Meeting Environmental Requirements for Future Production

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Meeting Environmental Requirements for Future Production

Abstract.

The highly productive EAF meltshop of BSW reached a yearly production of more than 2.2 million tons of good billets in 2008 which, at the same time, meant the maximum throughput according to the production permit granted from the regional board of the state of Baden Württemberg. Due to its location on the river Rhine and the close proximity to the Black Forest strict environmental regulations apply for BSW which got even more severe with the new production permit granted in 2009 for a yearly throughput of 2.8 million tons of good billets. In order to comply with these regulations, BSW modernized the emission control system. Beside the governmental regulations, the modernized off-gas system has to meet the specific requirements of BSW, taking into consideration its high plant productivity and cost efficiency.

After a comprehensive concept was elaborated, the project realization took place from the beginning of 2012 to the beginning of 2014. BSW increased their baghouse capacity by 50% and with melting and casting emissions completely separated, both EAF lines are now evacuated from one dedicated baghouse and an entirely new automation and visualisation has been implemented.

This paper describes BSW’s approach, the project execution and the achievements after 15 months of operating the new system.
Introduction.

Since its establishment in 1968 and even more since the participation in the Eco-Audit according to EU regulation 1836/93 (EMAS I) in 1997, BSW assures an eco-friendly and ecological coexistence with its environment. Over the years the production of BSW has been steadily increased from about 500,000 t in the early 80's to reliably above 2,000,000 t in the last 10 years (refer to Figure 1).

During this time period, only smaller investments and modifications to the emission control system have been executed, such as the installation of a pocket-filter in 2002 in order to improve the building ventilation.

Along with the approved production permit for 2,800,000 t in 2009, BSW did a detailed investigation of the existing emission control system in order to determine the current utilization of the baghouse, the duct-work, cooling system and building evacuation capacity. By using BSE's and BENDER's expertise in the field of emission control system layouts and revampings, a Fluid Dynamic Model (FDM) study has been executed to determine the necessary modification to the building and the required flow rates for proper building ventilation followed by a comprehensive conceptual engineering project.

The expanded emission control system was started up in January 2014 and operates satisfactory since evacuating offgas from two electric arc furnaces, two ladle furnaces, the ladle preparation stands, providing proper ventilation for the melt shop building and the casting aisle without major delays or errors.

Figure 1: BSW melt shop production development

Initial objective.

For the new production permit, BSW's requirements in terms of emissions and emission control became even more stringent. Baden-Württemberg's control board determined the following requirements:

- No fugitive emissions are allowed from the caster aisle (no emissions from the melting aisle ever since)
- Emissions from sources potentially contaminated with Dioxin/Furan must be captured and guided to the old positive pressure reverse air baghouse
- Dioxin and Furan sources must not be diluted
- Existing threshold values for particulate matter, Carbon Monoxide and Mercury are to remain in force
- Continuous monitoring of Hydrogen fluoride (HF), total carbon and Nitrogen oxide (NOX)

In the same course, BSW's management outlined their requirements for a safer operation and improved building ventilation.

- In order to avoid a counter-contamination of radioactive compounds, each furnace emission control system must be dedicated to one separate baghouse
- Reduced respirable dust on the operating platform (employee’s exposure to dust)
- Lower operation costs by implementing highly efficient motors, reducing the system pressure losses and smart damper control logic
A stepwise Approach.

After a comprehensive evaluation of the existing system in terms of pressure losses, gas flow rates and velocities, temperatures and dust loads, a fluid dynamic model study at BSW’s subsidiary BENDER Corporation in Beverly Hills, CA has been executed. By use of this simulation tool, the building ventilation of the entire melt shop and caster aisle was simulated and the necessary building modifications and required flow rates for a proper roof exhaust was determined.

![Figure 2: Tapping of BSW’s EAF #1 in the Fluid Dynamic Model (FDM) study](image)

At the same time, BSE’s and BENDER Cooperation’s inhouse computer programs determined the heat and off gas amount for the primary emission control system for the anticipated furnace operation for the 2,800,000 t annual production. As a summary of the fluid dynamic model tests and the computer runs for the off gas calculation a Conceptual Engineering (CE) for the entire melt shop and casting aisle was undertaken.

