Design features of the ULTIMATE EAF

The new ULTIMATE EAF series from VAI FUCHS features a combination of the latest technologies and design features for highest furnace performance and a tap-to-tap time of approximately 30 minutes. Features which include increased use of robotics and automation, carbon and oxygen injection, split shell design with one bucket charging, are all proven in existing operating plants.

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During the past 20 years electric steelmaking has provided most of the growth in world steel production. Modern electric arc furnace-based steelmaking plants feature the following main advantages:

- Relatively low investment costs compared to the integrated blast furnace/oxygen steelmaking route
- Utilisation of a wide range of raw materials such as scrap, DRI, HBI and hot metal
- Ability to fulfill a wide range of production targets and steel qualities to meet the specific market requirements
- Low operational and thus conversion costs, promoting a relatively short return on investment

For more than 35 years VAI FUCHS has been an innovator and front runner in the development of new technologies for electric steelmaking. Highlights include the introduction of water-cooled equipment, current-conducting electrode arms, single-point roof lifting, shaft furnaces, twin-shell furnaces and combined burner refining systems for enhancing productivity. To date, VAI FUCHS has supplied more than 100 EAFs of both AC and DC design.

As a result of the continued emphasis on research and development and through the combination of advanced technologies and design features, VAI FUCHS now offers a new generation of EAFs which offer the possibility of previously unattainable productivity levels at very low conversion costs. Referred to as the ULTIMATE series, a single EAF vessel with, for example, a tapping weight of 120t and an average tap-to-tap time of about 30 minutes is now capable of producing approximately 1.8Mt of steel per annum. A general view of an ULTIMATE EAF is shown in Figure 1.

PLANT DESIGN

General The ULTIMATE EAF has been designed on the basis of extensive know-how and plant-building experience in electric steelmaking. In addition to changes in the basic design of the EAF, a number of additional improvements were carried out in the mechanical equipment, power supply, water-cooled parts, robotic systems, measurement units, oxygen- and carbon-injection systems, process control, automation, de-dusting and environmental equipment. Overall plant logistics were also reviewed to avoid operational bottlenecks and match the capacities of all EAF-related facilities and systems, and to ensure an optimised production route for achieving the designed production targets.

On the basis of detailed calculations in combination with the results from various operating plants the main design features of this new furnace type on the basis of a furnace with a tapping weight of 120t can be summarised in Table 1.

Equipment and systems An ULTIMATE EAF includes the following equipment and systems, each of which is reliably operating in various furnaces worldwide:

- Automatic scrap bucket pre-positioning
- Door-cleaning robot
- Contact-free temperature measurement of the steel bath
- Ultra-high-power oxygen- and carbon-injection technology with RCB
- Automatic tap control from the main EAF pulpit via video camera
Automatic slag detection during tapping with the IRIS system (InfraRed Identification System)

Tap hole cleaning robot

Crane equipped with two auxiliary hooks for quick electrode exchange

Electrode stand with spray water cooling

The RCB oxygen- and carbon-injection system, installed in more than 40 installations worldwide (see Figures 2 and 3) boosts the exothermic energy input and actively promotes post combustion. Deep bath penetration with highly effective oxygen/carbon reactions are ensured thanks to the unique design of the system nose panel (see Figure 4). The door cleaning robot keeps the door area free of scrap during charging and so a door burner or door lance is no longer necessary. The IRIS slag detection system defines the ideal tapping time for minimum slag carryover (see Figure 5). With the tap hole cleaning robot not only are tap hole cleaning times considerably shortened and plant availability increased, but risks to maintenance operators are also greatly reduced (see Figure 6).

