Application of thermal analysis in the examination of phase composition of converter slag

Iwona Jonczy*, Ewa Strzałkowska

Department of Applied Geology, Faculty of Mining and Geology, Silesian University of Technology, Gliwice, Poland;
*iwona.jonczy@polsl.pl

Metallurgical slags are characterized by variable phase composition, which results from the technological process in which they were formed. The identification of individual components of slag requires precise research, often conducted based on a wide range of scientific methods. This is largely a result of the mode of formation of slag components. Large amounts of glaze are formed as a result of the rapid cooling of alloy, whereas well-formed oxide or silicate phases are rare, usually constituting fine grains which are difficult to identify using e.g. microscopic identification. The presence of the metals in the waste materials often raises business owners’ interest as these may be reused. The chemical form of the metals, however, and the way these are bonded with the waste components, is important. Most of the heavy metals are dispersed in the glaze or occur as a substitution in structures of silicate phases and rarely constitute own minerals. The situation is different as far as iron is concerned which, occurs mainly in the form of own oxide and hydroxides phases. Microscopic examination in transmitted and reflected light demonstrated the presence of magnetite and hematite in the slag, while the determination of other iron forms (e.g. hydroxides) was hindered due to their microcrystalline structure and high dispersion.

Thermal analysis is one of the analytical methods which supplement the studies of slag phase composition and the transformations occurring under the influence of high temperature. This article presents the results of the research conducted for converter slag obtained from current production of a metallurgical plant. An attempt was made to determine the extent to which the thermal analyses (DTA, TG and DTG) of converter slag may contribute to the refinement and increase in accuracy of the determination of phase composition.

The tests have been conducted using 5 samples of converter slag obtained from the current production of a metallurgical plant from 5 production cycles of a furnace. Before the tests, the samples were averaged by quartering, milled in a bead mill and sieved through a sieve with a 0.01 mesh.

X-ray structural tests were conducted in the Institute of Ceramics and Building Materials, Refractory Materials Division in Gliwice, Structural, Thermal and Thermomechanical Testing Laboratory. The analysis of the phase composition using X-ray diffraction (XRD) was conducted using a PANalytical XPert PRO MPD powder diffractometer with an X-ray lamp with a Cu anode, a graphite monochromator at the diffracted beam side, X'Celerator semiconductor strip counter and a spinner. X-ray diffractograms were made for the range of angles of 5°-80° 2θ at lamp operational parameters of 35 mA and 45 kV. To identify the phase composition, HighScore software by PANanalytical as well as the ICDD PDF-4+ (2011 issue) database were used. The quantitative analysis of the phase composition was conducted using the Rietveld method with the SIROQUANT software. The following corrections were applied emissions, which allows to develop a method for their safe management [1÷5].

Thermal analysis is also applied in the analyses of phase composition of commonly used cements containing added waste materials such as blast-furnace slags or volatile ashes, i.a. for determining the amount of bounded water, calcium hydroxide and calcium carbonate as well as determining the mass losses during roasting [6, 7]. The studies referred to above also indicate that this method allows to estimate the content of slag and ash in cement.

Thermal analysis is also applied in metallurgy, especially in the determination of physical and chemical properties of mineral materials, metals and alloys [8÷10]. Numerous studies encompassing the use of thermal analysis were conducted by the Stanisław Staszic Institute for Ferrous Metallurgy in Gliwice; this may be exemplified by e.g.: studies on slag-forming stock including limestone, dolomite and burnt lime applied in metallurgy [11]. Moreover, the processing of slag-forming components, reduction of hematite ore and the phase transformations in low-carbon steel and cast-iron [12÷14].

2. MATERIAL AND METHODS

The tests have been conducted using 5 samples of converter slag obtained from the current production of a metallurgical plant from 5 production cycles of a furnace. Before the tests, the samples were averaged by quartering, milled in a bead mill and sieved through a sieve with a 0.01 mesh.

