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Online Cleaning with Shock Pulse Generators – Current Experience

Shock Puls Generator (Generator Impulsów Uderzeniowych) – czyszczenie online – dotychczasowe doświadczenia

Increasing the plant efficiency and reducing the maintenance costs is important for an economic operation of existing power plants. One part of this task involves keeping the boiler heating surfaces as clean as possible and therefore increasing the heat transfer, reducing the maintenance efforts and avoiding unplanned standstills of the plant. One of the most innovative and efficient technologies to fulfil this task are the so-called Shock Pulse Generators.

The Shock Pulse Generators (SPG) developed and produced by the Swiss company Explosion Power GmbH are online-steam-generator cleaning devices that produce automated shock pulses through the ignition of pressurised gas mixtures. The area of application of these Shock Pulse Generators covers various steam generator designs and a variety of solid fuels. The SPGs are thereby utilised from the combustion chamber/first pass, the hottest zone of the steam generator, through the radiation and contact passes, up to the coldest steam generator zones in the economiser. Plant operators confirm significantly longer uptime for steam generators, higher efficiency and longer operational lives for the steam generator pipes, resulting in a sustainable and economic plant operation. Leading plant suppliers regularly choose to install SPG technology into new plant in order to additionally benefit from the modular system configuration and the compact design.

Overview of the reference plants

In December 2017, 8 years after their introduction to the market, more than 400 units are either in operation or being currently delivered. Following the initial launch onto the European market for residential waste as fuel, this innovative technology has become available virtually everywhere in the world in the meantime, thanks to the corresponding partnerships. An expansion has also occurred in the areas of industrial waste, biomass, hazardous waste and coal, while a strong increase in the number of reference plants that use Shock Pulse Generators is expected, in particular in the coal-fired power station field.

Due to the high level of standardisation in Shock Pulse Generators, Explosion Power GmbH has created the possibility of permanently leasing the units, which can be a very interesting alternative for plants with limited residual service life, for example, or also for situations in which the plant owners and operators are not identical.

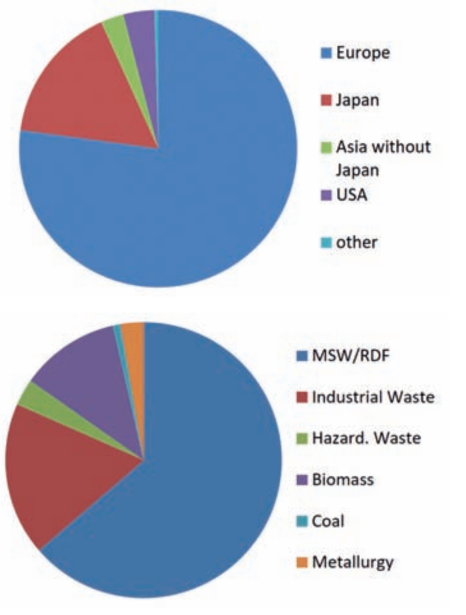

Fig. 1: Distribution of the reference installations by region and solid fuels/industrial sector

System overview

The Shock Pulse Generator System consists of the following components:

- Shock pulse generator mounted on the steam generator wall.
- Control cabinet connected to the process control system (PCS).
- Pressure control sections, which reduce the gas cylinder pressures of the natural gas/methane, oxygen and nitrogen to 40 bar.
- Valve panel as a pre-assembled module.