![Figure 3: BSW’s melt shop Process Flow Diagram (PFD) based on FDM and CE outcome](image)
During the conceptual engineering and the subsequent Basic Engineering (BE) – also done by BSW’s subsidiary BENDER Corporation – the new duct routing and the supports of the same (with main focus on the melt shop building) were developed. As BSW’s melt shop was built in the late 1960’s, it has to be detail investigated if the current structure can withstand the future loads from new ducting and auxiliaries.

Therefore a consulting company was consulted to run structural calculations of the entire building including the future loads. Luckily, the building structure was able to withstand the loads with only minor reinforcement at certain bracings and just a few additional bracings mostly for the additional forces.

At this stage all, information for a proper tender document was available. Therefore, several suppliers for steel structures and duct work manufacturing were inquired.

In a next step the associated equipment such as the main fans, dust conveying systems, hydraulics, electrics, automation & visualization has been evaluated and the concept for a reuse and implementation of new equipment has been developed. In close cooperation, BSE and BSW developed the Process and Instrumentation Diagram (P&ID) which served as the foundation for the electrical inquiries.

Figure 4: Schematic overview of the EAF and LF evacuation
Implementation.

The project implementation and realization can be divided into five major segments: the preparation works for the first shut down, the shut down itself, the preparation for the second shut down, the ensuing plant stoppage and the start up.

Preparation works
(August 2012 – December 2012)
Jobs that can be done during the production (e.g. foundations, clearing of duct passages, temporarily supports, cable trays, etc.) and preparation works which are essential for the first plant outage were initiated and assigned to BSW’s standard contractors. The lay-down area in close proximity to the working side has been vacated, leveled, secured and released to the main contractor.

In order to check the quality, accuracy and welding skills, BSE and BSW executed 2 supervision services on site at the fabricator’s premises.

1st shut down
(20.12.2012 – 07.01.2013)
Main focus during this period was on the baghouse platform and the new EAF1 rectangular main fan inlet duct (refer to Figure 5).

In order to clear the future scrap car passage and to level the baghouse extension with the existing elevations, the current round shaped duct could not persist and had to be changed to a rectangular shape. Therefore, the round duct was completely dismantled, the steel structures for the 10 meter elevation platform were built and the new duct was hung from the platform. Finally, connections to the main fans were installed and the fabric for the expansion joint was put in place.

In the meantime a second team embedded the EAF #2 roof exhaust duct (corridor) into the gable peak of the melt shop (refer to Figure 6).

Although this duct was not needed before the winter shut down 2013/2014, its realization reduced the work load for this stoppage and assured a safer workplace for the connection of the main EAF 2 duct.

Figure 6: Corridor installation below gable peak

Two more teams worked on the installation of the new ladle furnace ducts. The new concept of the ladle furnace evacuation system moved the booster fans from the constricted area around the ladle preparation to outside of the shop and therefore new ducts were needed. At the same time, the diameter of the duct has been increased to be able to evacuate more gases during the ladle treatment to reduce the heat and dust load inside the casting aisle. Also these activities were performed with foresight to facilitate the work load during the next shut down.

Preparation works
(January 2013 – December 2013)
In the first quarter of 2013, right after the shutdown, the field measurements were put back into operation, the 10 meter platform of the baghouse was finished and BSW started with the manufacturing of the key components such as the poppet valves and the order for the main fans was placed.
In the second quarter the pre-assembling of the new 4.4 m duct started. At the same time, the foundations for the same have been poured and the electrical programming was executed.

During the summer shutdown 2013 on July 3rd both ladle furnace evacuation ducts were put in place and ladle furnace #1 was entirely completed and started. Subsequently, the baghouse structural works were finished, the baghouse sheeting was put in place, the duct saddles and bearing were installed and the dust conveying system was manufactured.

