“SIMETAL EAF QUANTUM™
The Way of Environmental Friendly and Efficient Steel Making”

BY

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1. INTRODUCTION

1.1 MARKET CHANGE AND DEMAND

The rising demand for Steel, higher energy and personnel costs, stricter safety and environmental requirements force steelmakers to react as can be seen in figure 1.

![Image of market changes](image_url)

Figure 1: Future challenges for steel makers

Lately, there are two market trends becoming obvious: Energy Prices are on the rising edge triggering headaches for steelmakers as much as environmental authorities are implementing new rules and regulations but also getting stricter regarding the compliance with the respective values.

This paper is presenting the consequent and logical answer of SIEMENS VAI as a result of the recent market trends in conjunction with and based on the experience and know how developed and realized in house: The EAF QUANTUM™.

This new furnace concept stands maximized output and environmental compliance with minimum conversion costs. Through the utilization of the furnace offgas during the heat cycle, 100% of scrap can be preheated prior to final melting in the furnace vessel. This means considerable energy and cost savings with the substantial reduction in tap-to-tap times (< 33 minutes). An energy consumption of 280kWh/t in combination with a reduced consumption of oxygen and a CO2 reduction of about 20 percent make the EAF QUANTUM™ the most efficient and environmental compliant EAF in the market.

1.2 BASIS OF EXPERIENCE & REFERENCE

The new EAF QUANTUM™ provides the right answer to customer needs. Based on an optimized preheating and melting concept the EAF QUANTUM™ stands for minimum conversion costs, maximized output and environmental compliance.

Out of more than 20 Years of experience in preheating technologies, where the operating references for shaft furnaces and finger shaft furnaces can be seen in figure 1, and more than 40 Years of experience in Electric Steelmaking, Siemens VAI developed a new furnace concept combining the experience of more than 20 still operating EAF with scrap preheating and the capability of leading new and innovative ideas to the market.
It is important to mention that nearly all components of the concept has individually proven its industrial operation in different installations around the world, like the moving lower shell concept at Sherness UK (today Thamesteel), the FAST at Buderus Edelstahl, etc.

The major differences compared to the above mentioned shaft and finger shaft furnace technology are the following and will be described in detail later on:

- Improved tightness leading to minimized false air ingress due to fixed shaft structure and movable lower shell
- Improved, trapezoidal shaped shaft design for optimum scrap distribution and efficient preheating, especially with lower scrap density
- Newly designed scrap retaining system for improved scrap fall into the shell
- Increased liquid heel for improved heat transfer and fast melting process
- New configuration shaft to electrodes for flicker free steel melting
2. GREEN TECHNOLOGY - ENVIRONMENTAL COMPLIANCE

2.1 SIEMENS POLICY

Siemens history in electric steelmaking is relatively short – so one have to put immediate attention towards such a giants policy to understand its ambitious targets and developments presented to the market: The MOST important Siemens policy - "One Siemens" - is to develop environmental compliant products and solutions fulfilling environmental regulations wherever these products and solutions are installed, providing a leading green product portfolio for our customers.

This policy was the base line for the development of the QUANTUM™ furnace as a comprehensive concept solution backed up by many stand alone improvements and applications already realized and implemented at different clients established as proven technology!

In order to realize environment friendly Steelmaking along with the steelmakers demand for energy savings and highest productivity, Siemens developed, based on its long experience related to shaft furnace operation, a revolutionary concept for electric arc furnace steelmaking by utilizing primary energy (off gas heat) as the most efficient way to save energy.

The saving of primary energy is leading to lower kWh/t consumption at the EAF, resulting at the same time also into increase of productivity (lower power on time = lower tap to tap time = more heats per day = more t/h).

2.1 QUANTUM™ @ SIEMENS POLICY

With respect to environmental aspects, the new QUANTUM™ incorporates:

- An improved offgas treatment system with a special hood to cover all dust and offgas emissions.
  - That means dust and offgas emissions from processing as well as from charging are transferred to the primary offgas suction line (DEC – direct evacuation) via automated offgas-stream modification.
  - The secondary suction line (SEC – secondary evacuation) will be tremendously reduced related to size and installed suction capacity (investment and operation costs) as it needs to capture only the remaining fumes such as tapping, de-slagging, fumes through the electrode.

