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ABOUT RESEARCH OF PHYSICAL AND TECHNOLOGICAL PROPERTIES OF COMPOSITE MATERIALS BASED ON ALUMINUM

This article discusses aluminum-based composite materials and its use in the technological process. The production of alloys and composite materials based on aluminum with specified physical, chemical and mechanical-technological characteristics is one of the key tasks of modern materials science. The properties of these materials depend on the purity and structure of the aluminum. There are numerous data on the thermodynamic properties of aluminum alloys, but they often differ due to differences in testing methods and purity of materials. Modern analysis methods, such as optical emission spectral analysis (OESA), allow achieving high accuracy and compliance with international standards. OESA is fast, highly accurate, has low detection limits and simple sample preparation. The Spectral Laboratory of State Unitary Enterprise «TalCo» carried out studies that confirmed the effectiveness of OESA for the analysis of aluminum alloys, providing high accuracy and reliability of the data necessary to improve the performance characteristics of materials, improve the quality, availability and expand their use in various industries.

Keywords: thermodynamic properties, microstructure, spectral analysis, emission spectrum, phase inclusions.

Introduction

The production of various alloys and composite materials based on aluminum with certain physical-chemical and mechanical-technological characteristics is one of the key tasks in modern metallurgy. Aluminum and its alloys are widely used in various industries due to their unique properties, such as lightness, high corrosion resistance, good thermal and electrical conductivity. However, to achieve optimal performance characteristics of materials, it is necessary to carefully control their composition and microstructure [1].

The physical and technological properties of composite materials based on aluminum in various states depend not only on its purity, but also on microstructural features, such as grain size, the presence of phase inclusions and the distribution of alloying elements. This is why it is so important to conduct a detailed analysis of the chemical composition and microstructure of samples. There is a wealth of data on the thermodynamic properties of various aluminum-based alloys and composite materials, but they often vary due to differences in research techniques and material purity used by different researchers [2]. This highlights the importance of conducting experimental studies to accurately determine the composition and microstructure of materials.

Materials and methods

Modern analysis methods, such as optical emission spectral analysis (OESA), provide high accuracy and compliance with international standards. OESA is one of the most popular methods for analyzing the elemental composition of materials due to its rapidity, high accuracy, low detection limits, low cost and ease of sample preparation. In metallurgy and mechanical engineering, OESA is widely used to analyze the composition of metals and alloys, which makes it possible to control product quality and optimize production processes [3; 4].

The operating principle of an optical emission spectrometer is that atoms of elements emit light of specific wavelengths when excited. To do this, the atoms must be excited, for example, using an electrical discharge or a laser. The intensity of radiation of a certain wavelength is proportional to the number of atoms of a given element in the sample, which allows for quantitative analysis. This makes OESA an indispensable tool for accurately determining the content of elements in a material [5; 8].

Our experimental studies, carried out in the Spectral Laboratory of State Unitary Enterprise TalCo, made it possible to determine the chemical composition and microstructure of the samples with high accuracy. Using advanced analysis methods and modern equipment, we ensured the reliability and reproducibility of the data obtained, which is important for the further use of these materials in various technological processes. Thus, accurate analysis of the chemical composition and microstructure of aluminum alloys and composite materials is an important step towards improving their performance characteristics and expanding their applications.

To ensure that the intensities of the spectral lines we selected did not differ too sharply from each other, we chose lines whose intensity ratio does not exceed 10, i.e. is within the range of $0.1 \leq I_{pr} / I_{basic} \leq 10$, since otherwise the accuracy of the determinations decreases. In addition, both lines (analytical line λ_{pr} and the comparison line λ_{basic}) must be in the same part of the spectrum within ¬approximately 10 nm (λ_{pr} – λ basic = 10 nm) so that the dependence of the radiation receiver readings on the wavelength does not affect [6]. Thus, the main requirements for the selected pair will be:

$\Delta E \leq 1$ eV

$\lambda_{pr} - \lambda_{basic} \leq 10$ nm

$0.1 \leq I_{pr} / I_{basic} \leq 10$

A pair of lines that meets these requirements is called a homologous pair, which we took into account during the analysis.

Depending on the method of intensity assessment, the following methods of quantitative spectral analysis are distinguished: 1) visual; 2) photographic; 3) photoelectric ¬[7].

Results and discussion

To analyze the samples, we used the photographic method of spectral analysis; we chose a tungsten electrode as the counter electrode [9]. Observing the above conditions, we studied the chemical composition of 15 samples of composite materials. Below, Table 1 shows the results of the spectral analysis.

