Environmental compliance and profitable steelmaking – always a challenge!

With more than 25 years’ experience of environmental protection in the steel industry, Badische Stahl-Engineering GmbH can offer innovative concepts and solutions to other mini-mills that will shorten the implementation time of environmental protection and avoid expensive mistakes. These concepts deal with the reduction of emissions to air, water and soil and with the recycling of all by-products from steelmaking. Their success is proven by the very low emission values of Badische Stahlwerke GmbH and by the profit derived from recycling by-products.

Authors: Torsten Doninger and Dr Jens Apfel
Badische Stahlwerke GmbH and Badische Stahl-Engineering GmbH

Badische Stahlwerke GmbH (BSW) in Kehl, Germany, is on the river Rhine close to the Black Forest. It is a recreational area so the environmental regulations for BSW are even more stringent than the already strict German regulations. BSW has produced many concepts over the years for the reduction of environmental impact by a steel plant. These deal not only with the reduction of emissions to air, water and soil, but also the recycling of all by-products from steelmaking, such as slag, dust and scale. Their success can be seen in BSW’s very low emission values and the profit derived from the recycling of by-products. Other concepts aim to minimise noise emissions and to detect radioactive sources, which can arrive with the scrap.

TYPICAL EMISSIONS FROM STEEL PLANTS

Emissions from EAF steel plants are linked to input material. All organics and heavy metals enter the process via the scrap and are therefore difficult to control. CO₂ emissions are linked to the fuel and carbon used during the process, either for chemical energy input into the furnace or the burner installations in reheat furnaces in rolling mills. Dust is generated during meltdown of scrap through vapourisation of metals, mainly in the electric arc. Inorganic gas generation is linked to the process itself.

The main pollutants of EAF steel plants therefore are:

- Carbon dioxide (CO₂) Considered a main cause of global warming
On the other hand, the legal situation concerning limiting values for certain pollutants is very confusing. There is no single limiting value for a pollutant that all industrialised countries have in common. The European Union (EU) aims to harmonise environmental law, but it is still a long way from setting common emission values. The only way to get the full picture is to compare the range of emission factors throughout the industry. The current database is not very big but the IPPC office of the EU is publishing emission factors in the ‘Best available techniques’ reference document for the Iron and Steel industry (BREF document). The last release was in 2001, the next is expected in 2011.

ENVIRONMENTAL PERFORMANCE AND PRODUCTIVITY AT BSW

BSW is a mini-mill founded 1968 by Willi Korff. The steelmaking facilities include an EAF melt shop with two 100t EAFs equipped with 90MVA transformers, an average tap-to tap time in 2010 of 42.4min and a productivity of 285t/h for both furnaces, having produced 1.92Mt of billets in 2010.

The single line bar mill is equipped with BSE multi-slit rolling technology and is operated with an availability of 84.9% of the operating time. The final rolling speed is 10m/s. In 2010, the bar mill reached an annual output of 0.58Mt with an average diameter of 15.7mm.

The two-strand wire rod mill can reach 95m/s finishing speed and has an availability of 90.8%, which resulted in a total production of 1.24Mt of plain and deformed wire rod at an average diameter of 8.3mm.

BSW uses state-of-the-art equipment for its fume extraction systems. The generated off-gases are sucked off directly from the furnaces through the fourth hole as well as via a melt shop ventilation system with a combined capacity of 1.8MNm³/h and cleaned in the dedusting systems with a filter area of 38,000m². A schematic drawing of the off-gas system is shown in Figure 1.

Baghouse I takes the primary and secondary fumes from the furnaces; baghouse II takes the secondary fumes only. BSW is obliged to perform detailed stack measurements every three years. Additionally, continuous measurement devices for particulate matter, carbon monoxide and mercury are installed in both stacks.

CO₂ EMISSIONS FROM GERMAN STEEL PLANTS

The allocation process of CO₂ emissions from EAF steel plants started in 2005. Since it is very difficult to measure all CO₂ emissions, an algorithm for calculation has been developed.

This algorithm is basically a carbon balance of all incoming and outgoing material from the plant including fumes, and is shown below.
All carbon that is leaving with solid material (steel, slag, dust etc.) is assumed to be converted into CO₂. A comparison of 10 EAF plants in Germany in 2008 showed that BSW has the second lowest emission factor with 68kg/t of steel and was the lowest for AC furnaces. In 2010, this figure was reduced to 61kg/t of steel.

Also, in comparison with plants from other EU members such as the UK, this figure is a good benchmark. An overview of the results of the comparison in 2008 is shown in Figure 2.

EMISSION OF ORGANIC COMPOUNDS
Organic compounds are generated mainly by scrap impurities. Since 'clean scrap' does not exist, it is not possible to select the input material to ensure low organic missions 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 installed in most fume systems to burn CO 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 through slow cooling of the fumes. The principle of dioxin reduction by a combination of combustion and quick cooling works for all the organic compounds and is shown in Figure 3.

