Abstract

Ironmaking and steelmaking is always associated with waste production that presents for the entire metallurgical process either reversible and/or reusable material or lost waste not applicable in further production. At present the waste from iron- and steelmaking finds hardly applicability as secondary raw material.

Evidence has been given that the low-temperature plasma could replace the existing routes of less-suitable pyrometallurgical treatment of such waste that are therefore processed by hydrometallurgical route.

As the metallurgical and technological features of this application are verified, its economy must be considered. The economical point of view of the metal-bearing waste is discussed by example of proper situation.

The economical efficiency of that route can be in principle determined by comparison of the calculated costs with the price of ready product.

On the basis of a complex examination of trial results this work provided evidence on metallurgical readiness and economical efficiency in implementation of plasma heating at processing of the metal-bearing oxidic wastes under conditions prevailing in the steelworks.

Keywords: economical efficiency, profit and profitability, calculated and processing costs, metal-bearing oxidic waste, plasma heating

1. INTRODUCTION

On the basis of a complex examination of trial results this work provided evidence on metallurgical readiness and economical efficiency in implementation of plasma heating at processing of the metal-bearing oxidic wastes under conditions prevailing in the steelworks. [2,3,4,] 

Ironmaking and steelmaking is always associated with origination of waste that presents for the entire metallurgical process either reversible and/or reusable material or lost waste not applicable in further production. At present the waste from iron- and steelmaking finds hardly applicability as secondary raw material. The majority of solid waste is deposited outside of plant as a dumping loss. For the reasons of economy and environmental protection such dumping loss should be recovered as much as possible otherwise such expensive waste depots additionally menace our surrounding world. [5,6,7]

Evidence has been given that the low-temperature plasma could replace the existing routes of less-suitable pyrometallurgical treatment of such wastes that are therefore processed by hydrometallurgical route [1].

As the metallurgical and technological features of this application are obvious then more light should be thrown into the economy. The economical insight into efficiency of the assumed processing of the metal-bearing waste is dealt in detail with by example of a concrete situation at VHM,a.s..
2. EVALUATION OF THE ECONOMICAL EFFICIENCY

Technical and technological sources

We assume all the occurrence of metal-bearing waste available at the VHM,a.s. to be subjected to “plasma” processing in the modified melting unit with some 15-ton capacity. The field of charged waste is assumed some 60% which means that about 9 tons of melt would be acquired from each heat. Processing of the metal-bearing waste in this furnace would last for about 60 minutes. Here, four products are the possible outcome of melting, i.e.

- metal with guaranteed chemical composition in liquid and solid state
- liquid or solid steelmaking hot metal
- solid foundry hot metal
- solid special foundry hot metal called Sorel

The different qualities of melt are reached by reasonable selection of the metal-bearing waste.

3. PROCEDURE OF ECONOMIC EVALUATION

For the sake of proper economical evaluation the assumed calculation of the own expenses of the ready product should be compiled first. The assumed sum of the own expenses for ready product is then compared with its assumed market price. The obtained difference (profit or loss) shows the economical attractive feature of processing the metal-bearing waste.

3.1 Proper evaluation of the economical benefit from waste processing

The entire average volume of the metal-bearing waste at the VHM,a.s. (as per the actual occurrence in 1998 and 1999) is reaching some 50 000 tons a year. The dust separated from the units such as the LF, the SL and the DH and/or the sludge from oxyvit route and from rolling mill cannot be economically processed by the orthodox technological procedures and thus, it is deposited. From the available documents is obvious that the relevant lump sum for “deposition” attains 420 up to 900 Kč/t and is of considerable significance in the economy of plant. The average “price” of the metal-bearing waste makes 162.4 Kč/t and the potential customer of the VHM,a.s. has to pay for it.