In the last quarter of 2013 the preparation works for the shutdown were executed. Main fan foundations were cast and the fans were installed, hydraulic piping for the poppet valves was mounted, dust conveyors were pre-assembled, the 4.4 meter duct was erected (refer to Figure 7) and all interfering structures, ladders and walkways were dismantled.

**Figure 7:** EAF #2 main duct installation

2nd shut down  

During 34 working days, the old ductwork on the melt shop roof was completely dismantled and the new ducts (for EAF #1 + EAF #2 primary evacuation, caster ventilation, ladle treatment, material handling system) were put in place. The EAF #2 main duct was connected to the newly erected corridor duct and the old corridor above EAF #1 was completely removed.

During the corridor works, the entire melt shop operating platform was closed so that the inoperative fume capturing hood above EAF #2 could be disassembled also.

The baghouse extension was connected to the existing section and the entire baghouse was then divided into two separate systems. The reverse air system was modified, the old sheeting was removed and the field measurements and limit switches were installed. A newly constructed dust conveying system collects the discharge from the hoppers and conveys the dust via two elevators into two silos.

A completely new motor control center (MCC), a new visualization and damper control logic (PLC) as well as a new hydraulic power unit including valve train were set up and installed.

One more team developed the heat removal hoods at the ladle heating stations and the primary evacuation during the ladle treatment (refer to Figure 8).

**Figure 8:** New ladle treatment evacuation system

Start-up  

On Monday January 27th 2014, the revamped emission control system was released to the BSW production personnel and the first heat was successfully tapped at noon at EAF #1. In the following weeks, the damper settings were fine-tuned and the BSW production, maintenance and electrical people were trained for the new system. Smaller defects were eliminated, e.g. a more powerful motor was installed at one of the dust conveyors and the damper actuators needed a better shielding against EAF radiation.
Achievements.

After one year of operation the entire emission control system performs very well without any delay or interruption. The latest dioxin measurement, executed by the German Control Board – TÜV –, showed a drastic decrease of emissions at the stack from 0,05 ng/m³ (TEF) in 2010 to 0,02 ng/m³ (TEF) in 2014 (BSW’s threshold value is 0,1 ng/m³). Even by taking the volume flow increase of 50 % into consideration, the total mass flow of dioxins has decreased (refer to Figure 9).

BSW measures the dust emissions from the baghouse roof monitors (Q1) and the pocket filter stack (Q2) continuously by means of an extractive scattered light detecting device. The comparison of the 2013 and 2014 dust concentrations can be seen in Figure 10.

This graph shows that the mass concentration has not changed drastically. With an annual average of 0,25 mg/Nm³ for the baghouse and 0,17 mg/Nm³ for the pocket filter in 2013 compared to 0,23 mg/Nm³ and 0,18 mg/Nm³ in 2014, BSW is well below the threshold value of 4,0 mg/Nm³.

In addition to the emissions from the baghouse ventilator and the pocket filter stack, BSW emitted dust also through the roof ventilators above both casters. TÜV measurements at these openings were performed on a regular basis (until the revamping when they were closed) in order to determine the total dust emissions from the shop.

Consequently, the mass flow from all sources need to be compared in order to reflect the improvements from the revamping (refer to Figure 11).

95 % of the dust emitted to the environment came from the casting aisle roof ventilators (Q3) while the stack of the baghouse (Q1) and of the pocket filter (Q2) contributed only 3,8 % and 1,2 % respectively. Therefore, the total mass flow of dust was reduced by about 93 % from 7,9 kg/h to 0,5 kg/h.

Figure 9: Dioxin emissions of BSW

Figure 10: Stack dust concentration of BSW

Figure 11: Dust mass flow of BSW
Since the European Union banned mercury switches in cars in 1995, the stack emissions at BSW are well below the threshold value of 50 μg/m³ and after the revamping dropped from 18,90 μg/m³ in 2013 to 8,75 μg/m³ in 2014 (refer to Figure 12).