- In combination with reduced furnace movements and maximized false air tightness a complete offgas supervision/monitoring is assured.

- Further the preheating system is optimized in terms of leak tightness and efficiency. This is realized by trapezoidal shaped shaft design in combination with a re-designed retaining system which leads to a better scrap distribution and an improved offgas-routing for optimized heat transfer, avoiding scrap sticking and blocking inside the shaft. The preheating temperature in the shaft will be at the minimum at 600°C, up to 1000°C.

- Technical Solution for: VOC (Smell), DIOXIN and FURAN as well as CO.
  - Additionally a post-combustion chamber with burner power, implemented directly after the primary and secondary suction line, fits together to regulate offgas temperature at around 800-850°C and combust harmful substances in the offgas stream. Due to the tight design of the QUANTUM™, restricted and limited false air is entering the system, leading to a higher temperature at the end of the pre-heating shaft, enabling a decent power input for heating the temperature up to 850°C, with consumption of approx 4 Nm3/t of Gas/Oil consumption only. Since there will be no Burner installation required on the furnace anymore, no Gas/Oil is
consumed on the EAF while the consumption takes place on the PC chamber, but limited, leading to 40% savings in comparison to conventional furnaces.

- The fumes are quenched afterwards to a temperature of below 300°C to avoid de-novosynthesis - back-formation - of furans and dioxins being in compliance with the environmental regulations. The quenching system is a well proven technology on the market and successfully implemented in many steel plants.

- In order to fulfill even the most stringent government regulations respectively setting benchmarks related to dioxin and furan values, activated carbon will be injected.

- Most efficient way to prevent CO2
  Related to the world demand of lowering the CO2 emissions, the impact at an electric arc furnace is mainly towards the consumption of electrical energy. The QUANTUM ™ is giving the answer to this demand by realizing consumption figures far below 280 kWh/t – for a better environment.

THE reference related to Shaft Furnace Technology applying all environmental regulations can be seen in Switzerland at Stahl Gerlafingen, operating with a Finger Shaft Furnace while the steelplant is located mid of a town under stringent environmental regulations.
3. EFFICIENT STEELMAKING - SIMETAL QUANTUM™

3.1 GENERAL LAYOUT

Starting from scrap yard, scrap can either be loaded with trucks into the scrap chute on the elevator system or, as shown in figure 2, with magnets and crabs via a so-called intermediate loading station. In this solution, scrap is prepared by crane directly into one of the two intermediate scrap containers, which then unload the scrap into the scrap chute.

![Figure 2: General view from tapping side](image)

Advantage: only small service crane is needed, with a compact system taking care on efficient scrap yard layout.

3.2 SCRAP CHARGING VIA ELEVATOR SYSTEM

The new charging concept – an elevator system with chute for scrap transfer from a subsurface dumping station into the furnace - allows a defined and flexible charging logistic. A crane or basket for scrap charging is not necessary. Furthermore, based on an exact duty cycle and charging time, a full fledged automation concept is applicable. The complete cycle from loading of chute to charging of the scrap into the shaft is shown in figure 3.

![Figure 3: Scrap chute on elevator from loading to charging position](image)
3.3 RE-DESIGNED PREHEATING SYSTEM

Efficient energy recovery due to 100% scrap preheating is the base for energy consumption lower than 280kWh/t. This is realized by a trapezoidal shaped shaft design in combination with a re-designed retaining system which leads to a better scrap distribution and an improved offgas-routing for optimized heat transfer, avoiding scrap sticking and blocking inside the shaft.

After having preheated the scrap, the fingers are opened for charging by pulling the fingers out of the sidewalls of the shaft (picture 4). Thanks to the new opening mechanism and a large "horse shoe" shell volume, the preheated scrap is loaded into a big liquid heel and the fingers can be closed immediately afterwards for loading and preheating the next batch of scrap. All this can be done under power-on.