Table 1 – Results of spectral analysis of samples

Sample No.	Calculated composition of samples	Results of optical atomic emission analysis (OESA)			
		Al (%)	C (%)	Cu (%)	Impurities
1	Al (Pure Ingot)	99.6			0.4
2	Cu (Pure Ingot)			99.7	0.3
3	Al (Pressed powder)	99.6			0.4
4	95% Al +5% C	94.5	4.7		0.8
5	90% Al +10% C	89.4	9.7		0.9
6	85% Al + 15% C	84.2	14.6		1.2
7	80% Al + 20% C	79.2	19.6		1.2
8	70% Al + 30% C	69.1	29.6		1.3
9	95% Al +2.5% C+2.5% Cu	94.6	2.2	2.6	0.6
10	90% Al +5% C+ 5% Cu	89.4	4.8	5.1	0.7
eleven	85% Al +7.5% C+7.5% Cu	84.2	7.2	7.5	1.1
12	80% Al +10% C+10% Cu	79.2	9.6	10.2	1.1
13	70% Al +15% C+15% Cu	69.2	14.4	15.3	1.1
14	60% Al +20% C+20% Cu	59.8	19.3	20.2	1.1

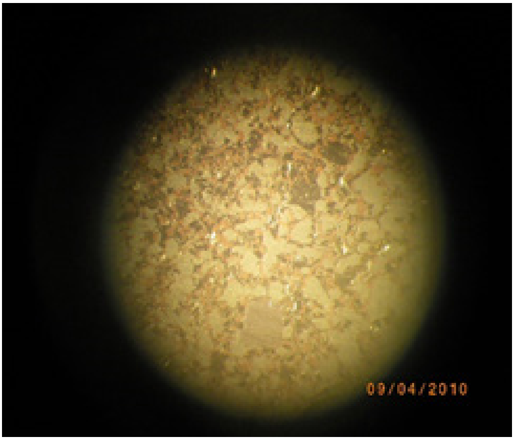
Microstructural analysis was carried out to study in detail the structure of the objects under study using a high-precision microscope on specially prepared samples. To record the microstructure, a "Metallographic Aggregate Microscope" model "METAM - P1" was used, which has the ability to magnify the image in the range from 50 to 507 times. The microanalysis methods used in the study made it possible not only to determine the shape and size of crystal grains, but also to identify changes in the internal structure of the samples caused by heat treatment or mechanical stress. In addition, it was possible to detect microcracks and other defects, which plays a key role in assessing the quality of the materials under study [10].

Microstructural analysis was carried out on microsections, the preparation of which took into account the following requirements: – the section must have a minimal deformed layer; – there should be no scratches or pits on the surface of the polished section; – the section must be flat, without “blockages”, so that it can be examined at high magnifications. A thin section, that is, a sample with a flat polished surface, was prepared mechanically as follows. First, the sample was processed to a plane (facing) using a wheel. The edges were chamfered so that during subsequent operations the polishing cloth would not be damaged. Then grinding was carried out on special paper with different abrasive grains, laid on the glass. When moving to the next paper number, the sample was turned 90º and polished until the marks from the previous processing disappeared. After sanding on the last paper, the sand was washed in water to prevent abrasive particles from getting onto the polishing wheel. This was followed by polishing: the polishing section was lightly pressed against a rotating circle, on which cloth was stretched, constantly wetted with a suspension of fine abrasive and water. The abrasives used for polishing were aluminum oxide (white) and chromium oxide (green). For our samples, a paste with diamond powder was used, and polishing continued until a mirror surface was obtained. After this, the section was washed in alcohol and dried with filter paper [11].

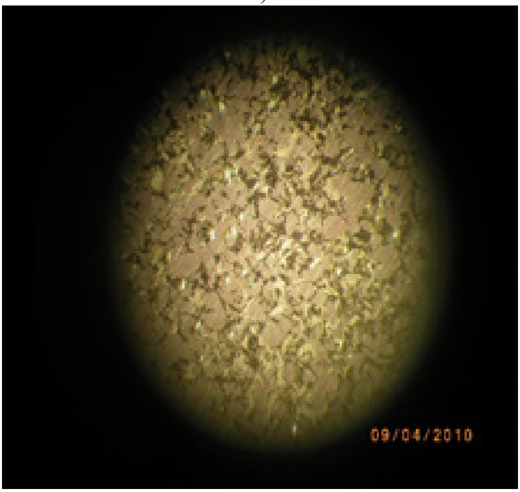
After polishing, the microstructure usually remains invisible on the surface of the samples, except in cases where the structural components of the alloys differ significantly in composition and hardness, which can lead to the formation of a pronounced relief. This relief becomes visible due to different degrees of polishing of different areas of the sample, which is associated with different hardness and chemical composition of the material.

