SMS Demag’s ARCCCESS® EAF Technology
Successful furnace design concepts and benefits

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Abstract
SMS Demag and the other companies of the SMS group have built more than 1300 electric arc furnaces worldwide and have now implemented different design concepts and customer solutions under the new EAF family name “ARCCCESS®”. The report describes in detail the features of this design concept, the productivity and the reference plants.

Our customers’ requirements resulted in SMS Demag designing EAF-based steelmaking plants with very high productivity and design capacities of 2.0 million tons per year or even more. In order to meet these requirements, SMS Demag had to focus on the following tasks:

§ EAF design improvements, e.g. unique lower shell changing system or special design for high amounts of hot metal
§ Improved process technologies and equipment, e.g. SIS oxygen injection system with multiple support for the meltdown process with burner post-combustion and supersonic injection process mode
§ Flexibility in the selection of possible charge materials, e.g. reliable equipment for hot metal charging or single bucket charging
§ Intelligent automation software modules for electrode regulation and level 2 systems

Furthermore the report presents reference plants which are already successfully in operation, under construction or in the project phase.

An example for efforts to overcame limitations is the CONARC® process as a part of the ARCCCESS® family. This process combines both EAF and BOF technologies and fills the input gap between the classical production routes. Benefit for customers is the awarded flexibility in terms of input materials.

SMS Demag's ARCCCESS® technology allows our customers to produce steel using the best technologies available on the market, taking due account of the flexible use of charge materials, thereby ensuring lowest production costs.
1. Introduction

SMS metallurgy comprises all companies within the SMS group that serve the global metals industry. Within SMS metallurgy, the following well-reputed companies are available to meet customers’ demands:

The SMS metallurgy companies supply the complete range of technology for metals production and processing, starting with liquid-steel and ferroalloy production and extending to finishing line and processing technology even for non-ferrous metals.

For steelmaking and casting technology, SMS Demag including its affiliate MEVAC are responsible for the technologies needed to produce flat products either via the BOF converter route, the electric steelmaking route and combined process technology and, furthermore, for the entire process for stainless steelmaking. Additional services like turnkey solutions, electrical and automation systems, maintenance strategies and financing are also a part of SMS Demag's product line.

The company CONCAST, a member of the SMS group, serves the market for long-product electric steelmaking and casting technology.

2. ARCCESS® Electric Steelmaking technology

Since the beginning of 2004, SMS Demag and CONCAST have been cooperating in the field of electric steelmaking technology by sharing their profound knowledge and developed solutions as well as their experience gained from numerous references in the worldwide market.

The common arc furnace strategy led to the ARCCESS® philosophy which focuses on the customer's “Total Cost of Ownership (TCO)” to indicate the real value of an investment based on superior design competence and advanced process know-how.

ARCCESS® stands for customer's success in electric steelmaking.
The following overview is a brief introduction to the major field of improvements:

- Improved technology devices for electric steelmaking process
- Optimized production concepts depending on the charged material
- Environmental concepts
- Automation and control

### 2.1 EAF melting and refining process solutions

Modern arc furnace technology does not depend on the use of electric energy alone. Oxygen and carbon lance systems as well as shell-changing concepts featuring a split-shell design help to minimize not only power-on but also power-off times, thus optimizing the overall steel output to yield the aimed-at high productivity level.

Further potential has been detected in the single-bucket charging operation and customized control and automation packages.

An extended refractory lifetime and minimization of energy losses by superior design also support the efficient furnace concept.

The **ARCCESS®** technology focuses on customers’ benefits. Therefore, further improvements have been developed for electric arc furnace operation. This especially means minimizing EAF power-off times and regular downtimes.

**One-bucket charging**

For example, the single-bucket charged furnace can minimize the EAF power-off time. This operational benefit has proved its efficiency at Nucor Jewett where it has been in operation since the start-up of the furnace with a successful performance.

Today the furnace operates at a very high production level of 39 heats per day.

**Split-shell design**

Another major improvement is the use of the split lower shell design. This concept saves maintenance time by allowing a quick furnace restart.

The ring between the lower and upper shell can be removed separately. The ring is designed without any cooling, so no flexibles need to be disconnected. The plates used are installed in such a way that they can expand independently. The ring can also be used for water distribution.

The major benefit is the possibility of separately removing the upper ring of the lower shell. In the case of a retrofit installation of cooling blocks, these are installed also in the upper ring of the EAF lower shell.

This technology can be used even in existing furnaces, thereby avoiding the need to increase the overhead crane capacity.
SIS injection technology

In recent years a clear goal of all producers of steel based on the EAF technology was to improve the productivity of their equipment. The reduced tap-to-tap time was achieved by the introduction of oil or natural gas burners, oxygen technology as well as by an increased electrical power input of up to 160 MVA.