3.2 Compilation of the calculation of costs from processing the metal-bearing waste

The first item of cost of this calculation is the proper metal-bearing waste whose utilization is assumed for some 60%. Accordingly, one ton of product would require some 1666.7 kg waste. Then, the cost of waste with a price of 162.4 Kč/t would be 270.7 Kč/t.[1]

Determination of the cost items arranged into processing costs

Calculation of costs for the electric energy for “melting” is going out from the assumption that a plasma torch of an output of 15 MW would be installed at the melting furnace. With a melting time of 60 minutes and the weight of ready product the consumption of energy would reach some 1666.7 kWh/t. When considering the present-day’s price of electric energy of 1.6 kWh/Kč then the relevant specific cost would be 2666.72 Kč/t. (When determining the costs for electric energy there is to note that under actual working conditions a considerable drop in consumption should be taken into account. In this respect the first experimental verifications show a consumption of some 1100 to 1300 kWh/t only.) The costs for the plasma-forming gas (nitrogen) are going out from an hour’s input of 36 Nm³, which with a price of 0.43 Kč/Nm³, attain some 1.7 Kč/t. The occurrence of waste gas is assumed to be some 537 Nm³/t of ready product. The gas will be entrapped and utilized in the power-energy system. Then, such a credit note would attain 221.2 Kč/t.
The total power system costs attain some 2447.2 Kč/t. To determine the expenses for the furnace lining one is going out from the costs for lining and from the average lifetime of lining of some 300 heats. The resultant cost will then reach 111.1 Kč/t. Calculation of expenses for ladle lining is going out from similar considerations. Thus, the relevant cost would reach some 182.5 Kč/t. In this respect the total lining expenses attain 293.6 Kč/t.

The costs of graphite melting electrode are considered to be 100 Kč/t due to its negligible consumption. The calculation of expenses for direct wages is going out from the assumption that in total 7 workers are attending the melting unit with the necessary handling operations, whereby the rough wage of a person would be 15000 Kč/month. Thus, the expenses for direct wages attain 989.4 Kč/t.

For the sake of calculation of the depreciation allowances one has assumed the modification of the melting unit would require some 25 Mill. Kč. The building work should consume 4 Mill. Kč, the aspiration would need some 6 Mill. Kč and the proper installation work would consume some 2 Mill. Kč. The total capital expenses would so reach some 37 Mill. Kč. With a depreciation time of 15 years and with assumed annual production of 28020 tons the depreciation allowances would attain some 90.4 Kč/t.

The total non-specified costs were assumed for 300 Kč/t. The total value of the s.-c. other costs (electrodes, wages, depreciation allowances and non-specified costs) would then reach some 499.5 Kč/t.

### 3.3 Evaluation of the calculation of costs compiled for ready product

The calculated processing costs would reach 3329.6 Kč/t., the own expenses in total would attain 3600.3 Kč/t. Thus, the processing costs refer to 92%. The costs for the charging material attains 8% only. The most significant item of the processing costs refers to the energy, i.e. 78%, the other costs refer to 16% and that for lining and for charge 8% each (Table 1, Fig. 1).

#### Table 1 Calculation of costs for processing metal-bearing waste

<table>
<thead>
<tr>
<th>Price Untils</th>
<th>Price sum</th>
<th>Amount</th>
<th>Expenses Kč/t</th>
<th>Expenses %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charge – metal-bearing waste</td>
<td>Kč/t</td>
<td>162,4</td>
<td>1666,7</td>
<td>270,7</td>
</tr>
<tr>
<td>Processing cost – Energy - electricity</td>
<td>Kč/kWh</td>
<td>1,6</td>
<td>1666,7</td>
<td>2666,72</td>
</tr>
<tr>
<td>- nitrogen</td>
<td>Kč/Nm³</td>
<td>0,43</td>
<td>4</td>
<td>1,72</td>
</tr>
<tr>
<td>- waste gas – credit note</td>
<td>Kč/Nm³</td>
<td>0,412</td>
<td>-537,0</td>
<td>-221,2</td>
</tr>
<tr>
<td>- total</td>
<td></td>
<td></td>
<td>2447,2</td>
<td>68</td>
</tr>
<tr>
<td>Linings - furnace</td>
<td></td>
<td></td>
<td>111,1</td>
<td>3</td>
</tr>
<tr>
<td>- ladle</td>
<td></td>
<td></td>
<td>182,5</td>
<td>5</td>
</tr>
<tr>
<td>- total</td>
<td></td>
<td></td>
<td>293,6</td>
<td>8</td>
</tr>
<tr>
<td>Melting electrode</td>
<td></td>
<td></td>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td>Direct wages</td>
<td></td>
<td></td>
<td>98,4</td>
<td>3</td>
</tr>
<tr>
<td>Depreciation allowances of melting unit</td>
<td>Kč/t</td>
<td>90,4</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Non-specified expenses</td>
<td></td>
<td></td>
<td>300</td>
<td>8</td>
</tr>
<tr>
<td>- other expenses</td>
<td></td>
<td></td>
<td>588,8</td>
<td>16</td>
</tr>
<tr>
<td>Processing costs in total</td>
<td></td>
<td></td>
<td>3329,6</td>
<td>92</td>
</tr>
<tr>
<td>Own costs in total</td>
<td></td>
<td></td>
<td>3600,3</td>
<td>100</td>
</tr>
</tbody>
</table>
4. ECONOMICAL EFFICIENCY OF PROCESSING THE METAL-BEARING WASTE WITH APPLICATION OF PLASMA

The economical efficiency of that route can be in principle determined by comparison of the calculated costs with the price of ready product.