In order to fully reveal the microstructure and gain a detailed understanding of the internal structure of the material, our sections were subjected to an etching process. Etching is a special method of treating the surface of a sample with a short-acting reactive solution. During this process, the selection of optimal parameters was carried out, including the choice of etchant composition and optimal exposure time, based on many years of experience and the results of systematic experiments.

The etching and microstructural analysis results are illustrated in Figure 1 [12], providing a visual representation of the data obtained and their interpretation for the scientific and engineering community.



a)



b)

Figure 1 – Microstructure of samples: a) sample 10; b) sample 14

Conclusion

The production of aluminum-based alloys and composite materials with specified physical, chemical and mechanical-technological characteristics plays a vital role in modern metallurgy. The study confirmed the importance of the purity and microstructure of aluminum in the formation of its performance properties. Differences in data on the thermodynamic properties of aluminum alloys, due to differences in testing techniques and sample purity, highlight the need for accurate and modern analytical methods. Optical emission spectral analysis (OESA) has established itself as a highly effective method for analyzing the chemical composition of materials, due to its rapidity, high accuracy and ease of sample preparation. Experimental studies conducted in the Spectral Laboratory of State Unitary Enterprise TalCo showed that the use of OESA allows one to achieve reliable and reproducible results. These data are important for further improvement of technologies for the production of aluminum alloys and composites, which opens up new opportunities for their use in various industries. Continuing research in this direction will contribute to the development of analysis methods and improvement of the quality of produced materials.

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АЛЮМИНИЙ НЕГІЗІНДЕГІ КОМПОЗИТТЫҚ МАТЕРИАЛДАРДЫҢ ФИЗИКАЛЫҚ-ТЕХНОЛОГИЯЛЫҚ ҚАСИЕТТЕРІН ЗЕРТТЕУ ТУРАЛЫ

Белгіленген физикалық, химиялық және механикалық-технологиялық сипаттамалары бар алюминий негізіндегі қорытпалар мен композициялық материалдарды өндіру қазіргі материалтану ғылымының негізгі міндеттерінің бірі болып табылады.

Бұл материалдардың қасиеттері алюминийдің тазалығы мен құрылымына байланысты. Алюминий қорытпаларының термодинамикалық қасиеттері туралы көптеген деректер бар, бірақ олар сынау әдістері мен материал тазалығының айырмашылығына байланысты жиі өзгереді. Оптикалық эмиссиялық спектрлік талдау (OESA) сияқты заманауи талдау әдістері жоғары дәлдік пен халықаралық стандарттарға сәйкестікке қол жеткізуге мүмкіндік береді. OESA жылдам, өте дәл, анықтау шегі төмен және үлгіні қарапайым дайындау. «ТалКо» мемлекеттік унитарлық кәсіпорнының спектрлік зертханасы материалдардың пайдалану сипаттамаларын жақсарту және оларды әртүрлі салаларда қолдануды кеңейту үшін қажетті мәліметтердің жоғары дәлдігі мен сенімділігін қамтамасыз ететін алюминий қорытпаларын *талдау үшін OESA тиімділігін растайтын зерттеулер жүргізді. өнеркәсіп.*

Кілтті сөздер: термодинамикалық қасиеттер, микроқұрылым, спектрлік талдау, сәуле шығару спектрі, фазалық қосындылар.

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ОБ ИССЛЕДОВАНИИ ФИЗИЧЕСКИХ И ТЕХНОЛОГИЧЕСКИХ СВОЙСТВ КОМПОЗИЦИОННЫХ МАТЕРИАЛОВ НА ОСНОВЕ АЛЮМИНИЯ

Производство сплавов и композиционных материалов на основе алюминия с заданными физическими, химическими и механико-технологическими характеристиками является одной из ключевых задач современной металлургии. Свойства этих материалов зависят от чистоты и структуры алюминия. Имеются многочисленные данные о термодинамических свойствах алюминиевых сплавов, но они часто различаются из-за различий в методах исследования и чистоте материалов. Современные методы анализа, такие как оптико-эмиссионный спектральный анализ (OESA), позволяют добиться высокой точности и соответствия международным стандартам. OESA характеризуется быстротой, высокой точностью, низкими пределами обнаружения и простой пробоподготовкой. В Спектральной лаборатории ГУП «ТалКо» проведены исследования, подтвердившие эффективность ОЭСА для анализа алюминиевых сплавов, обеспечивающего высокую точность и достоверность данных, необходимых для улучшения эксплуатационных характеристик материалов и расширения их использования в различных отраслях промышленности. отрасли.

Ключевые слова: термодинамические свойства, микроструктура, спектральный анализ, спектр излучения, фазовые включения.

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