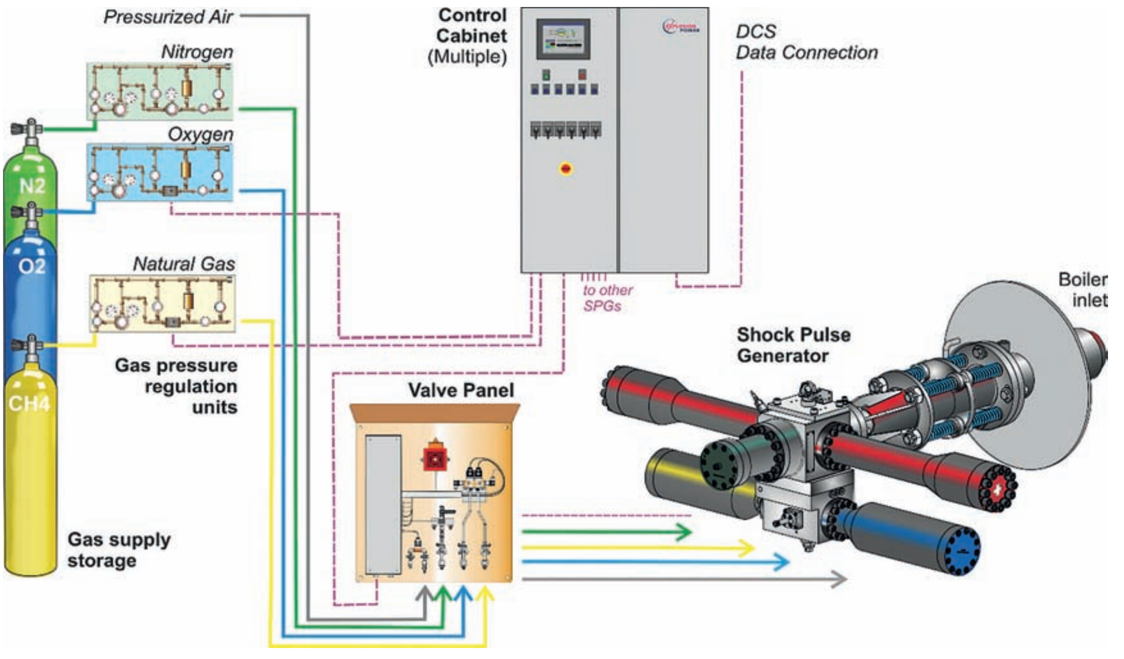

Fig. 2: System overview of the Shock Pulse Generator technology

Function and specification

With SPG, the automatically triggered combustion reactions take place outside the steam generator in a stable, pressure-resistant container, and the generated pressure wave is passed through a Laval nozzle to the steam generator. The pressure wave generates a structure-borne sound oscillation within the caking, and sets the flue gas flow and the heating surfaces into a short-term vibration. The contamination is efficiently cleaned away through these simultaneously occurring effects. The penetration depth of the shock wave depends on the type of device and can be above 10 m.

The following steps are carried out during a cycle:

1. The SPG is in its waiting time. The freely moving piston closes off the outlets gas-tight due to the nitrogen pressure.
2. After being enabled by the controller, the dosing container will be filled to the set pressure with the necessary small amounts of natural gas and oxygen. The two gases are still completely separated from each other, and are therefore non-combustible.
3. The transfer solenoid valve for natural gas and oxygen are opened, and the two gases flow into the combustion cylinder, where they mix with each other and are now combustible.
4. The glow plug is ignited, and triggers the combustion. Due to the sudden pressure increase to 350 bar in the combustion chamber, the piston is shot backwards and opens up the outlet.
5. The pressure wave passes through the outlet nozzle into the steam generator, and spreads out there, initially linearly and then spherically.
6. After the pressure wave has left the unit, the piston is pressed against the outlet again by the nitrogen pressure, and closes it.