X-ray structural tests were conducted in the Institute of Ceramics and Building Materials, Refractory Materials Division in Gliwice, Structural, Thermal and Thermomechanical Testing Laboratory. The analysis of the phase composition using X-ray diffraction (XRD) was conducted using a PANalytical XPert PRO MPD powder diffractometer with an X-ray lamp with a Cu anode, a graphite monochromator at the diffracted beam side, X'Celerator semiconductor strip counter and a spinner. X-ray diffractograms were made for the range of angles of 5°-80° 2θ at lamp operational parameters of 35 mA and 45 kV. To identify the phase composition, HighScore software by PANanalytical as well as the ICDD PDF-4+ (2011 issue) database were used. The quantitative analysis of the phase composition was conducted using the Rietveld method with the SIROQUANT software. The following corrections were applied.
in the analyses: the effect of anomalous X-ray scattering and the microabsorption. The elementary cell parameters were determined using the Rietveld method only for the phase components in case of which the diffraction spectrum was well-formed. The results of the determinations of the elementary cell parameters were compared with catalogue data of the ICCD PDF 4+2012 database to identify solid solutions.

The X-ray microspectral analysis was conducted in the Institute of Non Ferrous Metals (Department of Material Engineering and Powder Metallurgy) in Gliwice, using an X-ray JXA 8230 microanalyser manufactured by JEOL. The analyses were conducted using metallographic specimens coated with a thin layer of carbon to transfer the electric charge. X-ray mapping of elements was conducted using Energy Dispersive Spectroscopy (EDS). Local quantitative analyses of selected grains were conducted.

The thermographic tests were conducted using a Paulik and Erdey derivatograph in air atmosphere using the standard heating rate of 10°C/min. The samples were heated to 1000°C in corundum crucibles while assuming the following parameters: analytical sample of 1100 mg, sensitivity of DTA – 1/5, TG – 100 mg, DTG – 1/10. AlO₃ was used as the inert substance.

3. RESULTS AND DISCUSSION

Previous research has shown that the chemical composition of studied slag samples is similar; the following main elements has been distinguished: Ca (∼30%), Fe (1–17%), Mn (∼1%), Ti (0.2–0.4%), Cr (86–1580 ppm), V (12–728 ppm), as also Si, Al, P, Ba, Cu, Ni, Pb, Zn. The identification of components using X-ray diffraction method has indicated that the content of the analysed slags exhibits a high participation of amorphous substance accompanied by oxide and silicate phases. Table 1 presents the list of components of the slags.

In samples No. 1, 2, 3 and 4, the amorphous phase was the dominating component, with content from 45.1% (sample 4) to 54.5% (sample 3). A quite significant amount of amorphous substance has also been identified in sample No. 5: 46.6%. In the latter sample, the gehlenite-akermanite solid solution constitutes a similar portion – 48.4% (Tab. 1).

Wustite was identified in all samples; its largest content was exhibited in sample 1 (7.5%), while it was the smallest in sample 5 (0.8%). Also, sample No. 5 was the only one not to contain the CaO enriched wustite solid solution – its largest content was found in sample No. 1 (10.7%).

Small amounts of the following were found in the slags: magnetite (samples 1, 2, 3), srebrodolskite (sample 4) and mayenite (samples 1, 2, 3).

From among oxide phases, the presence of the solid solution of brownmillerite-srebrodolskite was found in samples 1, 2 and 3. Its content was (respectively) 13.4%, 13.1% and 15.4%.

Silicate phases are represented by larnite (samples 1, 2, 3), fayalite (sample 1), tephroite (sample 5), jadeite (samples 2, 3) and the solid solution of gehlenite-akermanite (samples 2, 3, 5).

Presence of the Ca₃SiO₅ phase was exhibited in samples 1–4 — its content reached 11.5% in sample No. 4. The phase may be identified as alite, which has no counterparts in natural environment, while it is a characteristic component of clinker, responsible for early bonding of cement and a phase present in metallurgical slags.

