ENVIRONMENTAL COMPLIANCE AND PROFITABLE STEELMAKING – ALWAYS A CHALLENGE!

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SYNOPSIS:

Badische Stahlwerke GmbH (BSW) in Kehl, Germany is located on the river Rhine close to the Black Forest, which is a recreational area. As a consequence, the environmental regulations for Badische Stahlwerke are even more stringent than the already stringent German regulations. Badische Stahlwerke has been elaborating over the years many concepts for the reduction of environmental impact by a steel plant. These concepts deal with the reduction of emissions to air water and soil, but also with the recycling of all by-products from steel making like slag, dust, scale and some others. The success of these concepts can be seen by the very low emission values of BSW and also the profit derived from the recycling of by-products.

Other ideas have been worked out to minimise noise emissions and to detect radioactive sources that are coming together with the scrap into the steel making process. This problem is getting more and more serious.

With the experience of more than 30 years in environmental protection in the steel industry, Badische Stahl-Engineering GmbH (BSE) offers these concepts and solutions to other mini-mills to shorten implementation time of environmental protection and to avoid expensive mistakes.

This paper shows which level of emissions can be reached without having any disadvantage on productivity and gives an overview of various standards and practices in Europe and worldwide.

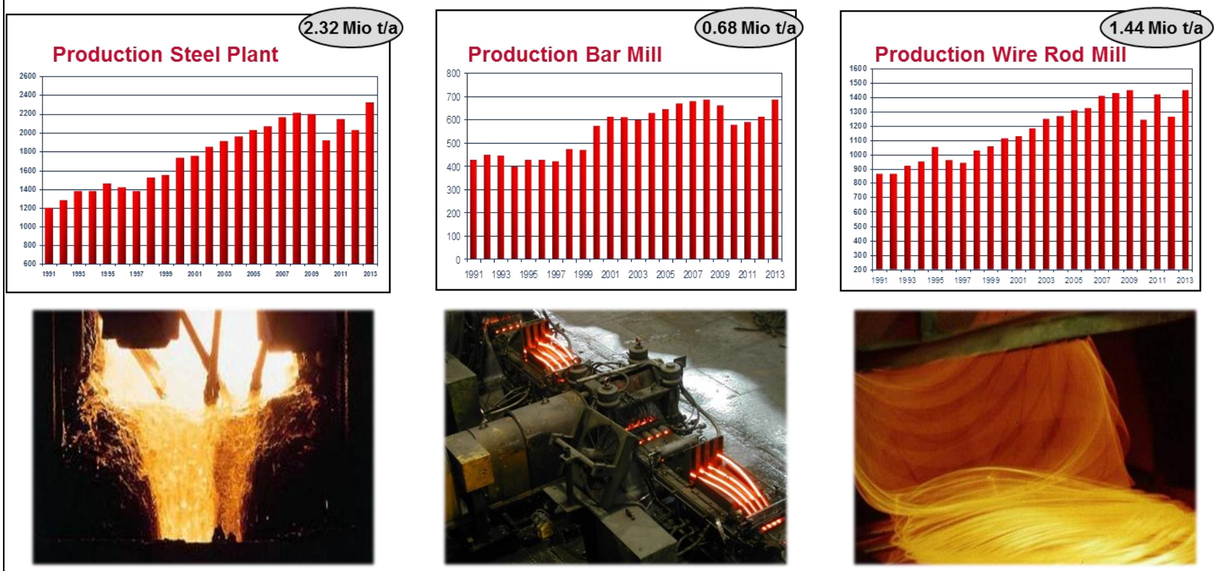
KEYWORDS: Productivity, Emissions, Environmental standards

1 INTRODUCTION AND PRODUCTIVITY OF BSW

BSW, located at Kehl/Germany, is a so-called mini-mill founded 1968 by Willi Korf. The steelmaking facilities comprehend an EAF meltshop with two 100t-EAFs equipped with 90 MVA transformers, an average tap-to-tap time of 40 min and a productivity of 307 t/h for both furnaces, having produced 2.32 million tons of billets in 2013.

