BSE NEWS
BADISCHE STAHL-ENGINEERING GMBH THE BSE STEELMAKING MAGAZINE 1 | 2016

EDITORIAL

Dear valued friends,

The massive influence of China on the global steel market has been the prevalent topic of the last months, forcing steelmakers worldwide to increase their efficiency and innovative capacity.

For more than 30 years, BSE has been supplying steelmakers with products & services for efficiency increase by optimisation of equipment and processes. Additionally, BSE has been developing innovative products for the mega-trends safety and environment.

I am proud to present you some of our latest projects and product developments for these challenges on the next pages. How to master these challenges together will be also the main topic of our next BSE Symposium in 2017 (see preview on page 7). I would be pleased to welcome you to this event which will be hosted at an interesting new location near our premises in Germany.

With the best personal greetings

Torsten Rummler
Managing Director

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Survival of the Fittest in Times of Overcapacity

Consulting for Cost Reduction and Efficiency

Being efficient is crucial to survive. This applies to steel plants all over the world – also in China, where the huge steelmaking overcapacity shall be reduced substantially by governmental policy. As a consequence, BSE has been conducting several consulting projects with steel plants in China and other countries in order to improve their cost efficiency, thus to be among the fittest.

Mini-Mill Culture

The customers for the consulting projects are integrated plants as well as EAF based plants with various steel grades and steelmaking equipment. The target of BSE is to optimise their productivity and efficiency by smart adaptation of selected method and technology from mini-mills, based on the experience of the own steel plant BSW – one of the world's most successful mini-mills.

BSW mini-mill in Kehl / Germany – an example for operational and cost efficiency

Many mini-mills have very similar equipment and material flow. But, what has made BSW to one of the most efficient mini-mills of the world can be described to the point with the widely-known **"Badische Philosophy"**: Educated and well-trained people care for reliable equipment, and high productivity leading to low cost production.

Project Approach

Transforming this philosophy into appropriate, feasible targets is the first task of the BSE consultants and customer management.

Subsequently, a team of BSE/BSW experts does an elaborate investigation at the customer plant and develops concrete measures together with their customer counterparts.

The next integral part are management seminars and operation / maintenance seminars for selected customer personnel at BSE/BSW in Germany.

Finally, BSE assists the customer with implementation of the measures by few follow-up visits at the customer site.

Seminar groups of Nanjing Iron & Steel at BSW – Classroom training and plant observation with BSW/BSE personnel

Current Projects in China

The following overview of current BSE consulting projects for cost reduction shows a clear focus on China:

- Nanjing Iron & Steel
- Shandong Laigang Yongfeng Steel
- Zhuhai Yueyufeng Iron & Steel
- Maanshan Iron & Steel

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The new Finite Network Method – uniquely with BSE – allows for precise Calculation and Simulation of EAF High Current Systems

Optimisation of Electrical Components with Finite Network Method (FNM)

To date, the electrical design of arc furnace high current systems – especially current conducting electrode arms and transformer bus-tubes – is mainly based on experience and very basic modelling and according to unrealistic electrical calculations. BSE is exploring new ways of improved design of AC and DC arc furnace high current systems with the Finite Network Method (FNM), featuring a high-accuracy calculation of all electromagnetic effects of high current systems.

Background / Development

BSE's high-accuracy calculation is based on the innovative work of Prof. Farschtschi and has been further developed for application at EAFs by BSE electrical experts. The Finite Network Method allows for the first time to accurately calculate properties of the high current system that were inaccessible in the past and thus allows to ultimately explore potential for optimisation.

Application

In general, BSE utilises FNM as a standalone computation service for optimisation of existing customer equipment as well as for tailor-made design of electrical hardware components delivered by BSE, e.g. current conducting electrode arms.