Slags are a waste material characterized by a relatively variable mineral composition. Often only the application of several testing techniques allows for the comprehensive identification of all their components. Besides the X-ray diffraction, X-ray spectral microanalysis was applied in the testing. The method allowed to identify the presence of free lime CaO (Fig. 1, Tab. 2), as also calcium aluminate: CaO·Al₂O₃, 2CaO·Al₂O₃, and CaO·2Al₂O₃, as well as calcium phosphates represented by CaO·P₂O₅, identified by Biełanki et al. [15] as whitlockite.

Among silicate phases, the X-ray spectral microanalysis has shown the presence of melilitite (mostly akermanite), dicalcium silicate, alite and silicates with a general formula of Ca₅Si₅O₁₅, identified in literature [16] as rankinite which is one of the characteristic components of metallurgical slags.

The tests of the mineral composition of converter slags were supplemented by thermal analysis, based on which conclusions were drawn regarding the transformations of individual components of slags under the influence of heating. The results of the study are presented in Figures 2–4 and in Table 3.

While analysing the curves of the obtained thermoanalytical curves, high similarity of samples 1, 2 and 3 may be noted, while sample No. 4 is less similar. The intensity of individual thermal curves, high similarity of samples 1, 2 and 3 may be noted, while sample No. 5 was the only one not to contain the CaO enriched wustite solid solution – its largest content was found in sample No. 1 (10.7%).

Table 1. Components of converter slag, results of X-ray structural analysis, wt %

<table>
<thead>
<tr>
<th>Component</th>
<th>Quantitative share of components in individual samples</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Amorphous substance</td>
<td>46.5±1.2</td>
</tr>
<tr>
<td>FeO, wustite</td>
<td>7.5±0.4</td>
</tr>
<tr>
<td>[Ca, Fe]O, wustite with CaO, solid solution</td>
<td>10.7±0.2</td>
</tr>
<tr>
<td>(Fe, Mn)O or (Fe, Mg)O, wustite with Mn and Mg, solid solution</td>
<td>—</td>
</tr>
<tr>
<td>Fe₃O₄, magnetite, solid solution</td>
<td>—</td>
</tr>
<tr>
<td>Ca₂[Fe₁₋₄Al₄₋₃]O₁₅, srebrodolskite, solid solution</td>
<td>—</td>
</tr>
<tr>
<td>Ca₂(Fe₁₋₄Al₄₋₃)O₁₅, brownmillerite-srebrodolskite</td>
<td>—</td>
</tr>
<tr>
<td>Ca₂Al₂O₅, mayenite</td>
<td>—</td>
</tr>
<tr>
<td>β-Ca₅Si₅O₁₅, larnite</td>
<td>7.4±0.3</td>
</tr>
<tr>
<td>γ-Ca₅Si₅O₁₅, calcium olivine</td>
<td>6.2±0.3</td>
</tr>
<tr>
<td>Fe₂[SiO₄]₃, faujalite</td>
<td>0.6±0.1</td>
</tr>
<tr>
<td>MnFe₂[SiO₄]₃, tephroite</td>
<td>—</td>
</tr>
<tr>
<td>Ca₃SiO₅, alite</td>
<td>6.2±0.3</td>
</tr>
<tr>
<td>NaAl₅O₈, jadeite</td>
<td>—</td>
</tr>
<tr>
<td>(Ca, Mg)₃Al₅Si₅O₁₈, gehlenite-akermanite</td>
<td>—</td>
</tr>
</tbody>
</table>

Table 1. Składniki żużła konwertorowego — wyniki analizy rentgenostrukturalnej, % mas.
individual thermoanalytical curves. The thermoanalytical curve of sample 5 is by far different.