The single line bar mill is equipped with BSE multi slit rolling technology and is operated with an availability of 84.2 % of the operating time. The final rolling speed is 10.5 m/s. In 2013, the bar mill reached an annual output of 0.68 million tons at an average diameter of 16.2 mm.

The two strand wire rod mill can go up to 95.5 m/s finishing speed and shows an availability of 89.1 %, which results in a total production of 1.44 million tons plain and deformed wire rod at an average diameter of 8.7 mm.



Key figures		Key figures		Key figures	
Tapping weight	100 t	Type	single-strand	Type	two-strand
Transformer	90 MVA	Availability	84.2 %	Availability	89.1 %
Tap-to-tap time	40.2 min	Final rolling speed	10.5 m/s for 10 mm rebar	Final rolling speed	95.5 m/s for 5.5 mm
Productivity	306.7 t/h				

Figure 1: Main equipment and key performance figures of BSW

2 ENVIRONMENTAL PERFORMANCE OF BSW

2.1 EMISSIONS

2.1.1 BSW DEDUSTING SYSTEM

The dedusting system of BSW was built in the year 1972. The generated off-gases are evacuated directly from the furnace through the fourth hole as well as by a secondary ventilation system in the roof of the meltshop building. With more stringent regulations the dedusting system has grown during the years. The total capacity of the dedusting plant was 1.8 million Nm³/h. To adapt the dedusting system to the modified production and to fulfil the stringent regulations, BSW has optimised the existing off-gas system. The filtration area was increased by 50 % to a total area of 50,000 m². The production lines are now separated completely from each other. The advantages of these modifications are:

- No fugitive emissions
- Less operational cost due to less pressure losses, efficient working power units, intelligent controls
- Improved atmosphere in the meltshop
- Shorter maintenance shutdowns
- Increased safety in case of accidental melting of radioactive scrap

The stepwise project, executed together with BSE and its subsidiary company Bender Corp., started with a fluid dynamic model study. Based on the results of the fluid dynamic model study Bender Corp. developed the conceptual engineering for the dedusting system. The stepwise construction started in the year 2012, and the complete system was commissioned in January 2014. *Figure 2* shows the new arrangement.

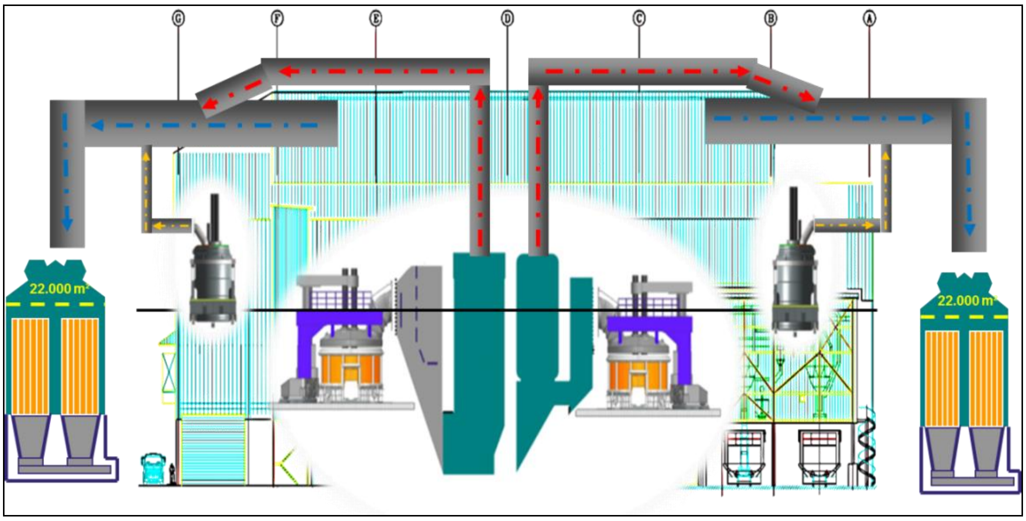


Figure 2: Off-gas arrangement BSW since January 2014

2.1.2 CO_2 EMISSIONS

The allocation process of CO_2 emissions from EAF steel plants started in 2005. Since it is very difficult to measure all CO_2 emissions from the premises of a steel plant, an algorithm for a calculation has been developed. This algorithm is basically a carbon balance of all incoming and outgoing material from the plant including fumes. A rough formula is shown in Figure 3.

