Consteel® and conventional EAF: a comparison of maintenance practices

In addition to the well-documented process benefits of the Consteel® system, further cost benefits derive from the lower cost of maintenance, logistics and dust disposal, resulting from the inherent design of the system. These amount to some 44% of the total cost savings when compared to a conventional EAF.

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Until now, comparison of EAF steelmaking technologies has been made by considering the melting process alone. For example, the Consteel® system was compared to the conventional EAF by looking at performances figures, mainly taking into account the technological and energy differences of the continuous charging and preheating system compared to bucket charging. The present study extends the comparison to include logistics, disposal cost of waste products and overall equipment maintenance.

The study was carried out by considering a top-charged EAF (TC), then determining what would happen by applying the Consteel® (CS) system to the same process conditions. Figure 1 shows a typical Consteel furnace.

Since different melting processes can be compared only when considering the same charge mix and tapping conditions, a normalisation of the mass-energy balance is necessary to compare technologies. This avoids the effect of different charge and energy utilisation with different processes as the production target, and hence the charge mix, has a great influence on the melting process. Since we want to highlight the possible benefits coming from one technology on the other, the same operating constraints and the same level of productivity has being assumed.

APPLICATION OF THE COST MODEL

The cost model permits us to appreciate the influence of each part of the process on the total cost. The model calculates the final cost/ton of liquid steel for both processes.

<table>
<thead>
<tr>
<th>Process</th>
<th>TC</th>
<th>CS</th>
<th>Delta</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical energy, oxygen, natural gas, slag forming additives, carburising additives, metallic charge</td>
<td>€/tls</td>
<td>281.8</td>
<td>274.4</td>
</tr>
<tr>
<td>Handling</td>
<td>€/tls</td>
<td>11.0</td>
<td>7.3</td>
</tr>
<tr>
<td>Maintenance</td>
<td>€/tls</td>
<td>9.3</td>
<td>7.1</td>
</tr>
<tr>
<td>Sum</td>
<td>€/tls</td>
<td>302.0</td>
<td>288.8</td>
</tr>
</tbody>
</table>

Fig 1 Consteel furnace (Trierer Stahlwerke, Germany)

Table 1 Cost comparison of conventional and Consteel® EAF steelmaking with reference to the ORI Martin melt shop
Looking at the results, it is possible to distinguish costs based on the melting process, scrap handling, furnace and equipment maintenance and waste product handling.

Table 1 gives the results of the analysis performed with the cost model on the ORI Martin Acciaieria e Ferriera di Brescia furnace, an 80t EAF producing ~600,000t/yr of quality steels.

The greatest difference in costs in the process area is due to the better yield of Consteel®, however, as this topic has been the subject of many studies, this paper will focus on the 44% of cost reduction given by logistics and maintenance.

SCRAP HANDLING

The most important operation is the management of the scrap flow from the scrap yard to the furnace. This is by bucket preparation in the conventional EAF and by the continuous charging system in Consteel®. Raw materials handling is usually performed by overhead travelling cranes in sufficient number to have an adequate margin of safety against breakdowns. The number of cranes depends on the number of buckets that must be prepared in the given time, considering the heat size of the furnace, the scrap density and size of the buckets.

The Consteel® system adopts a different organisation of the scrap yard, usually storing the raw materials at the side of the charging conveyor. The size and number of the charging cranes depend on the maximum scrap feeding rate required by the furnace (see Figure 2).

The number of operators required increases with the amount of equipment involved. In this regard, the Consteel® system simplifies the logistics as it minimises scrap movements and hence the equipment involved.

MAINTENANCE PRACTICE

This involves maintenance of the scrap yard equipment, furnace bay equipment and EAF furnace, together with slag and dust disposal (see Figure 3 & 4).

**Scrap yard and furnace bay equipment** Maintenance costs for the scrap yard depend mainly on the amount of equipment involved in material handling. The Consteel® system has lower costs because it only has the overhead travelling cranes for the conveyor charging, which can also perform the weighing operation for each lift.

**Maintenance of the EAF** This is strongly influenced by the melting process in use. The thermal and chemical stresses which affect the consumable components of the furnace depend mainly on the parameters of the melting process (see Figure 5).

Electrode consumption has the highest maintenance cost, however, Consteel’s is about 15% lower and is
governed by the lower oxidation rate due to the lower post-combustion ratio inside the furnace.

Electrode erosion also depends on the productivity of the melt shop. At the same working condition, Consteel® has a higher productivity, thus the electrode consumption can be considered the same as a conventional EAF with lower productivity. Also, flat bath operation maintains a good stability of the electric arcs and practically eliminates the occurrence of electrode breakages.

The Consteel® system also has lower refractory lining wear because operating conditions are smoother than the conventional EAF and it produces less iron oxide in the slag. With Consteel®, provided that slag is foaming correctly, the electric arcs can be completely covered and buried under a protective layer which reduces arc radiation to the furnace refractory for almost the entire power-on period. It also eliminates electric discharge on the furnace roof and shell because panel maintenance is drastically reduced.

**Maintenance of the Consteel® conveyor** Consteel® conveyor maintenance is very simple and has been reduced to the level of periodic inspection of the mechanical structure, electric motors and hydraulic equipment, and the planned maintenance of the most critical parts. The refractory lining of the preheating section has no particular stresses and can normally be re-bricked annually.

The connecting-car tip is the most stressed component of the conveying system because it receives both the thermal stress of the melting bath and the mechanical load produced by the conveying of the scrap (see Figure 6). It should be part of a planned maintenance programme and, as experience suggests, has an average lifetime of four months. The suspension rod is easily replaced, usually during the furnace turnaround. Failure analysis shows an average 100 suspension rod breakages a year for a well-charged conveyor.

**DUST AND SLAG DISPOSAL**
The Consteel® process achieves lower slag and dust production than a conventional EAF, being strongly dependent on the main characteristics of the system: the continuous charging and the preheating of the metallic charge. The elimination of the bucket charge reduces dust formation in the canopy hood, and the pre-heating section of the conveyor works like a settling chamber where the dust can deposit on the scrap, promoting dust recycling into the furnace. The overall dust emission of 5-9kg/tls is less than that of a conventional EAF.

**CONCLUSIONS**
The cost analysis indicates that the Consteel® system has benefits over and above those of different melting processes, with savings of more than 40% for handling, maintenance and disposal of byproducts.

As well as the economic advantages, technological benefits exist which lead to maximum process efficiency, improving the yield of the metallic charge and reducing energy demands. The Consteel® system also represents the simplest and most efficiently solution to achieving environmentally friendly preheating of the metallic charge, avoiding the uncontrolled emission of pollutants typical of the conventional bucket charge. **MS**

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