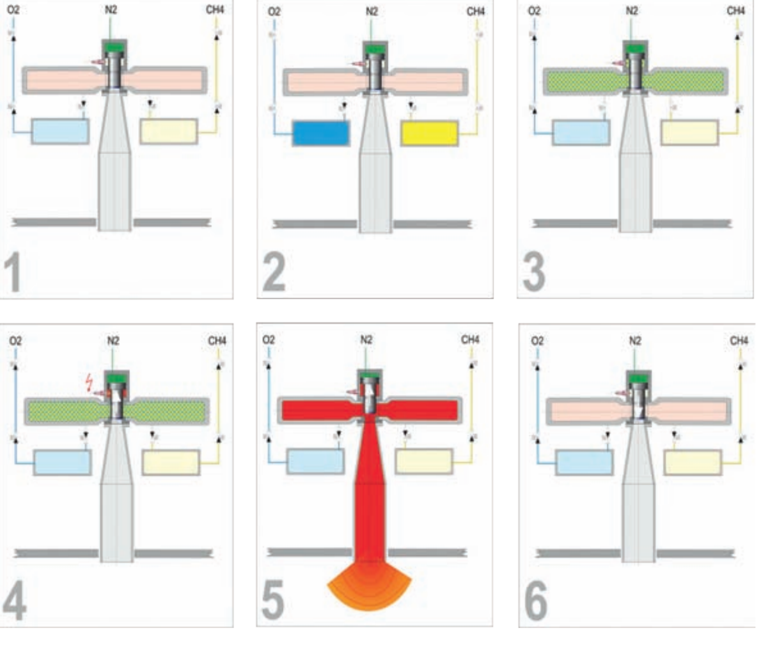

Fig. 3: Sequence of a Shock Pulse cycle

The following four models of SPG are currently available, whose use is governed by the size and design of the steam generator and the type of fouling:

Shock Pulse Generator		EG10	EG10L	EG10XL	TwinL
Volume of combustion chamber	l	2.5	3.5	4.4	2 x 3.5
Filling pressure of the CH_4 and O_2 dosing tanks	bar	29	32	35	direct filling
Consumption of CH_4/O_2/N_2	g/SP	16/34/1	22/48/1	28/61/1	44/96/2
Connection size of boiler flange	DN	125	125	250	2 x 125

The gas supply to the SPG can be easily realized using individual cylinders or small bundles. The piping to the SPG has a nominal diameter of only 12 mm, and a line pressure of 40 bar. A small compressor can also be used for natural gas with the existing mains connection.

The SPG is mounted horizontally on the steam generator wall or vertically on the ceiling.

Fig. 4: Horizontally-installed Shock Pulse Generators

Application areas for Shock Pulse Generators

The generators are used in existing plants as a replacement or supplement for previously installed boiler cleaning technologies, as well as increasingly in new systems, where, as a further advantage, they provide a significant reduction in the steel construction and the enclosed building volume, and thereby lead to reduced invest costs. The low construction volume of approximately 1 m^3 per generator even makes installation in confined spaces possible.

Reference examples of existing plants for different fuels and installation positions are described in the following.

Application example of use at the waste-fired power plant in Lucerne, entire boiler

The power plant has three steam generators that were originally cleaned by soot blowers operated with compressed air and a shot ball cleaner. In the course of 2009, a total of eight Shock Pulse Generators were installed on the three lines, and twenty soot blowers and one shot ball cleaner were removed.

During five years, all the cleaning was exclusively carried out by the Shock Pulse Generators. All together, including the test phases, a total of around 500,000 shock pulses were carried out on the three steam generators, without any damage of any kind occurring. This illustrates that the impact of the shock pulse creates no stress for the steam generator components.

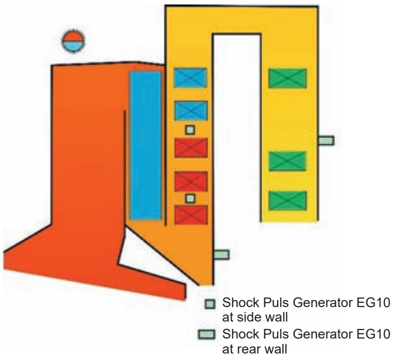

Fig. 5: Installation position of the Shock Pulse Generators in the Waste-to-Energy plant in Lucerne, Line 3

On the basis of the temperatures of Line 3, it can be clearly shown that the impact of the shock pulse is also present against the flue gas flow. Although no SPG was installed in the second pass, the outlet temperature of the second pass could be massively reduced, and this could be maintained at clean boiler conditions. Previously, values of more than 700°C occurred, which led to a high corrosion rate in the final superheater.

