APPLICATION OF WASTE ANTHRACITE DUST IN THE PROCESS OF COPPER MATTE SMELTING

This study presents the results of research on the process of smelting of copper matte with the use of anthracite waste dust as fuel. A method of introducing this carbon-bearing waste into the technological process carried out in a shaft furnace in the form of an additive to briquettes with copper concentrate was developed. These briquettes were tested for the required strength properties.

Keywords: copper matte, concentrate, anthracite dust, briquettes, structure

INTRODUCTION

The significant increase in the production of various types of materials for applications in many fields of technology, observed for many years, resulted in a relatively quick depletion of natural resource deposits. This also applies to fuels, used in large quantities in many pyrometallurgical processes, for which less expensive alternative carbon-bearing materials are sought [1-8]. An example of a technology that uses coke as fuel is the production of copper matte in a shaft furnace. In this process, coke constitutes about 10% of the total mass of the input processed with this technology [9-14]. When looking for alternative fuels, it should be remembered that they must ensure the proper course of a given technological process and thus not disturb its heat balance, do not cause additional consumption of fluxes or the formation of increased amounts of slags. In the case of metallurgical aggregates such as shaft furnaces the strength properties of the fuel also play a very important role, which clearly affect, for example, gas permeability of the charge.

This study presents the results of research on the smelting of copper matte with the use of fine-grained anthracite waste dust. The proposed solution reduces the costs of the discussed technology and at the same time is a method of managing waste generated in another production process.

MATERIALS FOR TESTING

A mixture of copper concentrates with the composition given in Table 1 was used in this research. Waste anthracite dust was used as fuel in the process. This material has a similar calorific value compared to the coke used in the analysed process of smelting copper matte in a shaft furnace.

Table 1 Chemical composition of copper concentrates used in the tests

<table>
<thead>
<tr>
<th>Content / wt %</th>
<th>Cu</th>
<th>Al</th>
<th>Ca</th>
<th>C</th>
<th>Fe</th>
<th>SiO₂</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>17,5</td>
<td>3,43</td>
<td>3,42</td>
<td>10,5</td>
<td>7,81</td>
<td>19,7</td>
<td>12,06</td>
</tr>
</tbody>
</table>

METHODOLOGY

Shaft furnaces are metallurgical units where input materials require appropriate preliminary preparation. This applies to the necessity to form them into pieces, ensuring adequate air circulation of the input column and preventing the input material from being lifted by waste gases. Therefore, it was assumed that a fine-grained carbon-bearing material would be introduced into the shaft furnace in the form of an additive to the briquette made of copper concentrate. Taking this into account, a programme consisting of the following two stages was adopted:

- Research on briquetting of copper concentrate – anthracite dust mixtures
- Smelting of copper matte from the obtained agglomerates.

The research on agglomeration conducted in the first stage was carried out after the initial homogenisation of the compacted materials with the use of a modern rotary mixer. The agglomeration was carried out using a punching machine with a pressing force of up to 30 tonnes. As a binder, sodium lignosulphonate was also used as a component of the agglomeration mixtures. The selection of this binder resulted from the fact that it is used for briquetting metal concentrates in industrial conditions. The obtained briquettes were subjected to drop strength tests and a quasi-static compression test.
The latter was carried out with the use of an INSTRON universal testing machine. In addition, the briquettes were subjected to homogeneity assessment, which was performed based on the analysis of the image obtained from the briquette cross-section. The analysis of the geometrical structure of the surface images was performed using the MountasMap version 7 software. The smelting of the copper matte from the prepared briquettes was carried out in a shaft furnace with air blast [7]. The basic parameters of this device are presented in Table 2.

| Table 2 Technical characteristics of a shaft furnace used for smelting copper matte |
| --- | --- |
| No. | Parameter | Value |
| 1 | Diameter | 350 mm |
| 2 | Productivity | 0.6 Mg/h |
| 3 | Useful height | 2.45 m |
| 4 | Number of nozzles | 1 |

**RESEARCH RESULTS AND DISCUSSION - INVESTIGATION OF THE PROPERTIES OF BRIQUETTES**

The briquetting process was performed on a Cu concentrate-anthracite dust mixture. Table 3 shows the determined values of compressive strength of briquettes obtained from these mixtures. The obtained compression curve is shown in Figure 1.

The data presented above show that the obtained briquettes are characterised by very good strength properties. This means that during processing in a shaft furnace there should be no disadvantageous phenomenon of their crushing and thus their removal along with the dust. As previously mentioned, the briquettes were also subjected to a drop strength test. Figure 2 shows examples of test results of drop tests for briquettes from the tested mixture obtained for samples after the maturing period. This strength was presented as the fraction of briquettes with a diameter greater than 10 mm in the total mass of briquettes. The presented results relate to the strength after 3 drops, because this number of drops was adopted as an illustration of the briquette transport process from the moment of production to the moment of loading into the shaft furnace (in industrial conditions).

The briquettes were also subjected to homogeneity assessment, which was performed based on the analysis of the image obtained from the briquette cross-section. Examples of the results of structure examination for the manufactured briquettes are shown in Figures 3-6.

No significant porosity was observed when analysing the results of structural examination of briquettes. No cracks or discontinuities were found on the cross-sectional surface of these briquettes, both in their original form and after the maturing period. This confirms the good quality of the briquettes and their suitability for use in the process of copper matte smelting.
In order to confirm the metallurgical quality of the obtained briquettes from the tested mixtures, copper matte melts from these charge materials were verified. The chemical composition of the obtained copper mattes is presented in Table 4. For comparison, the table also shows the average chemical composition of copper matte obtained under industrial conditions.

The data presented in Table 4 show that a satisfactory degree of transition of the components of the copper concentrate to the smelted copper matte was obtained. The Cu content in the copper matte is within the range of values obtained in industrial conditions.

**CONCLUSIONS**

Based on the results of the conducted investigations it was concluded that:
- It is possible to introduce waste anthracite dust to the process of copper matte smelting in a shaft furnace in the form of briquettes with copper concentrate. Thus, it can be a partial replacement for the coke breeze used in this process as a fuel.
- The maturing process does not reduce the compressive strength of the obtained briquettes.
- The introduction of anthracite dust in the mixture into the briquetting process in the amount of up to 10 wt% allows obtaining briquettes with the technologically required drop strength and compressive strength.
- The maturing process does not reduce the strength properties of the obtained briquettes.
- The content of Cu in the copper matte obtained in the process of remelting briquettes containing Cu concentrate and anthracite dust is within the range of values obtained in industrial conditions.

**REFERENCES**


Note: The responsible translator for English language is Ling House, Poland