Consequently, a foamy slag practice was developed for the flat bath period to handle the electrical power input without harming the furnace roof and walls. An improved productivity with a reduced tap-to-tap time also reduces energy consumption. This method quickly became general practice in the steel industry. Handling of the lances through the furnace door, however, required manpower and had its operational limits.

This development had to consider the following:

- There was the necessity that the oxygen not just had to reach the bath but also had to penetrate the slag layer at varying bath levels.
- The oxygen nozzle had to be protected to keep it free from slag and to maintain its flow characteristics.
- The solution to the previous point must not, as it frequently does, lead to high media consumption.

SMS Demag’s experience with third-party wall mounted lances was not satisfactory. So in the end it was decided to develop our own solution.

The outcome was an injector design distinctly different from the coherent jet technology known so far.

This design of the SIS Injector features a highly efficient oxygen injection technology. Air and natural gas are burnt inside the injector. This hot combustion gas to passes through a nozzle at the tip of the SIS injector to provide a hot high speed shrouding around the central oxygen jet which leaves the internal Laval nozzle at supersonic speed. The high speed of the hot gas means that there is no friction between the central oxygen stream and its immediate surroundings (iso-kinetic shrouding). The hot gas shrouding keeps the oxygen jet focused and its momentum preserved, even over long distances.

Extensive CFD calculations led to the optimum injector design. An important feature is that the sensitive Laval nozzle is placed in a retracted position where it is protected by the hot gas flow against the aggressive splashing slag. The injector opening of this design has been restricted to a minimum.

The low media consumption when the jet is in idle mode is a distinguishing feature of this design. Kaptan Demir Celik, a Turkish steel plant, first had a single SIS injector installed for a period of six months. The results are shown in Table 1. As a consequence, the furnace was fitted with a complete set of injectors this summer. In the EAF production tests, the SIS proved its efficiency by yielding extremely low production cost, stable operational parameters, thus providing a successful instrument for increasing productivity.
Two examples are given for the possibility of using ARCCESS® to optimize the production routes and process:

**DRI charging**

Modern arc furnaces are not only used for the production of steel based on 100% scrap charge only. Modern minimill concepts especially for the production of flat products are asking for steel limited in the content of tramp elements, e.g., copper, tin and other elements. These harm the mechanical properties of the steel for its further application.

Still the only way to control the chemistry of steel with regard to these elements is to control the scrap mix by the addition of virgin iron-bearing material such as DRI, HBI, pig iron and/or hot metal.

One of the most popular virgin iron-bearing materials is DRI or HBI. Depending on the steel grade to be produced, it is charged into the EAF in different amounts. Due to its smelting behavior both DRI / HBI is charged continuously.

The disadvantage of using DRI/HBI is, in fact, the increased electric power consumption. The situation can be improved by charging the DRI in hot condition. When doing so, an incoming DRI temperature of up to 600 °C is realistic and the melting process is accelerated accordingly.

Hot charging of DRI is part of the ARCCESS® philosophy. At present, four major hot DRI charging concepts are promoted:

- Conveying hot DRI in independent inert-gas flooded bin systems via mobile carrier and crane
- Supply of hot DRI via pneumatic tube system using the excess pressure and the process gas from the reactor to the top of the EAF

### Table 1: SIS performance

<table>
<thead>
<tr>
<th>Position</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical energy consumption</td>
<td>reduction minus 10 kWh/t</td>
</tr>
<tr>
<td>Productivity</td>
<td>increase. + 1 to 2 heats per day</td>
</tr>
<tr>
<td>Yield</td>
<td>unchanged</td>
</tr>
<tr>
<td>Refractory</td>
<td>no additional wear</td>
</tr>
<tr>
<td>Oxygen per SIS</td>
<td>5 Nm³/t</td>
</tr>
<tr>
<td>Natural gas</td>
<td>0.15 Nm³/t</td>
</tr>
<tr>
<td>Compressed air</td>
<td>2.1 Nm³/t</td>
</tr>
<tr>
<td>Clogging of Injector tip</td>
<td>no</td>
</tr>
<tr>
<td>Wear at Laval nozzle</td>
<td>no</td>
</tr>
</tbody>
</table>

2.2 Optimized production concepts

Two examples are given for the possibility of using ARCCESS® to optimize the production routes and process:

Modern arc furnaces are not only used for the production of steel based on 100% scrap charge only. Modern minimill concepts especially for the production of flat products are asking for steel limited in the content of tramp elements, e.g., copper, tin and other elements. These harm the mechanical properties of the steel for its further application.
SMS Demag has signed a cooperation agreement with the owner of the HYL technology, HYLSA in Monterrey/ Mexico. In Monterrey, the hot-DRI charging system Hytemp has been in operation for a few years with remarkable success.