The registered curves allowed to distinguish the following thermal effects:

- an endothermic effect in the temperature of approximately 150°C (visible on the DTA curves), related to the dehydration of the sample, accompanied by a slight loss of mass that may be read in the TG and DTG curves (Fig. 3 and 4) with a maximal value of 0.27 %;

- an exothermic effect related to the combustion of organic components (probably the residue from the non-combusted fuel used in the technological process); this transformation was also accompanied by loss of mass (Tab. 3);

- an endothermic effect at the temperature of approximately 450°C, probably related to the dehydroxylation of portlandite Ca(OH)$_2$; in case of sample 4, the intensity of the peak was slow, while in the DTA curve of sample 5 the effect does not occur;

- an exothermic effect with a maximum in the temperature of approximately 550°C, caused by the oxidation of wustite FeO and the formation of maghemite; this is related to the increase in the sample mass by maximally 1.32% in case of sample 1 and slightly lower increase in case of samples 2 and 3;

- an endothermic effect in a temperature over 700°C, related to the decomposition of calcium carbonate; as this process is accompanied by an emission of CO$_2$, in that temperature the TG and DTG curves (in samples 1, 2 and 3) exhibit a loss of mass of maximally 0.45% (Tab. 3);

- an exothermic effect in the temperature of 950°C (observed only in case of sample 5), related to the recrystallisation of silicate phases.

The final section of the thermogravimetric TG curve in case of all samples deviates towards the positive direction, which indicates that further transformations occur in the samples.

The presented study results confirm that thermal analysis is one of the scientific techniques that may be successfully used in testing waste materials that are diversified in terms of phase composition, such as slags. All physical and chemical transformations that occur in slags during the heating process are reflected in the DTA, TG and DTG thermal curves. Using this method, one may not only determine the temperature at which a given transformation occurs,

---

**Table 2. Components of converter slags; results of X-ray spectral microanalysis (Fig. 1), wt %**

<table>
<thead>
<tr>
<th>No.</th>
<th>Al$_2$O$_3$</th>
<th>SiO$_2$</th>
<th>MgO</th>
<th>CaO</th>
<th>FeO</th>
<th>MnO</th>
<th>TiO$_2$</th>
<th>Cr$_2$O$_3$</th>
<th>SO$_3$</th>
<th>ZnO</th>
<th>P$_2$O$_5$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>—</td>
<td>—</td>
<td>93.12</td>
<td>1.32</td>
<td>2.77</td>
<td>2.66</td>
<td>—</td>
<td>0.12</td>
<td>—</td>
<td>—</td>
<td>5.46</td>
</tr>
<tr>
<td>2</td>
<td>0.50</td>
<td>34.94</td>
<td>0.26</td>
<td>57.13</td>
<td>1.53</td>
<td>0.12</td>
<td>—</td>
<td>0.06</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>3</td>
<td>0.52</td>
<td>36.23</td>
<td>0.42</td>
<td>56.54</td>
<td>1.00</td>
<td>0.09</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>5.20</td>
</tr>
<tr>
<td>4</td>
<td>2.47</td>
<td>6.53</td>
<td>3.06</td>
<td>52.09</td>
<td>28.60</td>
<td>5.03</td>
<td>0.39</td>
<td>0.41</td>
<td>0.40</td>
<td>—</td>
<td>1.01</td>
</tr>
<tr>
<td>5</td>
<td>—</td>
<td>—</td>
<td>2.47</td>
<td>93.48</td>
<td>2.70</td>
<td>1.08</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>0.05</td>
<td>0.22</td>
</tr>
</tbody>
</table>

No. of point:
1 – periclase
2 – dicalcium silicate (Ca$_{1.69}$Fe$_{0.04}$Mn$_{0.03}$Mg$_{0.01}$)[(Si$_{0.96}$P$_{0.13}$Al$_{0.01}$)O$_4$] with admixture of Cr
3 – dicalcium silicate (Ca$_{1.66}$Mg$_{0.02}$Fe$_{0.02}$Mn$_{0.002}$)[(Si$_{0.99}$P$_{0.30}$Al$_{0.01}$)O$_4$] with admixture of Cr
4 – amorphous substance
5 – calcium oxide

---

**Table 3. Changing of weight connected with chemical and physical transformations observed in the thermoanalytical curves of the investigated slags**

