Boilers, Silos, Absorbers or ESP

Ash hoppers are potentially at risk for bridging i.e. in most cases the plant has to be shut down. This bridging is mostly caused by cold walls, false air or difficult ash compositions. The following methods are applied for the deblocking: "bang & clean" or high energy in almost all cases as well as the KRR CARDOX method for very hard and stationary build-ups. A typical cleaning sequence is shown in Table 1.

Safety

The following safety features of the KRR cleaning method and -equipment are assuring a maximum safety to humans and material.

The explosive gas mixture is mixed directly before the usage at its destination. Thus, all

Table 1. Cleaning sequence.

Example of a cleaning sequence:
• Arrival on site
• Co-ordination meeting; duration approximately 15 minutes
• Print boiler conditions from process control system
• Setting up of cleaning systems; duration approximately 1 hour
• Cordoning off area, pin information sheet
• Process conditions OK
• Acoustic signal: start cleaning
• Acoustic signal: explosion follows
• Explosion
• Check ash hoppers and ash transport system
• Ready for next explosion; time span between explosions approximately 1 minute; in practice limited by the ash transport system capacity.
• Acoustic signal: explosion follows
• .....
• End of cleaning, visual check
• Acoustic signal: end of explosions
• Print boiler conditions from process control system
• Packing of cleaning system

risks linked with handling, transportation, storage and usage of explosives are avoided. All KRR cleaning methods are applied under stringent safety measures. Our personnel are equipped with the optimal safety protection gears: hart hat with visor, goggles, dust mask, ear protection, fire-proof working clothes and safety shoes. The cleaning equipment is protected with a fail safe interlocking, that even in case of equipment failure the process runs into safe conditions. Thus, any risk of damaging boiler tubes is avoided. The results from our test laboratory have been confirmed in the field in more than 600 cleanings in over 100 waste-to-energy and power plants. Even when the explosion bags are touching the boiler walls and tubes there has never occurred any harm to the boiler.

Experience

According our experience the cleaning intervals are varying between four weeks and six months and are mainly influenced by boiler concept, waste composition and operating conditions. Cement-like deposits require special attention. These deposits can be formed through humidity introduced into the boiler via the ambient air when the plant is shut down or when a leakage occurs during operation. These deposits can be avoided through regular boiler cleaning before every shutdown.

Conclusion

It can be stated that the differed cleaning systems proved well in more than 100 plants. The cleaning systems are continuously improved and developed to assure the best cleaning efficiency to be achieved at maximum safety. □