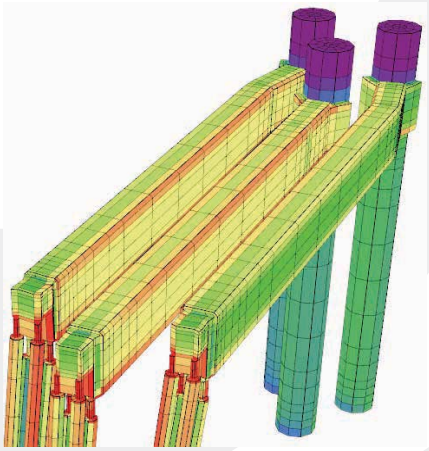
Specific optimisation potential is mainly hidden in:

- Regulating performance and power input:
  - Reduced dynamic unsymmetry by design
  - Direct arc voltage regulation by realistic real-time calculation of inductive couplings
- Mechanical design based on exact forces and momenta
- Loss optimised design

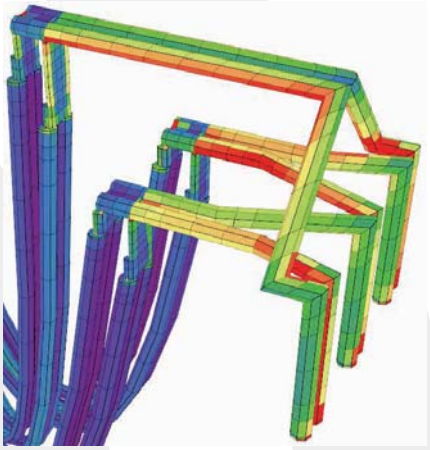
FNM allows for realistic calculation of:

- Current density at each point of the high current system (determines the local electrical and thermal stress in conductor material)
- Exact short circuit impedance and unsymmetry. Short circuit tests (dip tests) will not be necessary any more.
- Measure the real arc voltages in real-time, improve regulating performance
- Real static and dynamic forces and momenta acting on the mechanical system (masts, roller guides, electrodes, cables)
- Magnetic field strength at any point around the furnace including shielding effects
- Induced eddy currents in peripheral conductive parts of the furnace (heating by losses)
- Consider the effects of ferromagnetic material like steel

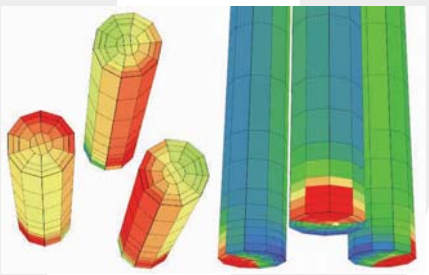
Examples



Current displacement towards the edges of the arms, indicating the high load of the cable connections. Compared to the upper parts of the electrodes the difference in current density magnitude is of order 1:100.



Very inhomogeneous current density distribution at the external delta closure of the transformer. Local differences are of order 1:5 up to 1:10.



Situation inside the graphite electrodes. Clearly visible is the proximity effect and the current displacement outwards (skin-effect). The current density differences are varying and are of order 1:2 over the length, but of order 1:100 at the tip.

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Using the Latest Current Conducting Arm Technology together with the FNM

EAF Modernisation at Arkansas Steel Associates (USA)

In November 2015, BSE successfully installed the latest and most advanced equipment at Arkansas Steel Associates (ASA) in Newport, AR.

Project Approach

BSE previously commissioned successfully a TempSamp Manipulator at ASA in 2009, since then ASA and BSE had a very close relationship.

In 2014, ASA was asking to find a custom-made solution for their non-sturdy superstructure. When the project was jointly defined, it became clear that it was also necessary to upgrade other components at the EAF. The goal was a higher reliability and more power input in order to reach the highest possible productivity.

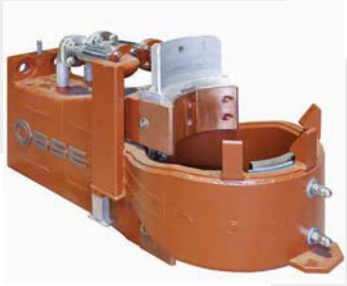
Scope of Supply

The conventional bus-type arms had to be replaced by the new innovative BSE current conducting Arms, together with new columns, state-of-the-art roller guides and the mentioned superstructure.

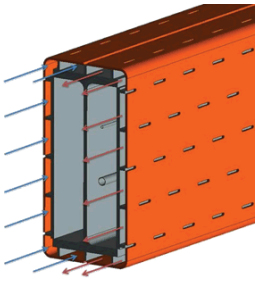
The main challenge of the project was initially the project time of less than nine months. BSE delivered the entire detail engineering in consideration of all local circumstances and with the aim to design a reliable and top performing furnace. State-of-the-art electrode lifting cylinders and the electrode guiding system were delivered by BSE. The manufacturing of the other equipment was made under the customer's scope in North America and Europe.