At an average incoming temperature of the DRI of 600 °C (100%), the productivity was increased by up to 22% by lowering the tap-to-tap time and the energy consumption dropped by up to 27% and consequently the specific production cost in the same amount.

CONARC® technology

Another possibility to dilute tramp elements, but also to speed up an electric arc furnace, is the charging of hot metal into the EAF.

By using advanced oxygen lance technology, hot metal can be refined in an EAF economically up to 30%, because decarburization starts to determine the process speed. Starting from approx. 80% hot metal, the BOF process produces steel more economically while using 20% solids as coolant.

The gap between 30 and 80% of hot metal as charge material must be closed by a process, combining both classical routes. To open this window SMS Demag has developed the CONARC® process which can be operated as a BOF converter and as a regular arc furnace and in combination of both.

The CONARC® is a twin-shell process using an oxygen top lance for hot metal refining, i.e., either one lance moving from shell one to shell two, or one lance per shell (60 to 100% of hot metal). The melting of solids and the superheating in the non-autothermic mode is effected by one set of electrodes moving from shell one to two, always mirror-inverted relative to the top lance. With this system, all types of raw materials can be mixed for various purposes, either to dilute tramp elements, to minimize electric energy consumption or to utilize cheapest input materials.

The CONARC® process is not limited to carbon steel production. In numerous tests a process route for the production of stainless steel was developed. These test heats not only widened our metallurgical competence but also enables customers to produce every steel grade in the same production unit.

This process is part of the ARCCCESS® family and is successfully operated in India at Ispat Industries and in South Africa at Mittal Steel Saldanha Bay. New CONARCs are under erection for Bhushan Steel & Strips Ltd. and Essar Steel (Hazira) Ltd. in India.

2.3 Environmental concepts

For all steelmaking products SMS Demag provides highly efficient gas cleaning systems for primary and secondary dedusting systems. All products are designed to meet the requirements of German and European environmental legislation which ranks among the strictest worldwide.

The pollution control technology of SMS Demag includes all tailor-made and technologically optimized facilities, e.g.

- cooling equipment
- spark arrestors
- quenching systems
filter systems

special hood design for secondary emissions, creating a highly efficient induced draft.

All these solutions are engineered with a view to maintaining the highest possible efficiency of the furnace process (control philosophy) while ensuring low maintenance and high availability of the entire system. Modern engineering tools like computational flow analysis and FEM calculations are used.

Numerous references for various types of tasks help us provide tailor-made solutions for the benefit of our customers.

2.4 Automation and control

Rapid project implementation, steep run-up curves as well as high reliability and permanent availability right from commissioning: these are the basic requirements of plant owners.

To satisfy these requirements, the quality of all plant components is, of course, the key factor for the integration of mechanical equipment, process technology, electrical and automation systems, as all are equally important.

At SMS Demag, interdisciplinary cooperation for all plant components is part of the daily routine. Two essential modules are part of SMS Demag's philosophy:

- "Plug & Work"
- "X-Pact"

Plug & Work is the concept of services to the customer's benefit. It implies that a customer's entire automation system ranging from instrumentation and control system to computers and process models is set up at SMS Demag. This allows the real data of the plant to be used for testing all control systems and functions of the contract plant.

X-Pact smoothly links the various levels of electrical systems and automation.

This means specifically:

- Level 0 addresses the drive units and power supply system.
- Level 1 includes the control system.
- Level 2 implements the plant processes, and
- Level 3 allows product planning.

With this clear-cut structure X-Pact can be used to co-ordinate all processing levels in the metallurgical process chain.

3. Summary

The ARCCESS® technology for the electric arc furnace process meets customer requirements with the total-cost-of-ownership approach. ARCCESS® takes care of all relevant functions which are necessary to form and operate the entire system.
With its superior mechanical design, extremely clever shell exchange tools, advanced injection and automation technology and supported by the most efficient methods of treating pollutants, the **ARCCESS®** technology really works to fulfill the Total Cost of Ownership principle.

An example for efforts to overcame limitations is the CONARC® process as a part of the **ARCCESS®** family. This process combines both EAF and BOF technologies and fills the input gap between the classical production routes. Benefit for customers is the awarded flexibility in terms of input materials.

SMS metallurgy, the SMS group's full line of supplies and services for the entire metal market, is the know-how carrier that satisfies all customer requirements.

Especially in the field of electric steelmaking technology, SMS Demag and CONCAST, both relying on the largest number of furnace references worldwide, provide the most efficient and advanced furnace technology required by all electric steel producers.

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