The plant in Lucerne was shut down at the start of 2015, as it was replaced by a new waste-fired cogeneration plant at the Perlen site. The three radiation passes in this plant are cleaned by three EG10L Shock Pulse Generators.

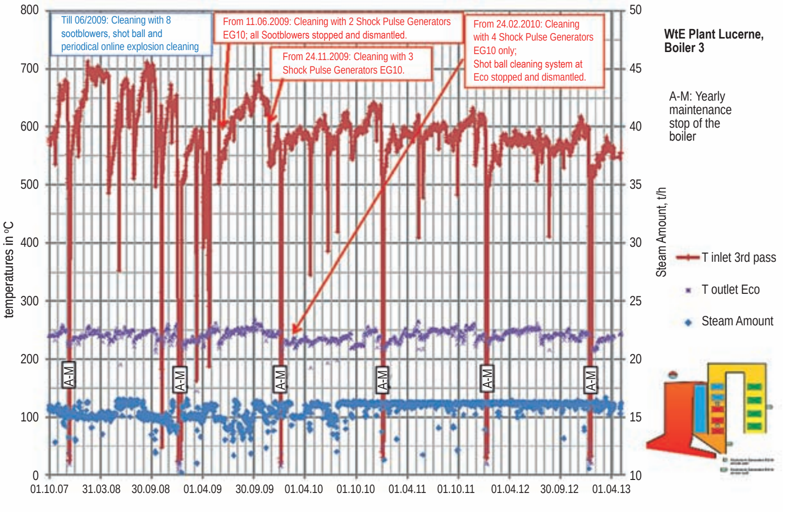

Fig. 6: Line 3 operating conditions before and after the installation of Shock Pulse Generators

Application example of the coal-fired power plant at Werdohl Elverlingsen, Block E4, Reheater 1

The Elverlingsen coal-fired power plant is operated by Mark- E, a company of the ENERVIE Group, and Block E4 has an electrical output of 321 MW. This is a Benson steam generator with 2 chambers, and double U-firing. The dimensions of the steam generator are approx. 11 x 13 x 80 metres.

Reheater 1 has been cleaned by two SPGs since September 2011, and three soot blowers have thereby been shut down. In addition to the steam saving, the service life of Reheater 1 has been considerably extended, as the damage caused by abrasion and/or erosion has been reduced.

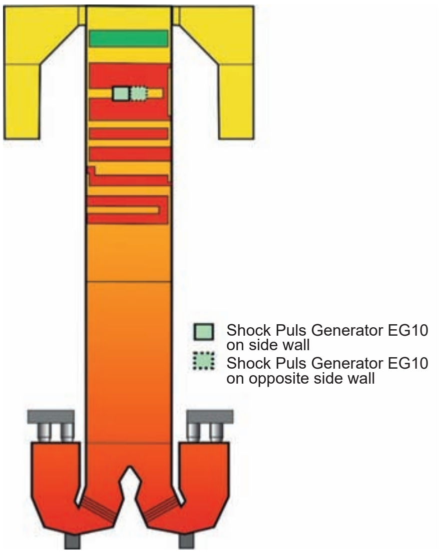

Fig. 7: Installation position of the Shock Pulse Generators in the Elverlingsen power plant, Block E4

Application example of the Zurich Josefstrasse WtE plant, radiation passes

The four-pass horizontal boiler (cf Fig. 8) has got a radiation pass width of 7.2 m and processes up to 13.25 t/h of waste, including up to 15% sewage sludge. The steam capacity is 52 t/h at 40 bar and 400°C. The third radiation pass is separated by a membrane evaporation wall, subdividing the pass into a left and a right half. A maximum flue gas temperature of 700°C should not be exceeded at the inlet of the horizontal pass, in order to prevent excessive corrosion rate of superheater tubes.