New Electrode Arms

BSE developed a new design for conductive electrode arms with a steel body and flanged holder.



New BSE design for electrode arms with copper and steel

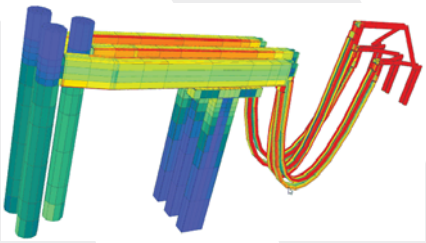


Cooling water flowing inside the gap between steel and copper

The BSE design does not rely on copper plating, but on a separate copper shell that surrounds the steel body with a gap. The copper shell is suitably welded to the steel body.
The advantage of this design is the very direct and homogeneous cooling of the current-carrying copper surface. Due to the high copper thickness of 10 mm, the current flow is optimised and the resistance is lower than with the conventional design. Furthermore, the negative impact from the "skin effect" is reduced to its minimum. On a conventional arm the currents tend to go to the corners, but with this new design the corners are round and bent (not welded anymore). From the maintenance perspective, the arm is easy to repair in case of arcing, because it can be patched (welded) with a standard copper sheet. So far, at none of the installations has this been necessary.

Application of FNM

To calculate the perfect power input design matching to this furnace, BSE used the new Finite Network Method (see page 2)



Extremely inhomogeneous current density distribution prior to the modernisation

Results / Benefits

The project implementation was done within 14 days of stoppage.
Also the operating results are excellent with the new copper / steel electrode arms. At ASA the bus tube arms with a long phase 2 have been exchanged by the new BSE design simulated with FNM beforehand. ASA reports an increase in power input by 1 MW on average and an improved power factor. Congratulations to ASA and thanks again for the great project!

Installation of components at ASA site

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Innovative Tool Exchanger providing new Functions and achieving Real Multifunctionality

Upgrade of BSE MultiROB with Automatic Tool Exchanger and Door Camera

Making complicated things simple. The new tool exchanger for the MultiROB follows this classic BSE principle by enabling a quick and easy exchange of tools for multiple applications at the furnace. Hence, beside the classic TempSamp function the tool exchanger allows also for flexible usage of a camera tool for furnace inspection – both tested and proven at BSW.

TempSamp Function

In the first stage of its development, the MultiROB was able to perform temperature measuring and sample taking. The cartridge exchange (in safe distance from the furnace door) is done either manually by the operator or automatically by means of a special cartridge rack.
BSE robots with this function are in operation in Asia and Europe.

MultiROB with classic TempSamp function installed at NISCO (China) ...

... and at Outokumpu Avesta (Sweden)

NEW – Tool Exchanger

The next step was to give the MultiROB more functions by using a tool exchanger. Since no simple and rigid solution could be found on the market, BSE has developed its own tool exchanger.
The BSE solution ensures highest flexibility at lowest maintenance effort. No pneumatic or hydraulic cylinder for clamping is needed. Also no limit switches indicating the tool readiness are implanted. The reason is the same as with the cylinders: The lifetime of such equipment operating at or in the EAF would be too short and maintenance intense. Furthermore, if there is a failure, the operator has the opportunity to attach (hang) the tool manually.

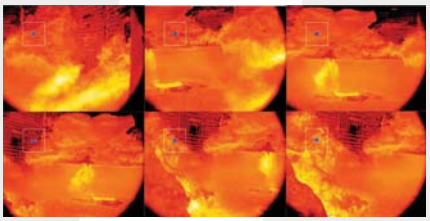
Tool exchanger in operation at BSW

Simple mechanical solution with special plates mounted on the tool to be used (left side) and robot arm (right side)

NEW – Door Camera

In order to increase safety and flexibility of furnace inspection, the idea came up and has been realised to equip the MultiROB with a door camera.
At the end of the heat, the TempSamp tool is quickly replaced (with the new tool exchanger) by a special camera tool, consisting of a thermal camera attached to a lance. The MultiROB carries the camera through the furnace door into the furnace, where it performs a predefined movement (different positions and angles) with the following tasks:

- Detection of skulls
- Searching for cooling panel leakages
- Scanning of refractory status
- Visual bath level measurement



Automatic EAF inspection with thermal camera at BSW

The system was successfully implemented at BSW and has been supporting the operators with furnace inspection, mainly detection of skulls and leakages, since.