<table>
<thead>
<tr>
<th>Type of change</th>
<th>No. of sample/results</th>
<th>mg %</th>
<th>mg %</th>
<th>mg %</th>
<th>mg %</th>
<th>mg %</th>
<th>mg %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dehydration</td>
<td></td>
<td>-2.97</td>
<td>-0.27</td>
<td>-2.97</td>
<td>-0.27</td>
<td>-2.97</td>
<td>-0.27</td>
</tr>
<tr>
<td>Coal burning</td>
<td></td>
<td>-2.53</td>
<td>-0.23</td>
<td>-1.54</td>
<td>-0.14</td>
<td>-1.98</td>
<td>-0.18</td>
</tr>
<tr>
<td>Dehydroxylation</td>
<td></td>
<td>-3.96</td>
<td>-0.36</td>
<td>-3.96</td>
<td>-0.36</td>
<td>-3.96</td>
<td>-0.36</td>
</tr>
<tr>
<td>Iron oxidation</td>
<td></td>
<td>+14.52</td>
<td>+1.32</td>
<td>+12.98</td>
<td>+1.18</td>
<td>+12.54</td>
<td>+1.14</td>
</tr>
<tr>
<td>Decarbonation</td>
<td></td>
<td>-4.95</td>
<td>-0.45</td>
<td>-3.96</td>
<td>-0.36</td>
<td>-3.96</td>
<td>-0.36</td>
</tr>
<tr>
<td>Iron oxidation</td>
<td></td>
<td>+9.46</td>
<td>+0.86</td>
<td>+2.97</td>
<td>+0.27</td>
<td>+7.48</td>
<td>+0.68</td>
</tr>
<tr>
<td>Total change of weight</td>
<td></td>
<td>+10.01</td>
<td>+0.91</td>
<td>+3.96</td>
<td>+0.36</td>
<td>+6.05</td>
<td>+0.55</td>
</tr>
</tbody>
</table>

---

Fig. 1. Microphotography of converter slag (sample No. 2); X-ray spectral microanalysis

Rys. 1. Mikrofotografia żużla konwertorowego (próbka nr 2); rentgenowska analiza spektralna w mikroobszarach
but also verify whether the transformation is physical or chemical, whether it is accompanied by a change of mass and to determine what is the rate of the change of mass against the function of temperature. The differential thermal analysis curve additionally allows to observe the thermal effects accompanying the transformations and to establish whether the reactions are exothermal or endothermal.

In case of the studied converter slags, the strongest effect was achieved during the oxidation of iron. As this reaction is accompanied by the production of heat, the DTA curve exhibits a broad exothermal effect in that range of temperature, with a maximum at approximately 550°C. The effect is caused by the oxidation of wustite FeO and the formation of maghemite $\gamma$-$\text{Fe}_2\text{O}_3$ and hematite $\alpha$-$\text{Fe}_2\text{O}_3$. The presented line of thought is confirmed by the phase composition obtained in the X-ray diffraction analysis, which indicated the presence of iron oxides (the most in samples 1, 2, and 3). One should, however, note the fact that the DTA, TG and DTG curves at this section of the thermoanalytical curve results from the transformations occurring in that range of temperature. This does not allow to estimate the exact contributions of the two exothermal processes: the oxidation of iron and the final stage of carbon combustion. Additionally, in a temperature over 700°C, the process of iron oxidation is simultaneous with the endothermal transformation probably related to the decarbonisation of the calcium carbonate which was formed in the sample.