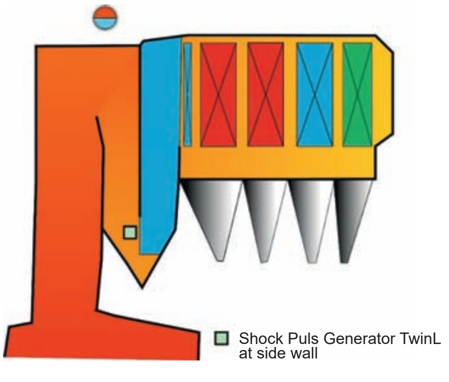

Fig. 8: Installation position of the Shock Pulse Generator in the WtE plant Zurich Josefstrasse

In 2016, one Shock Pulse Generator TwinL was installed at the lower part of the 2nd radiation pass, to improve the cleaning of the radiation passes.

The cleaning improvement by the Shock Pulse Generator is clearly visible (cf. Figures 9a and 9b).

In 2015 (Fig. 9a), without Shock Pulse Generator, the flue gas temperature at the inlet of the horizontal pass increased almost linearly, 7°C per day, and reached the critical value of 700°C less than one month after boiler start up. By using the shower cleaning system, the temperature could be kept around 700°C for 2-3 weeks. In order to avoid a further increase of the temperature, a manual online boiler cleaning was carried out, which reduced the temperature to a similar value as after the maintenance stop. Thereafter, the periods until shower cleaning and manual boiler cleaning were again necessary, became shorter and shorter.

After the installation of the Shock Pulse Generator (Fig. 9b), the flue gas temperature at the inlet of the horizontal pass increased in the first month to 600°C but could then be kept within 600 to 650°C for the rest of the 4 months operating period. The Shock Pulse Generator was commissioned one week after boiler start up. During week two and three the interval between Shock Pulses was 4 hours, during week four to five two hours and from week six onward 1 hour.

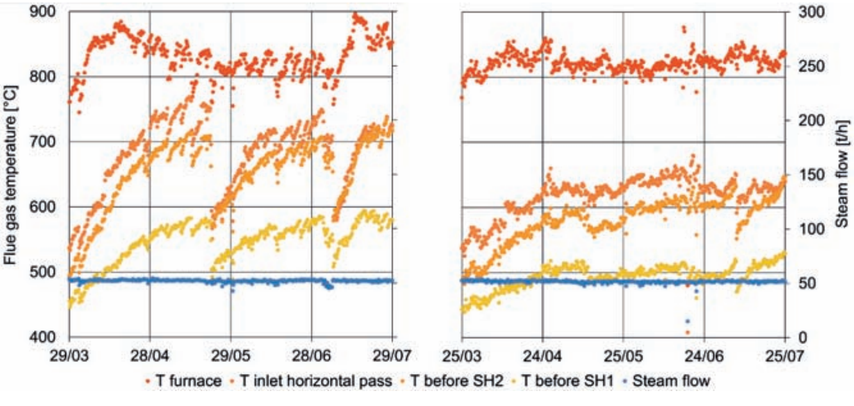

Fig. 9a: Operating period 2015 with shower cleaning and manual online cleaning

Fig. 9b: Operating period 2016 with Shock Pulse Generator (without shower cleaning, without manual online cleaning)

Further to the positive result of the reduced flue gas temperature and therefore lower corrosion rate at superheater bundles, the operator noticed positive effects for the additional manual online cleaning at the horizontal pass, which could be reduced from 3 to 1 intervention per 6 months operation. Additionally, the sand blasting during the maintenance stop could be carried out faster and less material needed to be disposed. Last but not least, the reduction of the flue gas temperature will allow overload operation of the boiler during periods with peak demand of the district heating.

Acknowledgements

We would like to thank the operators for allowing us to report on the experiences gained with the Shock Pulse Generators in their installations.

Information about further reference installations and publications can be found on www.explosionpower.ch.