$$CO_2\ emissions = \sum C_{content} input\ material - \sum C_{content} output\ material + CO_2 electrode + CO_2\ fuel + CO_2 carbon\ addition$$

Figure 3: Formula to calculate CO_2 emissions from EAF plants

All carbon that is not going out with solid material (steel, slag, dust etc.) is assumed to be converted into CO_2.

According to the verification report for CO_2, verified by Société Générale de Surveillance (SGS), BSW has the lowest emission factor. This ranking was focused on the 20 % most efficient installations, which corresponds to 18 installations out of a total group of 96 that participate in the benchmark exercise for carbon steel production. The ranking itself is based on the sum of direct and indirect emissions. *Figure 4* reflects the development of the CO_2 emission factor of BSW since the year 2000. The bar graphs display a steady improvement down to 59 kg_{CO2}/t_{steel} today.

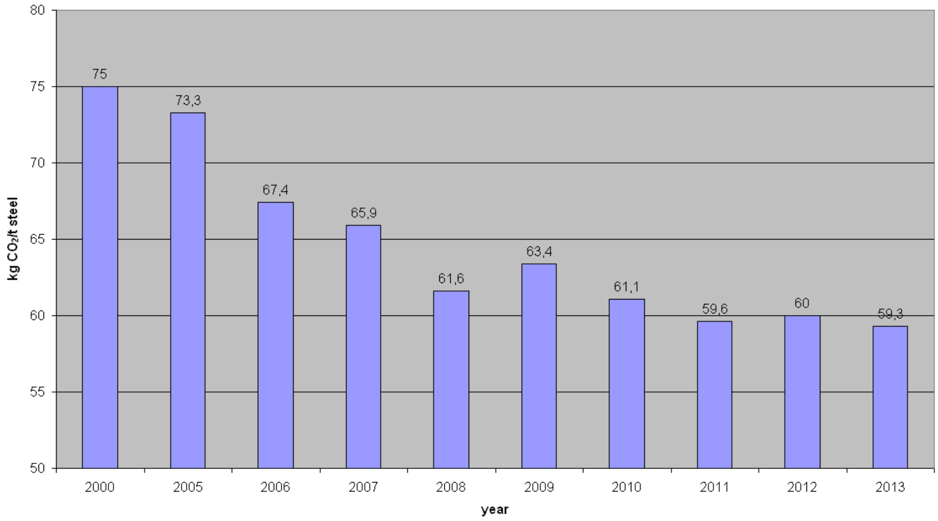


Figure 4: CO_2 emission factor of BSW

2.1.3 DUST

In Germany the limiting value for dust emission for EAF plants is 5 mg/Nm^3. With today's filter technology, it is no problem to comply with this rule. Nevertheless, BSW measures continuously the dust emissions on both stacks. The results are reported to the authorities in real time.

The figures of BSW are far below any limiting values. In comparison with other steel plants, BSW is again in the top range of the emission factors.

2.1.4 Inorganic gas

Nitrogen oxides (NOx) are considered the most important inorganic gas in the EAF process. NOx in an EAF is generated mainly by reaction of nitrogen and oxygen coming from false air in the electric arc. This reaction can be reduced when the air is kept away from the arc. The best way to do this is foamy slag practice. The arc is nicely covered with slag with the effect that the heat energy is transmitted in a more efficient way to the steel bath. As a result, the emission factor of BSW is a benchmark figure for the industry.