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

EMISSION OF INORGANIC GASES
The inorganic gases of most interest in the EAF process are nitrogen oxides (NOx). NOx is generated mainly by a reaction of nitrogen and oxygen coming from false air in the electric arc. This can be reduced when the air is kept away from the arc. The best way to do this is with a foamy slag practice, which also has other benefits, in that, when the arc is nicely covered with slag the heat energy is transmitted in a more efficient way to the steel bath. As a result the emission factor at BSW is a benchmark figure for the industry.

EMISSION OF PARTICULATE MATTER
In Germany the limiting value for dust emission for EAF plants is 5mg/Nm³ (0.0021 gr/scf). With today’s filter technology it is no problem to comply with this requirement, nevertheless BSW continuously measures the dust emissions on both the stacks. The results are reported to the authorities in real time. The figures for BSW are far below any limiting values. In comparison with other steel plants, BSW is again in the top flight when it comes to...
emission factors. The comparison is shown in Figure 4. The range of emission factors is very high, but at about 4mg/t of steel, BSW is very close to the minimum value.

EMISSION OF HEAVY METALS
Emission of heavy metals is well under control when dust emission is low since they are bound to dust particles. However, mercury is the exception. Mercury metal is very stable but it has a low boiling point and so can pass the filter bags as gas. In principle, there are only two ways to avoid mercury emission: use scrap that is known to be mercury-free or adsorb mercury in the off-gas stream using an adsorbent like activated carbon. The latter is not the preferred solution since it is linked with higher costs.

In a survey BSW found that shredded scrap has the highest mercury content of any scrap type. This comes mainly from the car industry, although, since 1995 the usage of mercury switches in cars has been banned in Europe so mercury content in scrap should reduce in the future.

BSW is also continuously measuring mercury in both stacks to monitor the scrap conditions at any time. The emission factor for mercury is shown in Figure 5 in comparison with other steel plants in Europe. Mercury emissions can vary from one heat to the other. BSW is always in compliance with the limiting value, however, the input material used leads to higher emission factors than in some other plants in Europe.

RECYCLING OF SLAG
Sustainable use of slag means 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 a slow growing market. A detailed market analysis is therefore the first step to produce and sell slag products.

BSW and its daughter company BSW Stahl-Nebenprodukte GmbH (BSN) have been operating a slag treatment plant for about 15 years. The plant essentially consists of crushing and screening equipment to produce slag products that differ mainly in grain size.

The first step in the production process is cooling the red hot slag with water, which gives certain physical properties to the slag. The second step is the separation of magnetic particles using magnetic separators. These metallic particles can be reused in the EAF 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 controls 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 for both environmental and economic reasons.

NOISE
BSW steel mill is situated on a narrow peninsula between the river Kinzig and the port basin of the river Rhine. The village of Auenheim is only 300m from the melt shop and the scrap yard. As a consequence, in 1976, noise measurements were carried out in the vicinity of BSW.

A 600m long, 10m high noise protection wall was built and vegetation planted. In 1987, changes in production and stricter environmental legislation caused BSW to develop an overall noise reduction concept with a leading technical institute.

The main measures for noise reduction are:
- Construction of noise protection wall at the scrap yard
- Construction of noise protection wall at the billet yard
- Noise insulation of the melt shop building
- Noise insulation of the rolling mill building

![Fig 5 Comparison of emission factors for mercury](image)
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 is a long noise reduction wall close to the neighbouring village made mostly of EAF slag. After this investment, noise levels are still below the limit given by the authorities.

RADIOACTIVITY DETECTION AND CONTROL
The number of radioactive finds in scrap and the number of times radioactive material has been melted have risen in the past few years. Depending on the nuclide, steel, slag or dust have been contaminated. Often, radioactive materials are being (unknowingly or illegally), disposed of. Melting radioactive material means decontamination is needed. This can lead to high losses of production time and, inevitably, high costs. Many companies cannot recover financially from such an incident.

To protect your plant, an optimised protection management plan is required. Well-trained staff are essential, as is functioning measuring equipment. Measuring systems should undergo scheduled checks to verify their proper function. If radioactive material is melted, an emergency plan will minimise production loss caused by a long shutdown. BSW has built up a well-functioning remedial system over the past 15 years.

SUMMARY
As shown, high productivity of an EAF plant is possible without compromising environmental performance, especially emissions.

Of course effort and investment are necessary to operate today’s technology in the right way. BSW is continuously investing in the environment in order to comply with the latest rules and obligations. It is possible, however, to keep track of environmental costs, and make steelmaking profitable in Europe. MS

Torsten Doninger is Manager, Environmental Protection at Badische Stahlwerke GmbH, Kehl, Germany. Dr Jens Apfel is Senior Vice President, Consulting at Badische Stahl-Engineering GmbH, Kehl, Germany.