In order to comply with the requirements from the authorities, BSW is forced to continuously monitor hydrogen fluorides (HF), total carbon and NOX as a combination of nitric oxide (NO) and nitrogen dioxide (NO₂) since 2013. Threshold value for hydrogen fluoride is 1,50 mg/Nm³ and the annual average has dropped from 1,10 mg/Nm³ to 0,16 mg/Nm³ (refer to Figure 13).

A Fourier Transform InfraRed (FTIR) spectrometer measures continuously the NO content at the baghouse stack. Due to the fixed correlation of NO, NO₂ and NOX, the NOX emission is internally calculated and monitored. BSW’s NOX emissions are far below the threshold value of 50 mg/Nm³ and has drastically decreased after the revamping (refer to Figure 15). This reduction can be explained by the adapted damper control which assures a proper EAF evacuation with lowest infiltrated air.

Total carbon emissions has decreased from 6,61 mg/Nm³ throughout 2013 to 2,75 mg/Nm³ in 2014.
Next to the official measurements, which are also reported to the authorities, BSW did their own investigations in order to determine the improvement on the building ventilation and the spark reductions at the baghouse. For the building ventilation evaluation, Bergerhoff-Samplers were placed in crucial locations on the operating platform and the dust fallout during a certain period of time was compared to the previous year. In Figure 16 a reduction of more than 15% of dust settlement on the operating platform can be seen.

In order to track the amount of sparks entering the baghouse, a spark detecting unit was installed in the main duct before the main fans. This tool enables BSW to compare the amount of sparks before and after the revamping. A drastic drop of sparks at the bag house can be seen in Figure 17. 18 consecutive heats were observed and the amount of sparks per heat dropped from 197 to 51.

Since not only the quantity but even more so, the quality of the sparks is important, the amount of spark holes in the filter bags were counted and compared to the situation after the revamping. This evaluation is still ongoing, but the tendency shows that much fewer spark holes damage the filter bags than before.

By applying spark-resistant layers to the existing filter bags BSW expects to reduce the maintenance efforts for spark hole plugging during operation to zero.

Figure 17: Spark detection at BSW

It is also worth mentioning that the new dust conveying system comes with the expected benefits. Although only running for one year, the drastically reduced wear on the chain and the wear-blades can be seen due to the frequency controlled drives that reduce the speed of the chain during normal operation. An increase in lifetime – especially for the chain – from two to up to eight years is anticipated.
Conclusion.

After one year of operation, BSW concludes that it is worth considering all aspects related to a revamping of the emission control system. This starts with a close cooperation with the authorities, a proper concept to be followed, and a competent project team in place with foresight for the future regulations and production. Most importantly, the FDM model study demonstrated in detail the necessary modifications and today’s achievements can be ascribed to the initial tests performed in 2010.

Acknowledgments.

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Abbreviations.

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<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>BE</td>
<td>Basic Engineering</td>
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<td>BSE</td>
<td>Badische Stahl Engineering GmbH</td>
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<tr>
<td>BSW</td>
<td>Badische Stahlwerke GmbH</td>
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<td>CA</td>
<td>California</td>
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<td>EAF</td>
<td>Electric Arc Furnace</td>
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<td>EU</td>
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<tr>
<td>FDM</td>
<td>Fluid Dynamic Model</td>
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<tr>
<td>FTIR</td>
<td>Fourier Transform Infra-Red</td>
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<td>HF</td>
<td>Hydrogen Fluoride</td>
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<td>LF</td>
<td>Ladle Furnace</td>
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<tr>
<td>MCC</td>
<td>Motor Control Center</td>
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<td>NOX</td>
<td>Nitrogen Oxides (NO and NO₂)</td>
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<td>PFD</td>
<td>Process Flow Diagram</td>
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<td>PLC</td>
<td>Programmable Logic Controller</td>
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<tr>
<td>P&amp;ID</td>
<td>Process and Instrumentation Diagram</td>
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<tr>
<td>TEF</td>
<td>Toxic Equivalency Factor</td>
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<td>TÜV</td>
<td>Technischer Überwachungs-Verein</td>
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