The complete finger system is placed on a sturdy fixed roof/shaft structure in order to prevent the forces coming from scrap loading going towards the water cooled parts, thus avoiding the risk of water leakages.

3.4 POWER OFF LESS - FLAT BATH OPERATION

Melting of scrap in big liquid heel leads to pure flat bath operation with lowest flicker and supports the preheating efficiency. In combination with the furnace advanced slag-free tapping system (FAST - siphon design) this new furnace concept allows charging, tapping and taphole refilling under power on and results in highest productivity with lowest tap-to tap time and virtually no power off time. Heat transfer from liquid heel to the preheated scrap and bath homogenization is improved by the operation of a bottom stirring system with argon.

Continuous input of electrical energy not only improves the productivity but is important for the energy infrastructure with respect to Flicker problems in the respective power grids of the country.

The working profile for the process with 3 baskets can be seen in figure 6.
A further advantage of this shell design is the slag free tapping concept that is enhancing the alloys yield and desulfurisation performances. Following pictures illustrate the tapping process. It can be seen that there is always steel above the tapping channel, no slag can enter and therefore sucked into the ladle.

### 3.5 MINIMIZED FURNACE MOVEMENTS

As all the shaft structure is fixed installed, the shell has to be manipulated for tapping and deslagging (if required). This is realized in this manner that the shell is sitting on base frame with cylinders and guides, allowing the shell to be tilted in both directions – tapping and slag side.

The gantry with the electrode lifting system and the lance holders for the oxygen and carbon lance is not tilting, but only swinging out for electrode slipping and fast roof center piece exchange. Heavy stress from furnace tilting like the gantry at the conventional EAF with all its consequences on support and bearing, high current cables, etc. is not existent.

For maintenance reasons, a simple shell transfer and moving concept reduces furnace movements and improves system maintenance aspects through quick shell exchange.

The transfer car is acting as tapping car as well as shell transfer car. The sequence of shell exchange is show in the pictures 10 to 13. In order to pick up the shell from the frame, the car has to be placed into the exchange position, underneath the shell. The shell will be lowered by means of the cylinder and guide system. When sitting on the car, the shell is free and can be moved outside the furnace area for refractory maintenance or shell exchange.
In order to prepare the furnace for restart, the shell can be loaded with remaining liquid steel or scrap prior moving to the operating position. Once again in operating position, the cylinder and guide system is moved up and then connecting the base frame with the shell.

3.6 OFFGAS PROCESSING CONCEPT

This new approach is completed via an offgas-processing with automated offgas-stream modification, maximized leak tightness and a special hood to cover dust and offgas emissions during charging. This concept full fills the future environmental compliance and leads to reduced canopy installation.

The size of the dedusting system can thus be reduced tremendously.
4. CONSUMPTION FIGURES

4.1 MAIN BENEFITS

In order to conclude, the main benefits are the following:

1. **Green Technology**
   - Optimized environmental compliance due to revolutionary design of offgas-processing preventing
     - Dioxin and furan
     - Smell (VOC)
   - Lowest CO2 emissions due to energy consumption far below 280 kWh/t
   - Flat bath operation prevents creation of noise and enables highest output even under weak power grids resulting in lowest flicker levels
   - Less Dust generation in Off Gas System due to scrap acting as a filter in the shaft

2. **Energy Savings**
   - Energy consumption of \( \leq 280 \text{ kWh/t} \)
   - Direct energy recovery due to 100% scrap preheating with smaller transformer installation
   - 60% saving of burner power (gas /oil) due to limitation of “re-heating” energy to 4 Nm3/t and no burner consumption at EAF

3. **Productivity Increase**
   - Through Tap-to-tap time of 33 min.
     - Power Off – less operation (Poff time: = 3 min)
     - Power On time reduction through lowest energy consumption values!
   - Increased productivity of 1.35 mio. t/a with an 100 t EAF arrangement and a 3-batch process
   - Charging, tapping and tap hole refilling under power on
   - Up to 30% reduced electrode consumption
   - 1% higher Yield

4. **Safety Improvements**
   - Full automation concept feasible
   - No crane movements in furnace area reduces danger from moving loads
   - Eliminated risk of explosion due to ice and snow
   - No risk of CO explosion

Due to the overall concept and taking into consideration the cost savings for the dedusting system and other facts like no necessity of scrap baskets and scrap crane, the EAF QUANTUM™ is a profitable investment for the steelmaker.