2.1.5 Organic compounds

Organic compounds are mainly generated by scrap impurities. Since something like "clean scrap" does not exist, it is not possible to select the input material in a way that we can expect only low organic emissions from a scrap based EAF. The only way to reduce organic emissions is to destroy them in the off-gas system by combustion. This is done in a post combustion chamber that is installed in most of the fume systems to burn carbon monoxide coming from the process. Some of the organics, especially dioxins and furans (PCDD/PCDF), need to be treated with a certain temperature profile to avoid reformation by slow cooling of the fumes. For this purpose, BSW uses the high temperature quenching technology: The gases from direct furnace evacuation are cooled down very fast by injection of atomised water into a water spray chamber.The principle of dioxin reduction by a combination of combustion and quick cooling works for all the organic compounds and is shown in *Figure 5*.

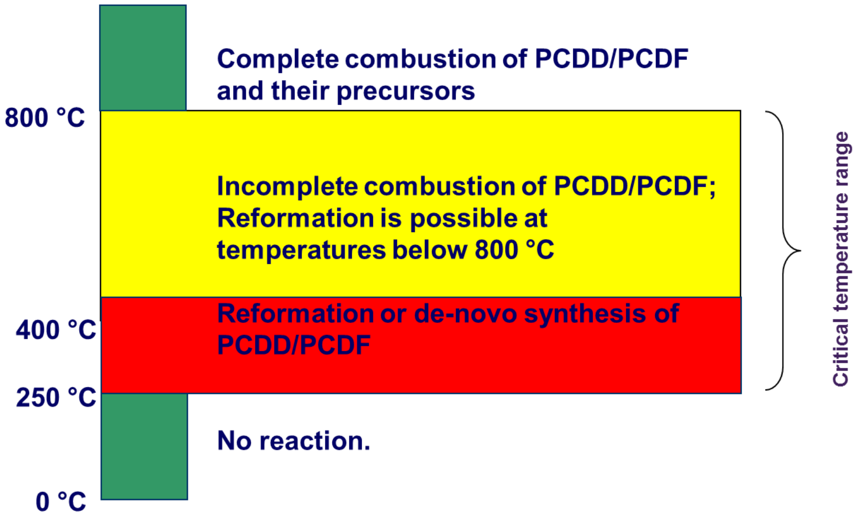


Figure 5: Principle of decomposition of organic compounds

Comparisons with other steel plants in Europe show, that BSW has also low emission factors for PCDD/PCDF as well as for PCB.

2.2 Noise

BSW is located on a narrow peninsula between the river Kinzig and the port basin of the river Rhine. The village of Auenheim is only 300 m away from the melt shop and the scrap yard. As a consequence, in 1976 the first noise measurements were carried out in the vicinity of BSW. After that a 600 m long and 10 m high noise protection wall parallel to the steel plant and the village of Auenheim was built and vegetation planted. In 1987, changes in production and stricter environmental legislation caused BSW to develop an overall noise reduction concept together with a leading technical institute. The main measures for noise reduction were:

- Construction of noise protection wall at the scrap yard
- Construction of noise protection wall at the billet yard
- Noise insulation of the meltshop building
- Noise insulation of the rolling mill building

With increasing production and higher power input the noise levels had been growing again and additional noise reduction measures had to be taken. The main measure was a long noise reduction wall close to the village of Auenheim mainly made of EAF slag. After that investment all the noise levels are still below the limit given by the authorities. Furthermore, permanent noise measurements are done around BSW, mainly in the nearby village Auenheim.

2.3 Recycling of by-products

2.3.1 Slag

The basis of sustainable use of slag is the production of slag aggregates of consistent quality and physical properties together with environmentally harmless behaviour. Standard procedures for slag treatment and its quality control are available and several plants in Europe follow these rules. Only proven and certified slag products can be brought successfully to an only slowly growing market. A detailed market analysis is therefore the first step in a process to produce and sell slag products.

BSW and its subsidiary BSW Stahl-Nebenprodukte GmbH (BSN) have been operating a slag treatment plant for about 20 years. The plant mainly consists of crushing and screening equipment to produce different slag products differing mainly in grain size. First step of the production process is the cooling of the red hot slag with water, which gives certain physical properties to the slag. An additional advantage of the fast cooling of the slag is the minimising of the chrome VI content in the slag. The second step is the separation of magnetic parts with magnetic separators. These metallic parts can be reused in EAFs as a cheap scrap replacement. 100 % of the processed slag is sold to building contractors who use the material mainly for road construction and earth works like dams and walls as well as for bank reinforcement in rivers. None of the material has to be sent to a landfill.