Free lime CaO, the presence of which is an indicator of insufficient conversion of the feed, is a disadvantageous component of slags. Moreover, calcium oxide is produced as a result of alite decay into 2CaO·SiO$_2$ and CaO, which occurs in a temperature below 1200°C. The presence of free calcium oxide in slags is the cause of their swelling and cracking, which is related to the properties of CaO, which is easily hydrated [17]. The presence of CaO in the tested slags is confirmed by the endothermal effect shown by the DTA curve, especially evident in case of samples 1, 2 and 3. It may result from the moisture level in the samples and the dehydroxylation of portlandite Ca(OH)$_2$ — formed from the free CaO present in the samples — which occurs in that temperature. The correctness of this thesis seems to be confirmed by the increased moisture content in samples 1, 2 and 3, as compared to samples 4 and 5 (Tab. 2). The presence of calcium hydroxide in the slags in concern is related to processes which must have occurred in the sample during its storing. A similar case was noted by Stecko, Różański and Zalecki [12] in their study on slag forming materials. As the authors provide, the reason for the reoccurring carbonatisation and the formation of portlandite, was the contact of the burnt lime sample with air. In the obtained thermoanalytical curves, the authors noted a low-temperature endothermal peak indicating the presence of moisture, while generally no moistness should occur in case of properly stored samples.

The exothermal effect in the temperature of 820°C, clearly visible in the thermoanalytical curve of sample No. 5 and slightly less distinct in the temperature of 950°C, was linked to the recrystallisation of the gehlenite-akermanite silicate phases present in the sample in large amounts (as confirmed by the X-ray structural tests). It should be remembered that metallurgical slags are usually solidified in vitrified form and the crystalline phases within them occur in the form of microcrystallites. The recrystallisation of the melted substances may be noted in the curves as a sharp exothermal peak, after which the substance returns from the thermodynamically unstable amorphous state to the proper crystalline state. As exhibited by the research of Kruger cited in the work [18], the peak is often comprised of several partially overlapping peaks which are the evidence of crystallization of a larger number of phases, the identification of which is, however, largely hindered.
5. CONCLUSIONS

The tests of converter slags conducted within this article allowed to formulate the following conclusions:

– the phase composition of metallurgical slags is diversified and each of the applied scientific methods considered in separation from other methods only provides an approximate image of the sample’s phase composition; to precisely determine the phase composition, it is necessary to apply several complementary scientific methods;

– the simultaneous application of three measurement techniques — DTA, TG and DTG, provided the necessary information on the following processes occurring under varying temperature: dehydration, coal combustion, dehydroxylation, oxidation of iron, decarbonisation and phase transitions; it is worth noting, however, that the correct interpretation of the obtained results requires giving consideration to be given to the complex physicalochemical character of the phenomena occurring in the sample;

– only using thermal analysis was it possible to exhibit the presence of organic matter in the tested material; the matter is probably a residue of the non-combusted fuel used in the technological process;

– the presence of free CaO was exhibited based on X-ray spectral microanalysis and thermal tests; thermogravimetry (TG) and also derivative thermogravimetry (DTG) allowed to estimate the quantitative share of that component in the tested slags;

– the test results provided above confirm that thermal analysis may constitute an excellent tool complementing the phase composition analysis of converter slags; this method allows to obtain much information and to draw conclusions regarding the technological properties of the tested material and the possible further usage thereof.

REFERENCES


Zastosowanie analizy termicznej w badaniach składu fazowego żużła konwertorowego

Iwona Jonczy*, Ewa Strzałkowska
Katedra Geologii Stosowanej, Wydział Górnictwa i Geologii, Politechnika Śląska, Gliwice; *iwona.jonczy@polsl.pl

Słowa kluczowe: analiza termiczna, żużel konwertorowy, skład fazowy.

1. CEL PRACY

Żużle hutnicze stanowią grupę odpadów, która charakteryzuje się zróżnicowanym składem fazowym zależnym od procesu technologicznego, w wyniku którego powstały. Identyfikacja poszczególnych składników żużła wymaga precyzyjnych badań, często prowadzonych za pomocą różnych metod badawczych.

Jedną z metod analitycznych stanowiących dobre uzupełnienie badań na temat składu fazowego żużli oraz przemian, jakie w nich zachodzą pod wpływem wysokiej temperatury, jest analiza termiczna. W artykule zaprezentowano wyniki badań prowadzonych dla żużła konwertorowego pochodzącego z bieżącej produkcji huty. Podjęto próbę ustalenia, na ile badania termiczne (DTA, TG i DTG) żużla konwertorowego mogą przyczynić się do uściślenia i dokładniejszego oznaczenia ich składu fazowego.

