Revamping Projects in the Waste-to-Energy Boilers in Brussels, Paris and Rome

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In waste to energy (WtE) plants the boiler is a critical component: it is the component most subjected to ash fouling and corrosion phenomena, it may have long shut downs in case of extraordinary interventions and it requires notified body inspections of the pressure parts.

Over the years the WtE market asked increasing pressure and temperature conditions aimed to increase thermal efficiency, to maximize electricity production and to make these plants more profitable. These increased parameters worsen the conditions of the boiler, which may be subjected to serious corrosion phenomena in a short time, if designed without the necessary attention.

In the same time fuel characteristics (municipal solid waste and refuse derived fuel) evolved towards higher calorific values and higher chlorine content.

This article will describe a few cases of boiler revamping interventions carried out to meet the needs to reduce maintenance costs and maximize plant profitability. In this case, the article will analyse the plant of Suez in Lagny (France), located a few kilometres from Paris, the Bruxelles Energie (Belgium) plant located in the city of Brussels, and the Hera plant in Pozzilli (Italy), located a few kilometres from Rome.

Finally, we will present the RDF (refuse derived fuel) combustion boiler project located in San Vittore del Lazio (Italy), our new and complete product, which summarizes our boiler technology for municipal solid waste (MSW) and RDF combustion.
1. Original configuration before the intervention

1.1. Suez – Lagny (France)

The intervention was focused on line 2 of the plant. The line, commissioned in 1995, was sized for 12 t/h of waste with a calorific value of 9,200 kJ/kg to produce 35 t/h of steam at 300 °C and 20 bar (g). The boiler, manufactured by Fire Power, is equipped with a roller furnace manufactured by Tunzini.

The boiler layout is shown in Figure 1.

![Figure 1: Line 2 boiler – Lagny](image)

The boiler has a vertical arrangement with five gas passes: the first three are empty, the fourth one has vaporizer platens and the fifth one has a superheater, two vaporizers and two economizers.
Since its start up, the steam generator showed some difficulties in reaching the 300 °C design temperature in clean boiler conditions. The technicians stated that the temperature was lower than 270 °C during the first three weeks of operation starting from clean boiler and lower than 280 °C in the subsequent eight weeks. The steam condition to enter the turbine were matched only after more than two months of operation.

In addition, since the boiler was equipped with only one superheater with no steam temperature control systems via intermediate attemperator, once the typical fouling of this kind of boiler was reached, the superheated steam at the output reached a temperature of 310 °C and more.

Unfortunately, once the desired temperature had been reached, the fouling phenomena were such that the boiler needed to be shut down for a complete sandblasting in order to make the plant ready to properly operate again.

As such, the operating ours of the turbine at designed temperature were really limited, even lower than 4,000 hours per year.

Failure to achieve the project temperature was mainly due to the very large vaporization surfaces, poor superheater sizing, absence of a temperature control system and limited efficiency of the cleaning system of the boiler.

1.2. Bruxelles Energie – Brussels (Belgium)

The three Bruxelles Energie boilers are identical and designed to produce 51 t/h at 395 °C and 40 bar(g) from MSW combustion. The boilers were manufactured by CNIM and commissioned in 1985. Their original configuration is shown in Figure 2.

The boilers have vertical arrangement with four gas passes: the first two are empty, the third one has a vaporizer and a high, medium and low temperature superheater, while the fourth one has only economizers.

The boilers immediately showed corrosion problems mainly in two areas: in the fins of the membrane walls of the first and second radiant passes and in the superheaters.

The first phenomenon, due to a too large fin, was initially solved by the client, by applying refractory material in areas affected by the phenomenon, while the replacement of the original walls with Inconel 625 coated surfaces is currently underway.

Regarding the superheater corrosion, the phenomenon was so damaging that the life of the first superheater was less than one year and the life of the second one was less than two years. These corrosion problems were solved by removing the first two superheaters and replacing them with independent gas-fired superheater, outside the boiler. As a consequence, the plant reduced extraordinary shut downs but suffered a significant increase in management costs due to natural gas consumption of the external burners. Figure 3 shows the boiler configuration, before our intervention.
Figure 2: Original Bruxelles Energie boiler

Figure 3: Bruxelles Energie boiler after superheater removal
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Editor: Karl J. Thomé-Kozmiensky • Publisher: TK Verlag Karl Thomé-Kozmiensky

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With this configuration, the boiler produced 65 t/h at 320 °C and 40 bar (g). The steam was subsequently heated to 395 °C by an external gas-fired superheater before being injected into the turbine.

1.3. Hera – Pozzilli (Italy)

The plant of Pozzilli (IT), located about 150 km from Rome, owned by HERA SpA, is an RDF combustion plant, equipped with Martin grate and CNIM boiler. The plant started operating in 2007 and is currently used to produce 61 t/h of steam at 400 °C and 60 bar(g), supplied to a steam turbine for the production of electricity.

