CONTIMELT: First Progress Report

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SUMMARY

This article discusses recent experience with CONTIMELT®, a new two-stage process for melting and refining copper, developed by Norddeutsche Affinerie in cooperation with Metallurgie Hoboken-Overpelt, that was featured in the January 1984 issue of Journal of Metals (Vol. 36, No. 1, pp. 62-66).

The anode shaft furnace, the first stage of CONTIMELT®, has been in operation at Norddeutsche Affinerie since September 1979. The second stage, the continuous poling furnace, began operation in April 1982.

This discussion focuses on saving primary energy through the use of oxygen-assisted burner technology in the anode shaft and optimizing poling furnace operation. The CONTIMELT® plant is capable of replacing 3-4 conventional reverberatory furnaces.

INTRODUCTION

The complete CONTIMELT® process has been used since 1982 for the continuous melting and refining of solid copper. Operations such as charging, melting, oxidation, poling, and casting taking place successively in a conventional reverberatory furnace are now performed with a slight chronological shift in parallel in the corresponding units of the plant. An output of 400 metric tons of anodes which requires a batch time of at least 24 hours in a reverberatory furnace needs a batch time of only one shift, i.e., 8 hours, with Contimelt. During the remaining two shifts, i.e., the afternoon and the night shifts, and over the weekend the plant is kept hot.

The high melting capacity, which can be as much as about 100 metric tons/h when oxygen burners are used, requires the use of an efficient continuous casting process. The CONTILANOD® process developed by Metallurgie Hoboken-Overpelt jointly with Norddeutsche Affinerie, which uses a modified Hazelett casting machine, is suitable for this purpose.

ANODE SHAFT FURNACE

Further melting campaigns with the anode shaft furnace have been carried out since 1981, the aim being to increase substantially the melting capacity of 40 metric ton/h and to superheat the copper, with the increased melting capacity, to an adequate temperature for the subsequent continuous poling.

From previous projects, it is known that the efficiency of superheating is particularly dependent on the following factors.

For a given furnace size, the holding time in the furnace decreases in the same ratio as the melting capacity increases. With constant fuel input the melting capacity is determined by the specific rate of heat transfer to the material charged. In order to achieve adequate superheating under all conditions, a sufficiently high flame temperature must be reached.

A clean surface on the bath provides the best conditions for good superheating. The aim should therefore be to produce an easily skimmed, low-viscosity slag which can be blown aside by the burner flame. The superheater burners should have sufficient impulse to blow the slag aside and produce waves in order to increase the surface area.

Due to the increased energy input in the hearth, the copper column at its foot is melted unilaterally; large pieces of copper can therefore enter the flow directly and hence cool the copper.

Knowing these factors, an attempt had to be made to superheat the copper to a temperature of about 1200°C for the continuous poling subsequently carried out in the poling furnace. For this reason, different types of burners were tested in the various regions of the anode shaft furnace and could be operated optionally with air, with oxygen-enriched air, or with pure oxygen.

A fan was installed to boost the pressure of the combustion air.

In contrast to the initial equipment consisting of 16 LP burners used in the anode shaft furnace, the following variants were tested:

- 3 LP burners in the hearth were replaced by 3 HP burners.
- Use of 11 oxygen burners — 6 in the melting zone, 3 in the hearth zone and 2 in the furnace roof.
- Oxygen-enriched LP burners for melting, HP burners in the hearth, and oxygen burners in the roof for superheating.

OXYGEN-ENRICHED AIR WITH LP AND HP BURNERS

The anode shaft furnace at Norddeutsche Affinerie is used to produce two different anode grades, and the charge materials for these differ distinctly with respect to analysis, weight, shape, and surface.

With an "easily melting charge" consisting of anode scrap, small cakes, and scrap copper, as shown in Table I, high melting rates can be achieved. The energy introduced into the hearth for superheating purposes leads to an increase in the melting rate because of good thermal utilization in the shaft.