BSN is controlling the quality of the slag products on a regular basis, especially technical properties and environmental impact.

Selling the slag products and using the magnetic parts results in a net profit which makes slag treatment interesting not only for environmental but also for economic reasons.

2.3.2 DUST

For each ton of produced steel 15-20 kg of dust are generated. The main components of the EAF dust at BSW are:

- Zinc 25 %- 30 %
- Iron 10 % - 40 %
- Lead 1 % - 5 %
- Chloride 1 % - 5 %

Zinc and iron are important resources, and it is worth to re-extract them. In a thermal process zinc and iron are separated. In a rotary furnace a mixture of the EAF dust and coke is heated up to 1,100 °C. The outputs are CO_2, O_2, ZnO and Fe.

Costs as well as profitability of the dust recycling mainly depend on the amount of zinc and iron in the dust.

2.4 RADIOACTIVITY DETECTION AND CONTROL

The number of findings of radioactive sources in scrap and therefore also the number of incidents in steel plants where radioactive material was melted have risen during the past several years. Depending of the nuclide either steel, slag or dust is contaminated. Quite frequently, radioactive sources are being, unknowingly or illegally, disposed of. Melting a radioactive source has triggered many decontamination situations. These can lead to high losses of production and also to inevitably high costs. Many companies cannot recover financially from such an incident. To protect your plant from such an incident, an optimised protection management plan is required. It is essential to have a well-trained staff, a functioning measuring equipment and many other measures to protect you and your company. The measuring systems are checked on a scheduled basis to verify their proper function. In a worst case scenario, when a radioactive source is melted in the EAF, an efficient emergency plan is implemented in order to minimise production losses caused by a long shutdown time. With the experience of the past 15 years, BSW has built up a well-functioning remedial system. Detections of the last years are shown in Figure 6. All this contaminated sources were in a size range from 1 cm up to 2 m. It is not a matter of size or intensity of radiation to detect radioactive particles.

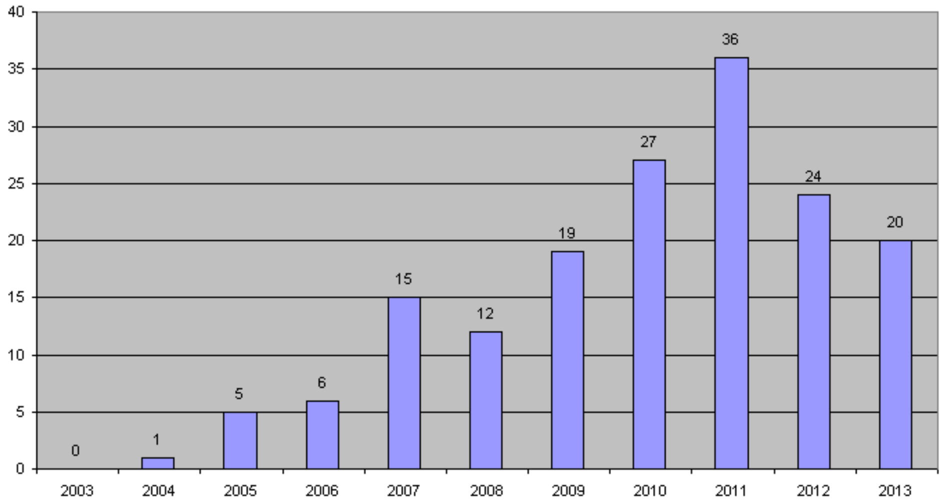


Figure 6: Findings of radioactive contaminated scrap at BSW

2.5 ENERGY SAVING

Energy saving is a fast growing topic worldwide. Resources diminish worldwide, overall energy costs rise fast and regulations become more stringent. Beside this, steel production is a very energy consuming industry. A lot of the energy, translated in form of heat in the off-gases, steel or slag, is lost by cooling down. Additional to the energy management system DIN EN ISO 50001, which contains the overall energy saving procedure, BSW has started different projects to recover energy from the waste heat that is normally released to the environment.