Figure 4 shows the boiler section.

Figure 4: Pozzilli boiler
The boiler has vertical arrangement and consists of five gas passes: the first one is empty, the second one has high and low temperature superheaters, the third one has a vaporizer and the fourth and fifth ones have economizers.

The boiler immediately showed significant superheater corrosion problems, due to high concentrations of chlorine compounds (typical in the RDF combustion products) and to an unfavourable thermal profile: the high temperature gas immediately faced with the superheater surfaces, with the highest tube skin temperatures. These phenomena shortened the superheater life to less than one year. As a consequence, it was decided to replace the superheaters with Inconel 625 coated surfaces, but, despite this change, the superheater life did not show significant improvement: their life span was about two years.

2. Smart thermodynamic solutions to solve frequent problems

Higher fouling than expected and significant corrosion phenomena are the main problems found in this type of plants. These phenomena lead to unexpected unavailability of the plant with long shut downs, which turn into extraordinary maintenance costs and loss of profits since the plants cannot be operated.

The typical approach of the managers to solve the fouling problems is often to install additional cleaning systems, such as soot blowers, bombing or rapping systems, that are very aggressive, are not always successful and can cause other sort of problems.

Regarding corrosion problems, it is usually necessary to replace the concerned parts with others coated with Inconel 625, with considerable financial investment.

Our approach is to make a new and complete boiler calculation in order to design a new heat profile focused on the reduction of the gas temperatures facing each thermal unit. This will lead to reduce molten ashes deposits, and to dramatically reduce the corrosion phenomena.

3. Modifications made to the plants

After having carefully examined the specifications required by plant managers and the operating data, significant changes to each plant were agreed upon.

3.1. Suez – Lagny (France)

The works for the modifications took place in August 2016 and plant commissioning occurred in September of the same year. The solution adopted to solve the problems concerning the failure to achieve the superheated steam temperature was to insert a superheater into the third flue gas pass, operating as a high temperature superheater. In addition to the aforementioned superheater, a desuperheating valve was inserted into the pipe connecting the two superheaters in order to actively control the steam temperature at the exit. Figure 5 shows a drawing of the modified boiler.
This thermodynamic solution was simple, but it was a bit more difficult to apply it to the existing boiler. Particularly the client was looking for the best solution for the cleaning system of the new superheater.

The new superheater was designed with a very large transversal and longitudinal tube pitches, in order to allow an easy passage of the combustion gases, reduce pressure drops and prevent the possibility of clogging due to ashes. The superheater has been equipped with a hammer cleaning system, placed at the top, outside the flue gas pass with our patented solution. Upon customer specific request, the superheater was provided with a 2 mm Inconel 625 coating to further protect the superheater from the instability of the furnace and ensure a very long life.

The superheater was inserted from the top of radiant no. 3 through an opening made on the ceiling, as large as the boiler. This required the repositioning of the water-steam mixture risers and an in-depth study of the circulation.
As a result of intervention, the plant is able to reach the requested superheater temperature of 320 °C from the very beginning and maximize the production of electricity. Moreover, after eight months of operation, the fouling of the superheater is according to our design and no stop for extraordinary cleaning of the superheater is needed.

3.2. Bruxelles Energie – Brussels (Belgium)

The changes made to the Bruxelles Energie plant concerned two of the three existing boilers with interventions in 2014 and 2015.

The goal was to produce superheated steam in the boiler at 350 °C, so as to reduce the external superheating and consequently reduce plant management costs, with the mandatory focus on not causing new superheater corrosion. Figure 6 shows the interventions on the boilers.

The interventions focused on the third flue gas pass, where the vaporizer surface was enlarged and a new superheater was inserted.
The increase in the vaporizer surface allowed the reduction of gas temperature at the superheater inlet, thus controlling the corrosion phenomenon. Downstream of the new vaporizing surfaces, a co-current low temperature superheater was installed so that the higher-temperature gas could come into contact with the surfaces crossed by the steam at a lower temperature, always to keep the corrosion under control. The existing superheater became a high temperature superheater, always placed in co-current with respect to gas directions. In the piping connection between the two superheaters, an attemperator was installed to allow temperature control. Special attention was paid to minimize steam pressure drops, in order to not affect the safety valves placed on the steam drum. All the soot-blowers of the concerned areas has been repositioned. The modified boiler showed immediately that the outgoing steam could reach the requested temperature of 350 °C. As after one year of operation no thickness reduction was found due to corrosion. The same intervention has been completed on line 2 with same positive results.