The Return of Invest (ROI) for a
- greenfield Investment can be seen between 2 to 4 years only, depending on energy cost and production program
- brownfield Investment (Revamp of existing furnace) can be seen between 0.5 to 2 years only due to savings of at least 20% of the conversion costs in comparison to conventional furnace operation!
4.2 CONSUMPTION FIGURES

In the following table 1, the main technical data with corresponding consumption figures are shown. The EAF QUANTUM™ is flexible to melt various kinds of scrap densities still keeping high productivity paired with low conversion cost.

<table>
<thead>
<tr>
<th>MAIN DATA</th>
<th>3 batch</th>
<th>4 batch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat size, average T</td>
<td>T</td>
<td>100</td>
</tr>
<tr>
<td>Hot Heel size. T</td>
<td>T</td>
<td>70</td>
</tr>
<tr>
<td>Diameter Lower Shell mm</td>
<td>6,300</td>
<td></td>
</tr>
<tr>
<td>Height Upper Shell mm</td>
<td>1,720</td>
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<tr>
<td>Scrap density t/m³</td>
<td>0,65 - 0,7</td>
<td>0,5 - 0,65</td>
</tr>
<tr>
<td>Number of charges per heat</td>
<td>-</td>
<td>3</td>
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<tr>
<td>Transformer Rating MVA</td>
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<table>
<thead>
<tr>
<th>TIME BALANCE</th>
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<tbody>
<tr>
<td>power-on time min</td>
<td>30</td>
<td>34</td>
</tr>
<tr>
<td>power-off times min</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>• charging (under power) min</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>• tapping, tap hole filling &amp; electrode slipping min</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>• delays min</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>tap-to-tap, ttt min</td>
<td>33</td>
<td>37</td>
</tr>
<tr>
<td>Productivity t/h</td>
<td>182</td>
<td>162</td>
</tr>
<tr>
<td>Productivity per Year with 7.500h t/a</td>
<td>1.360.000</td>
<td>1.220.000</td>
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<table>
<thead>
<tr>
<th>INJECTION TECHNOLOGY</th>
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<tr>
<td>Oxygen Injection capacity Nm³/h</td>
<td>2 x 2.900</td>
<td>2 x 2.600</td>
</tr>
<tr>
<td>Carbon Injection capacity Kg/min</td>
<td>2 x 20 - 60</td>
<td>2 x 20 – 60</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CONSUMPTION FIGURES for tapping temperature 1.610°C</th>
<th>3 batch</th>
<th>4 batch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical energy, up to kWh/t</td>
<td>280</td>
<td>295</td>
</tr>
<tr>
<td>Electrode consumption, up to kg/t</td>
<td>0,9</td>
<td>0,9</td>
</tr>
<tr>
<td>Oxygen, up to Nm³/t</td>
<td>25,0</td>
<td>25,0</td>
</tr>
<tr>
<td>Natural Gas Post Combustion &amp; FAST, up to Nm³/t</td>
<td>4,0</td>
<td>4,0</td>
</tr>
<tr>
<td>Total Carbon (charged &amp; injected), up to kg/t</td>
<td>25,0</td>
<td>25,0</td>
</tr>
</tbody>
</table>

Table 1: Main data and consumption figures

5. CONCLUSION

Siemens VAI Metals Technologies is glad in offering a pragmatic solution to meet the request for highest energy and cost efficiency, increased productivity and lowest emissions in electric steelmaking whether charging scrap, but also partly Hot Metal or DRI.

With the SIMETAL EAF QUANTUM™, SIEMENS VAI Metals Technologies has developed an EAF that can enable the steelmaker to achieve a high productive steelmaking at extra low conversion cost.