One of these projects is to convert the recuperated heat, generated at the pusher furnace, into electrical energy. This is done with the so-called ORC process (Organic Ranking Process). In *Figure 7* the ORC process is explained schematically. The big advantage of this process is the low heat level at which it works. The realised project at BSW is designed with a piston engine to create electricity. The piston engine is very immune to heat fluctuations compared to a steam turbine.

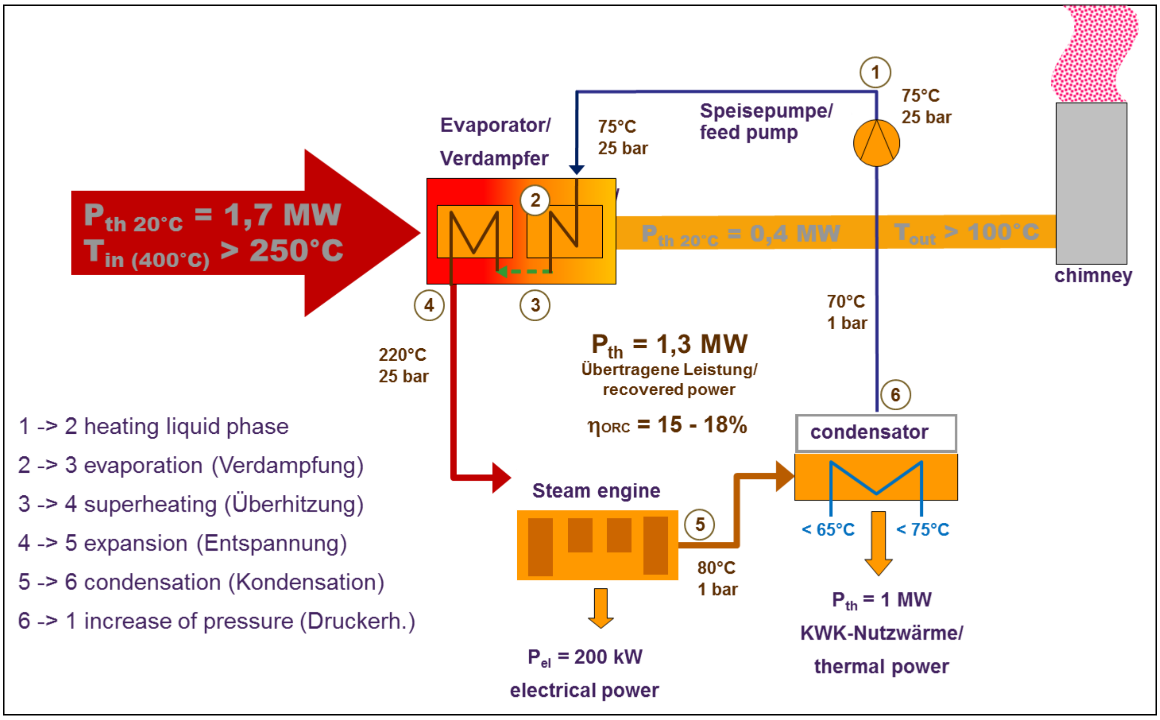


Figure 7: Organic Ranking Process

Another project to re-use the waste heat is a cross-border project to supply a new residential area in the city of Strasbourg/France and parts of the town of Kehl with community heating. In order to build up such a heating grid, high investment is required, but one benefit will be a stability of the price for the energy sold for at least 20 years.

3 Summary

As shown, high productivity of an EAF plant is possible without compromising on environmental performance, especially emissions. Of course, some efforts and investment are necessary to operate today's technology in the right way, and BSW has been investing continuously in environment in order to be in compliance with the latest rules and obligations. There are possibilities, however, to keep track of the costs for environmental efforts, and steelmaking can still be profitable in Europe.