When oxygen enrichment is used, melting rates of more than 60 metric tons/h are achieved and the thermal efficiency is increased by about 7%, from 66% to 73%. However, the superheating efficiency, referred to as the entire thermal input and the temperature of the copper, could be increased only slightly by oxygen enrichment. The specific gas consumption decreased about 10% to 25.5 m³/metric ton now with as oxygen consumption of about 14.7.

The trial results of melts with charges consisting of "materials which are difficult to melt," i.e., consisting of large blister cakes often with slag residues adhering, differ quite distinctly from each other as shown in Table I.

By suitable use of gas and oxygen enrichment it was also possible here to achieve melting rates in excess of 60 metric tons. The thermal efficiency, averaging 67% was still quite high: about 6% above that without using oxygen enrichment. The superheating efficiency was increased from about 2.4% to a maximum of 3.6% The maximum copper temperature reached was about 1200°C. With oxygen enrichment (average 13 m³ oxygen/metric ton, the specific

CALCULATION OF OPERATION DATA

To determine the performance parameters, only the measured values within a representative period of time — usually 2 to 3 hours before the end of a melting campaign — were employed. This made the data comparable and avoided deviations taking place during the initial and final phases of the melts.
gas consumption was reduced about 10% and is now 28.5 m³/metric ton.

A comparison of the different charge materials shows that large and heavy blister cakes are more difficult to melt and consequently a higher specific gas consumption of about 3 m³/metric ton is needed to maintain the melting rate. The temperature of the copper then rises by about 30°C.

Oxygen Burners

The desire for a vitally improved melting rate required a further series of trials using oxygen burners and pure oxygen. Table II shows that this objective was achieved even for charges mainly consisting of large cakes with melting rates of almost 90 metric tons/h and copper temperatures of 1200°C. When charge material which melts more easily was used, it was possible to increase the melting rate to more than 95 metric tons/h with an average copper temperature of 1147°C.

Table II also shows the influence of the excess air coefficient (λ) on the experimental results. Oxygen burner manufacturers recommend an air coefficient λ of below 1 in order to save oxygen without losing too much on flame temperature. Depending on the composition of the materials charged, employing a combustion air coefficient of 0.9 instead of 0.8 produces a saving in gas and oxygen, in addition to a substantial improvement in performance parameters.

The superheating efficiency is considerably improved by using oxygen burners. Referred to the total thermal input via gas, it is 3.9% for an easily melting charge and up to 9.2% for a charge which is difficult to melt. The temperature of the copper here, 1240°C, is indeed substantially above the desired temperature of 1200°C.

The specific gas consumption at λ = 0.8 was about the same for both types of charged materials. It could be reduced about 16% by using a value of 0.9. Despite increased excess air coefficient, the specific oxygen consumption is reduced for both types of charge.

Pure Oxygen Burners and Air-Operated Burners

The combined use of pure oxygen burners and air-operated burners in the anode shaft furnaces is a further variant on burner equipment. The results for this method of operation are shown in Table III. A comparison with the results of the trials with oxygen-enriched air shows that by using two oxygen burners in the roof of the hearth, much better superheating can be achieved than with oxygen enrichment of the combustion air for all burners. The degree of superheating — referred to as the total thermal input — was increased by 0.5 to 1.0%. This means an increase of up to 20°C in the temperature of the copper.

Oxygen Contents of the Copper

The average oxygen contents of the copper determined at the tap of the anode shaft furnace during the trial campaigns are also listed in the tables. Increasing the flame impulse by using HP burners already led to an increase in the oxygen content of the copper. Using oxygen burners had the same effect. For example, with an initial oxygen content of about 0.5% in the blister copper, the use of HP and oxygen burners resulted in the oxygen content of more than 1% in the molten copper.