**Table 1** Key data of a 120t ULTIMATE EAF

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tapping weight</td>
<td>120t</td>
</tr>
<tr>
<td>Hot heel</td>
<td>40t</td>
</tr>
<tr>
<td>Tapping temperature</td>
<td>1,620°C</td>
</tr>
<tr>
<td>1 scrap bucket</td>
<td>130t</td>
</tr>
<tr>
<td>Yield</td>
<td>90%</td>
</tr>
<tr>
<td>Scrap density</td>
<td>0.8t/m³</td>
</tr>
<tr>
<td>EOEBT* design</td>
<td>for Ø of 7.2m</td>
</tr>
<tr>
<td>Total panel length</td>
<td>3.4m</td>
</tr>
<tr>
<td>Roof height</td>
<td>1.5m</td>
</tr>
<tr>
<td>4 RCBs** (O₂ and C injection)</td>
<td>2,500Nm³/h</td>
</tr>
<tr>
<td>2 Burners</td>
<td>3.6MW</td>
</tr>
<tr>
<td>3 PC*** injectors (O₂)</td>
<td>400Nm³/h</td>
</tr>
<tr>
<td>3 Carbon injectors</td>
<td>70kg/min</td>
</tr>
</tbody>
</table>

*EOEBT = Energy-Optimised Eccentric Bottom Tapping
**Refining Combined Burner
*** PC = Post combustion

**Fig.2** Arrangement of oxygen and carbon injection tools

**Fig.3** RCB operation in Low-Fire mode (longer flame)

Mechanical design: The mechanical components of the ULTIMATE EAF have been specially designed on the basis of the latest operational feedback and process requirements. Their advantages and reliability are already well proven in existing VAI FUCHS installations. Design features of key mechanical components include:

- Simple construction with rugged and reliable components
- High vessel shell designed to allow for one-bucket charging
- Gantry design with single point roof lifting system
- Prismatic roller guide system for electrode columns to reduce vibration
- Split shell EAF design with the upper furnace-shell section divided into the following panel zones (see Figure 7):
  - Copper panel zone in the lower furnace and in the slag zone, including specially fixed high-velocity panels for RCB
  - Steel panel zone in the upper furnace
- Tightest possible sealing between the panels and panel fixing on the shell cage to avoid panel movements (see Figure 8)
- Improved, sturdy construction of the tilt platform

Also, it would be possible to reduce the number of
Fig. 4 Nose panel design allowing 50° impact angle.

Fig. 5 Example of an IRIS monitor screen.

Fig. 6 Tap hole cleaning robot.

Fig. 7 Panel arrangement for high-shell EAF design.

Fig. 8 Panel sealing and fixing.
operators to three persons per shift: one in the EAF pulpit, one floor operator and one crane operator.

CONSUMPTION FIGURES
The use of modern calculation programs have shown that the operation of an ULTIMATE EAF would result in reduced power-off times, a more constant production level, improved consumption figures and lower overall costs. The expected performance figures of this furnace type are summarised in Table 2.

| Electricity | 340KWh |
| Electrodes  | 1.2kg  |
| Oxygen      | 35Nm³  |
| Gas         | 5Nm³   |
| Charge coal | 10kg   |
| Coal powder (foamy slag) | 7kg  |
| Lime        | 40kg   |

Table 2 Specific consumption figures per tonne liquid steel (calculated)

To achieve a 30 minute tap-to-tap time the power-on time is maximised through an optimisation of physical and chemical process-related factors. The power-off time is reduced through the optimum utilisation of existing equipment and tools.

FIRST INDUSTRIAL APPLICATIONS
The first ULTIMATE EAF installations for carbon steel (CS) will be:

- ULTIMATE CS 180t at Magnitogorsk Iron & Steel Works (MMK), Russia in late 2005 with hot metal charging
- ULTIMATE CS 160t at Hadeed, Saudi Arabia in late 2006/early 2007 with hot DRI charging
- ULTIMATE CS 250t at Colakogu Metalurji Steel Works, Turkey in early 2007

SUMMARY
The new ULTIMATE EAF from VAI FUCHS provides the opportunity for a new era in electric steelmaking, both for new steel producers as well as for existing steelmakers who wish to expand production. All of the equipment and components are already developed and in operation; their function and reliability are confirmed in daily production and thus investor risk is minimised.

Adaptations in terms of tap size and annual capacity are easily made to allow producers to meet specific market needs and customer requirements. Proper scrap selection and preparation is, of course, necessary to achieve high performance figures, as with any existing furnace.

The ULTIMATE EAF is another example of the innovative and pioneering spirit of the company. The necessary pre-engineering and design work has already been done and VAI FUCHS is now in a position to implement this solution within the shortest time for the benefit and success of our customers. MS

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