2. MATERIAŁ I METODYKA BADAŃ

Badania przeprowadzono dla 5 próbek żużła konwertorowego pochodzących z bieżącej produkcji huty, z 5 różnych cykli produkcyjnych pieca hutniczego. Przeprowadzono badania rentgenostrukturalne, rentgenowską analizę spektralną w mikroobszarach oraz analizę termiczną.

3. WYNIKI I CH DYSKUSJA

Badania identyfikacji składników w składzie żużli konwertorowych pod wpływem ogrzewania (rys. 2÷4, tab. 2). Zarejestrowane odpowiedzi na wzrost temperatury to efekty endotermiczne i egzotermiczne, jak np. efekt endotermiczny w temperaturze powyżej 700°C związany z dehydroksylacją, utlenianiem i przemianami w składzie żużla konwertorowego, a efekt egzotermiczny w temperaturze 900°C związany z rekrystalizacją faz krzemianowych, końcowy odcinek krzywej termograwimetrycznej TG wszystkich próbek odchyla się w kierunku dodatnim, co sugeruje, że w próbkach następują dalsze przemiany.

4. PODSUMOWANIE

Przeprowadzone badania żużli konwertorowych pozwoliły na sformułowanie następujących wniosków:

- skład fazowy żużli hutniczych jest zróżnicowany, a każda z stosowanych metod badawczych rozpatrywana osobno daje tylko przybliżony obraz składu fazowego próbki; w celu jego precyzyjnego określenia jest wymagane zastosowanie kilku wzbogacających się metod badawczych;
- efekt egzotermiczny związany ze spalaniem składników organicznych (prawdopodobnie jest to pozostałość niespalonego paliwa użytego w procesie technologicznym), efekt endotermiczny w temperaturze ok. 100°C związany z utlenieniem wüstytu i utworzeniem maghemitu, efekt endotermiczny w temperaturze powyżej 700°C związany z rozkładem węglanu wapnia; procesowi temu towarzyszy wydzielenie CO2, więc na krzywych TG i DTG zaobserwowano zmniejszenie masy;
- efekt egzotermiczny w temperaturze 950°C związany z rekrystalizacją faz krzemianowych,
- efekt endotermiczny w temperaturze 450°C związany z przemianą portlandytu Ca(OH)2 w CaO i CO2, procesowi temu towarzyszy zmniejszenie masy w wyniku dehydratacji i utleniania; na krzywych TG i DTG zaobserwowano efekt endotermiczny w temperaturze powyżej 300°C zarejestrowany prawdopodobnie jako efekt endotermiczny związany ze spalaniem składników organicznych;
- efekt endotermiczny w temperaturze 450°C związany z przemianą portlandytu Ca(OH)2 w CaO i CO2, procesowi temu towarzyszy zmniejszenie masy w wyniku dehydratacji i utleniania; na krzywych TG i DTG zaobserwowano efekt endotermiczny w temperaturze powyżej 300°C zarejestrowany prawdopodobnie jako efekt endotermiczny związany ze spalaniem składników organicznych;
- efekt endotermiczny w temperaturze 450°C związany z przemianą portlandytu Ca(OH)2 w CaO i CO2, procesowi temu towarzyszy zmniejszenie masy w wyniku dehydratacji i utleniania; na krzywych TG i DTG zaobserwowano efekt endotermiczny w temperaturze powyżej 300°C zarejestrowany prawdopodobnie jako efekt endotermiczny związany ze spalaniem składników organicznych;
- efekt endotermiczny w temperaturze 450°C związany z przemianą portlandytu Ca(OH)2 w CaO i CO2, procesowi temu towarzyszy zmniejszenie masy w wyniku dehydratacji i utleniania; na krzywych TG i DTG zaobserwowano efekt endotermiczny w temperaturze powyżej 300°C zarejestrowany prawdopodobnie jako efekt endotermiczny związany ze spalaniem składników organicznych.

* iwona.jonczy@polsl.pl