The next idea is to combine the scanning of refractory status with gunning machines, i.e. the gunning machine shall receive the information from the camera in order to prepare / calculate the next gunning process according to this information.
BSE will keep you updated on this and further developments.

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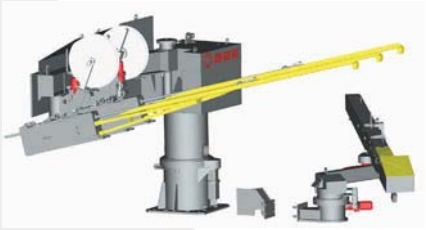
Flexibility of TSM Components for High Variety of Applications and Functions

Installation of First BSE Converter TSM and Axis-Controlled TSM at Tokyo Steel Kyushu (Japan)

Beside the MultiROB with its multiple applications, also the conventional TempSamp Manipulator (TSM) is upgraded continuously and adapted to specific customer equipment and conditions.

TSM Smart

The concept of the TSM Smart comprises a fully functional TSM unit added to a classic BSE lance manipulator by using the existing foundation and steel column of the lance manipulator. The TSM Smart together with the oxygen / carbon lances of the lance manipulator unit provide efficient slag door injection and accurate TempSamp function in one tool from one furnace side – no additional floor space is required.
The new TSM Smart is suitable for most existing classic BSE lance manipulators.



The new smart TSM unit (right) ...

... added to the lance manipulator without modification of its column

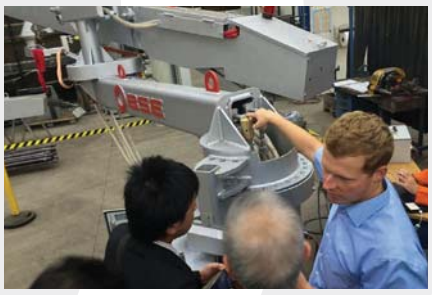
TSM for Converter

The customer intended to improve safety for its operators and increase productivity by replacing the manual temperature measuring / sample taking with an automatic manipulator.
The solution, mutually developed and engineered by BSE, comprises two identical, interchangeable TSMs for the two converters. While in parking position, the installation on the tapping side and the compact design of the manipulator leave enough work space in front of the converter and provide easy access to the manipulator for cartridge exchange and maintenance. Immediately before tapping, the temperature measurement and sample taking is performed simultaneously by means of a moving carriage. Due to the high flexibility of the manipulator, measuring is feasible at tilting angles from 65° to 90°, different refractory levels and skulls up to 750 mm.

Both TSMs were installed and started-up in March 2016. Beside the safety aspect the TSMs have also increased reproducibility, flexibility and resulted in a time saving of 2 minutes per heat compared to the old measurement practice.

TSM Axis-Controlled

BSE was awarded with the engineering and supply of a TSM for the 130 t DC EAF at **Tokyo Steel Kyushu** plant in Fukuoka (Japan).
The special space situation at site required a tailor-made solution and new approach.
BSE engineers designed a new generation of TSM that is equipped with a new axis control system.
With this new technology higher flexibility and a higher safety standard for operators are available.
The successful installation of the TSM took place in August 2015 within budget, schedule and expected results.



Explaining the functionality of the axis control system at BSE shop test

Team of Tokyo Steel and BSE after successful installation

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Clean and Efficient – Applied to Any Furnace Type, Size and Operation

High Temperature Quenching (HTQ) Technology for different Furnaces in Asia and Europe

Legislation on emissions becomes more stringent every year. This has been affecting also the steel industry, forcing it to invest in suitable offgas system equipment.

The new offgas systems must meet the local governmental limits in terms of dust, dioxins and furane, but they must be also capable of managing today's and future heat and dust loads of the furnace. Additionally, good environmental working conditions for the employees shall be achieved by applying the necessary exhaust to the building.
BSE also provides solutions to these challenges: various analysing tools (e.g. Fluid Dynamic Modelling), engineering services up to complete offgas system modernisation with High Temperature Quenching (HTQ) technology as a key component.