Given the excellent results achieved on lines 1 and 2, an intervention on line 3 is planned with a higher goal: allow a superheated steam temperature of 385 °C at the exit of the high temperature superheater in order to completely remove the external gas-fired superheater resulting in huge savings on management costs.

3.3. Hera – Pozzilli (Italy)

Among the three aforementioned interventions, the one made in the Pozzilli plant is undoubtedly the most complex. The intervention was aimed at modifying the vertical arrangement of convective pass of the existing boiler into a horizontal one.

The change, under construction, will be completed in November 2017 and the boiler commissioning is scheduled for December 2017. The modifications performed on the boiler are shown in Figure 7.

As it can be seen, the superheaters and the vaporizer will be removed from the second and the third flue gas passes, so as to create three radiant flue gas pass completely empty. This will allow the temperature to be lowered before entering the convective pass and the gas to be de-dusted.

In the upper area of the third flue gas pass, the existing opening to access the economizer area will be closed and a rectangular section opening will be carried out laterally. From it, the gas will pass through a new fourth empty channel realized with membrane walls, equipped with a flow diverter wall, and will flow into the new convective area, where four new superheaters and a new economizer will be installed. Downstream the new economizer, the gas will be conveyed again in the area of the existing economizers through a duct via a new lateral opening. The plan view shows the new horseshoe-shaped convective zone. This new superheater arrangement allows the boiler thermal profile to be improved, while ensuring that the gas enter the convective zone at lower temperatures, drastically reducing the corrosion phenomena. In addition, the cleaning system used for the new components is our patented hammers cleaning system.
Special attention was paid to the fluid dynamics study of the gas, in order to ensure the correct distribution in new thermal units. In addition, it was also necessary to minimize gas-side pressure drops as the technical specification required very low guaranteed values due to the fact that replacement of the existing extraction fan was not planned.

This type of approach is totally revolutionary for the major revamping cases concerning the existing boilers, as it extends the possibility for all vertical boilers to be turned into horizontal boilers with the known advantages that this implies: less fouling and boilers less subjected to corrosion. This means lower maintenance costs and greater annual plant availability.

4. Ruths boiler for the combustion of MSW and RDF

Thanks to our years of experience in the field of MSW and RDF combustion, both for new plants and for major revamping of existing boilers, our company developed
a project that ensures excellent reliability, minimizes management costs and guarantees a high annual availability without loss in performance due to progressive clogging and corrosion. A typical example of a project of our boilers is shown in Figure 8, related to the San Vittore del Lazio (Italy) plant, located a few kilometres from Rome. It is RDF-fired boiler that produces 60 t/h of steam at 420 °C and 43 bars, commissioned in October 2016.

The main features that allow high reliability to our boilers are:

- Three wide radiant channels: they allow the gas to be cooled down at the entry of the convective pass and thanks to their low speeds greatly help in de-dusting.
- Horizontal boilers: this type of arrangement improves the de-dusting capabilities of the boiler.
- Particular attention to the thermal profile: a good management of the boiler thermal profile naturally reduces corrosion and clogging phenomena, and consequently the number of shut down for extraordinary maintenance.
- External hammer cleaning system, positioned on the top: unlike soot blowers, which are very aggressive or hammer cleaning systems acting on the lower manifolds of the thermal units, our system ensures a good cleaning degree, without increasing the risk of corrosion or mechanical breakage.
- Very easy thermal unit replacement: all superheaters, economisers and even vaporizers, can be replaced without any welding activity because they have flanged connections and they leave our workshop already provided with the Notified Body certification. Therefore, the replacement time of any thermal unit is reduced to less than eight hours.
Air Pollutant Emissions and their Control
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This comprehensive text and practical handbook thoroughly presents the control of air pollutant emissions from combustion processes focusing on waste incinerators. Special characteristics are emphasised and the differences to emission control from combustion processes with other fuels are explained.

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Accordingly, this book is a guideline for planning a reasonable overall concept of an air pollutant control that takes the location and the segregation tasks into consideration. This book is addressed to students, decision makers, planners and the operating practitioners if for example the construction of a new system or the implementation of improvement measures have to be conducted.

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Waste Management, Volume 7
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ISBN 978-3-944310-37-4    TK Verlag Karl Thomé-Kozmiensky

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Publisher: TK Verlag Karl Thomé-Kozmiensky • Neuruppin 2017
Editorial office: Dr.-Ing. Stephanie Thiel, Elisabeth Thomé-Kozmiensky, M. Sc.
Janin Burbott-Seidel and Claudia Naumann-Deppe
Layout: Sandra Peters, Anne Kuhlo, Ginette Teske, Claudia Naumann-Deppe,
Janin Burbott-Seidel, Gabi Spiegel and Cordula Müller
Printing: Universal Medien GmbH, Munich

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