As mentioned above various sorts of ready products will be provided by reasonable selection of the metal-bearing waste to be charged. [8]

When determining the price for which the ready product will be sold to the customers, one has gone out from the existing price relations. From the viewpoint of production and economy metal with a guaranteed chemical composition in liquid state presents reasonable ready product, as its utilization for steelmaking seems to be rather attractive. This is due especially to its possible usage in a LF-unit or its usage as liquid charge for the EAF, the BOF and induction furnace. In all the examples cite here the economical effect would be favourable due to "acquisition" of the sensible heat of metal. If the liquid charge will be used at an EAF, then the economical effect will consists of the price of scrap (3200 to 3600 Kč/t) and at least of 50% of the processing costs required for metal melting at an EOP (about 1000 Kč/t). Then, the selling price of metal will be 4500 Kč/t at least, see Table 2.
Table 2 Economical effectiveness of processing metal-bearing waste

<table>
<thead>
<tr>
<th></th>
<th>Price range min (Kč/t)</th>
<th>Price range max (Kč/t)</th>
<th>Applied costs</th>
<th>Costs Kč/t</th>
<th>Possible profit Kč/t</th>
<th>Profitability %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scrap with guaranteed chemical composition – solid state</td>
<td>3200</td>
<td>3600</td>
<td>3500</td>
<td>3600</td>
<td>-100</td>
<td>-3</td>
</tr>
<tr>
<td>Scrap with guaranteed chemical composition – liquid state</td>
<td></td>
<td>4500</td>
<td>3600</td>
<td>900</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>Steelmaking</td>
<td>hot metal</td>
<td>4200</td>
<td>4500</td>
<td>4400</td>
<td>3600</td>
<td>800</td>
</tr>
<tr>
<td></td>
<td>solid metal</td>
<td>4500</td>
<td>4800</td>
<td>4700</td>
<td>3900</td>
<td>800</td>
</tr>
<tr>
<td>Foundry solid iron</td>
<td>5500</td>
<td>6300</td>
<td>6000</td>
<td>3900</td>
<td>2100</td>
<td>35</td>
</tr>
<tr>
<td>Foundry hot metal - Sorel</td>
<td>7500</td>
<td>8500</td>
<td>8000</td>
<td>3900</td>
<td>4100</td>
<td>51</td>
</tr>
</tbody>
</table>

4.1 Possible achieved profit with the individual sorts of ready products
In case of liquid metal with a guaranteed chemical composition the profit would reach 900 Kč/t and the profitability (profit referred to the costs) would be 20%. In case of melting steelmaking hot metal the profit of 900 Kč/t is reached, which refers to a profitability of 17 to 20%. With the foundry hot metal and with Sorel the possible profit varies from 2100 to 4100 Kč/t and the profitability makes 35 up to 51%.

4.2 Evaluation of the achieved profitability and of profit
The achieved profit varies within 545 and 4100 Kč/t and the profitability from 12 up to 51%. These results provide explicitly positive answer about the economical suitability of processing the metal-bearing waste with the help of plasma heating.[1]

5. CONCLUSION
The economical efficiency of that route can be in principle determined by comparison of the calculated costs with the price of ready product.
In case of liquid metal with a guaranteed chemical composition the profit would reach 900 Kč/t and the profitability (profit referred to the costs) would be 20%. In case of melting steelmaking hot metal the profit of 900 Kč/t is reached, which refers to a profitability of 17 to 20%. With the foundry hot metal and with Sorel the possible profit varies from 2100 to 4100 Kč/t and the profitability makes 35 up to 51%.
On the basis of a complex examination of wide trial results this work provided evidence on the metallurgical applicability and economical efficiency in implementation of plasma heating at processing the metal-bearing oxidic wastes under conditions prevailing in the steelworks.
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LITERATURA