The HTQ rapidly cools the gas from the direct furnace evacuation by **injection of atomised water through spray nozzles in a special cooling tower**. Beside the reduction of dioxins and furane, the HTQ increases the dedusting system efficiency by reducing the DEC system offgas volume and dust load to the filter. The water-spray nozzles can also be used separately in water-cooled ducts as"peak shavers", causing a better bag house utilisation by reduced and stable temperature.

The following overview of BSE's latest HTQ projects shows that the HTQ technology is applicable for various furnace types, sizes and operations:

Consteel Furnace

One customer had to comply with new limiting values for dioxins and furane emissions and therefore decided to equip the Consteel furnace (130 t) with the BSE HTQ technology.
Based on measurements at site and desktop analyses, BSE together with the customer developed the technical solution consisting of one cooling tower (engineered by BSE and constructed by the customer) equipped with 26 spray nozzles, one valve rack with two water booster pumps and the necessary electrical equipment.

Compact arrangement of HTQ components: inlet duct (right), cooling tower and valve rack (behind blue housing)

Conarc Furnace

The intention of another customer is to increase production of its meltshop (4 Conarc furnaces) from 2,9 million tons presently to an annual amount of 5 million tons. To reach this target the offgas system requires an upgrade to cope with the new situation. Furthermore, the design of the upgraded system must consider the limited baghouse capacity as well as the combination of converter process (with oxygen injection up to 24.000 Nm^3/h due to high content of DRI and hot metal) and EAF process.
The actual scope of supply was determined by an engineering study of the complete offgas system prior to the hardware upgrade, which finally consisted of tailor-made HTQ systems for all four furnaces.

Conventional EAF

Another customer operates two 95 t EAFs (one carbon steel furnace and one stainless steel furnace).
The existing fume emission control system from 1994 caused too high temperatures at the baghouse as well as high pressure drop and duct wear, leading to comparatively low dedusting efficiency.
After a furnace modernisation in 2012, featuring also a new BSE Lance Manipulator and Virtual Lance Burners, the heat load of the dedusting system increased even further.
As a consequence, BSE was awarded with a conceptual engineering study of the entire fume emission control system in order to adapt the system to the future production requirements with the aim to reuse most of the existing parts. The customer decided to implement some of the recommended measures, including a new damper control system, extension of the existing baghouse, new impellers and replacement of the force draft cooler by a HTQ chamber. A new dry duct will connect the exit of the HTQ chamber with the existing canopy exhaust.

Final test of HTQ valve rack at Badische workshop prior to shipping

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BSE Events: Learning and Networking – From Steelmaker to Steelmaker

Academy Course Programme 2016 and Preview BSE Symposium 2017

BSE Academy 2016

The 2016 programme of the BSE Academy features courses with various steelmaking topics for different skill and hierarchy levels. Apart from the acquired know-how, the course participants also appreciate and benefit from the exchange of experience with the participants from different companies.

- June 20-23
  EAF Electrics for Electricians
- July 05-07
  Preventive Maintenance in EAF
- September 26-30
  Environmental Challenges for the Steel Industry
- October 10-12
  Rolling Process and Technologies for Long Products
- November 07-09
  Process Metallurgy

Outlines of each course and detailed information on how to register can be found at our website:

www.bse-kehl.de

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New Symposium venue in the heart of the spa town Baden-Baden in Germany close to BSE/BSW

SAVE THE DATE

BSE Mini-Mill Symposium 2017

From **April 2 to April 5, 2017**, BSE will host the 6th International Mini-Mill Symposium in the famous spa town **Baden-Baden / Germany**.

Under the motto **"Together to the TOP"** (**T**echnology, **O**peration, **P**eople) BSE once more will provide you an ideal platform to experience the steelmaking community and to network with colleagues from all around the globe.

The Mini-Mill Symposium is an invitation only event. The **invitations will be sent out in summer / autumn 2016**.

If you would like to get more information about this event respectively receive an invitation, feel free to contact us by E-Mail or phone.

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Look forward to presentations given by high-level management and experts from all around the globe ...

... together with an enjoyable and memorable social programme