Advantages of Oxygen Burners

The use of oxygen burners in the anode shaft furnace has proven itself in achieving higher melting rates and higher superheating temperatures, and in achieving better control of these parameters. The following may also be listed as further advantages of oxygen burners:

- Smaller quantities of offgas, so that the successive equipment can be of substantially smaller capacity.
- Lower offgas temperature at the shaft top.
- Smoother furnace operation, i.e., improved down motion of the charge column due to more uniform melting at the charge foot.
- Widely differing shapes and weights of copper grades which can be melted with fewer problems.
- Better bath movement due to the flame impulse.
- Less wear on the furnace lining.

On the basis of the experience gained in the trial charges, Norddeutsche Affinerie has decided to equip its own anode shaft furnace with 10 LP burners in the melting zone, with the possibility of oxygen enrichment of up to 30%; with three HP burners in the side walls of the hearth section; and with two oxygen burners in the roof.

**Table I: Burner Operation with Air and Oxygen Enrichment, Heating Value: 8,900 kcal/m³**

<table>
<thead>
<tr>
<th>Feed Material</th>
<th>Excess Air Ratio</th>
<th>Smelting Rate, t/h</th>
<th>Natural Gas Used, m³/t</th>
<th>Oxygen Used, m³/t</th>
<th>Mean Copper Temperature, °C</th>
<th>Thermal Efficiency on Copper, %</th>
<th>Superheating</th>
<th>Mean Oxygen Content of Copper Melt, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anode scrap</td>
<td>0.8</td>
<td>78</td>
<td>28.3</td>
<td>44.1</td>
<td>1,148</td>
<td>71.8</td>
<td>3.3</td>
<td>0.75</td>
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<tr>
<td>Small cakes</td>
<td>0.9</td>
<td>96</td>
<td>21.3</td>
<td>40.1</td>
<td>1,146</td>
<td>88.5</td>
<td>3.9</td>
<td>0.8</td>
</tr>
<tr>
<td>Big cakes</td>
<td>0.8</td>
<td>89</td>
<td>26.3</td>
<td>43.1</td>
<td>1,195</td>
<td>74.2</td>
<td>5.6</td>
<td>1.0</td>
</tr>
<tr>
<td>Upto 2.2 tons</td>
<td>0.9</td>
<td>89</td>
<td>22.6</td>
<td>41.3</td>
<td>1,240</td>
<td>88.9</td>
<td>9.2</td>
<td>1.3</td>
</tr>
</tbody>
</table>

**Table II: Burner Operation with Pure Oxygen Heating Value: 8,900 kcal/m³**

<table>
<thead>
<tr>
<th>Feed Material</th>
<th>Excess Air Ratio</th>
<th>Smelting Rate, t/h</th>
<th>Natural Gas Used, m³/t</th>
<th>Oxygen Used, m³/t</th>
<th>Mean Copper Temperature, °C</th>
<th>Thermal Efficiency on Copper, %</th>
<th>Superheating</th>
<th>Mean Oxygen Content of Copper Melt, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anode scrap</td>
<td>No</td>
<td>55</td>
<td>28</td>
<td>—</td>
<td>1,115</td>
<td>65.9</td>
<td>1.5</td>
<td>0.5</td>
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<tr>
<td>Small cakes</td>
<td>Yes</td>
<td>61</td>
<td>25.5</td>
<td>14.7</td>
<td>1,128</td>
<td>73.0</td>
<td>2.3</td>
<td>0.8-1.0</td>
</tr>
<tr>
<td>Big cakes</td>
<td>No</td>
<td>54</td>
<td>31</td>
<td>—</td>
<td>1,140</td>
<td>60.6</td>
<td>2.4</td>
<td>0.5</td>
</tr>
<tr>
<td>Upto 2.2 tons</td>
<td>Yes</td>
<td>60</td>
<td>28.5</td>
<td>13</td>
<td>1,160</td>
<td>66.9</td>
<td>3.6</td>
<td>0.9-1.1</td>
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