Вісник Тернопільського національного технічного університету
Scientific Journal of the Ternopil National Technical University
2016, № 3 (83)
ISSN 1727-7108. Web: ***visnyk.tntu.edu.ua***

UDC 621.74

NON-DESTRUCTIVE ELEMENTAL ANALYSIS OF STEEL 30 AFTER BORON COATING WITH MODERN EQUIPMENT FOR MATERIAL QUALITY CONTROL

Oleg Cherneta; Roman Voloshchuk; Boris Sereda; Oleksandr Lavrik

Dneprodzerzhinsk State Technical University, Kamyanske , Ukraine

Summary. *Micro x-ray fluorescence analysis is widespread in industry and science due to its flexibility, accuracy and measurement speed, and ease of use.*

The method is based on the dependence of micro X-ray fluorescence intensity of the element concentration in the sample. When irradiating the sample stream powerful X-ray tube fluorescent radiation characteristic radiation arises atoms, which is proportional to their concentration in the sample.

Key words:*boron coating, non-destructive, material, analysis, micro x-ray fluorescence.*

Received 01.10.2016

Problem setting. The properties of any material are determined primarily by its chemical composition and structure, which is influenced by various external features. Therefore, in performing experimental studies it is necessary to determine the state of the material, and conduct its full chemical analysis as well. During the experiment famous steel make should be used. However, during the experiment (especially in a production environment) erroneous manipulation of the steel make are possible due to which there is urgent need for checking compliance of the selected steel make with the object of the study.

Analysis of the known research results. Surface condition largely determines the operational properties of machine parts and cars. This led to a new direction called surface engineering, which is carried out by means of combined energy and physical and chemical action. The development of surface engineering involves the development of new processes that allow the surface layer to modify radically its structure and properties. The question of improving the operational reliability of parts by technological methods because of lower oil loading of the layer dynamics and damping oscillatory process by technological methods has been covered in the works of several authors (S.N Poliovyi, V.D. Yevdokimov, N.A. Boucher, S.P. Kosyreva and etc.). Processing of the working surface with boron coating helps to increase life of the parts and materials. Before the main work it is necessary to determine the chemical state of the material to ensure durability and quality parts by non-destructive methods of analysis, which allows to directly defining a powder, solid and liquid samples of almost all chemical elements of the periodic system [1].

The purpose of the work. Evaluation of the chemical composition of steel 30 after boron coating with operational methods of approximate estimation of the chemical composition of steel with non-destructive analysis of samples by untrained models using semi-quantitative analysis of materials with the equipment M1 MISTRAL і M4 TORNADO

Research Materials. Shafts are made of solid 30 quality steel which is mainly used in the manufacture of engineering heavily loaded machine parts. These brands have a high resistance to wear and more resistant to corrosion. Table №1 gives chemical composition of steel 30 boron coating [2].

Corresponding author: Oleg Cherneta; e-mail: ocherneta@gmail.com

Table № 1

Chemical composition of steel 30 beforeboriding

C	Si	Mn	Ni	S	P	Cr	Cu	As	Fe
0,27 - 0,35	0,17 - 0,37	0,5 - 0,8	до 0,25	до 0,04	до 0,035	до 0,25	до 0,25	до 0,08	~97

Problem setting. The durability of machine parts depends on the processing quality of parts and condition of the surface layer, and the chemical composition of materials control. The introduction of new technological processes of analysis and research material ensures durability of parts and determines the optimum system parameters of the surfaces quality that would more fully reflect their performance properties.

To improve parts durability the method of thermochemical treatment (TCT) is used, which allows to get on the surface a full range of products of necessary properties: high hardness, corrosion resistance, wear resistance, heat resistance, etc.Boriding process refers to perspective TCT methods.

In comparative evaluation of existing boron coatingmethods (Table № 2), firstly, their technological advantages and disadvantages, performance (velocity saturation) and value (economic efficiency) should be considered.

It should be noted that at this time there is no boron coating method that would far superior to all others by its technical and economic performance.

In terms of technological simplicity the most advantageous is electrolysis boron coating. This process does not need any special equipment as it is carried out in conventional ovens – baths[3].

Table № 2

Comparative characteristics of boriding methods

№	Method	Advantages	Disadvantages
1	Liquid boriding (without electrolysis)	Technology simplicity, absence of special equipment	Increased viscosity Of the used alloys compared with net brown
2	Electrolysis boriding	A high quality of boriding layers, high performance	Необхіднаспеціальна енергоємна установка Requirespecial energy-intensive plant
3	Boriding in powder environments	The simplicity of the technological equipment, complex shapes products strengthening, minimum strain at processing	The biggest costs on owder mixture
4	Gas boriding	Complex forms products strengthening	Explosive

M1 MISTRAL and M4 TORNADO were selected to control the quality of the material before and after boron coating and research non-destructive method of elemental analysis. This equipment combines modern spectroscopic methods, allowing receiving the best and accurate analytical characteristics of the elemental composition by simple testing by users with any training.

M1 MISTRAL and M4 TORNADO aremicro and X ray and fluorescencespectrometers for elemental mapping of large surfaces intended for local elemental microanalysis of various objects: microelectronic circuit boards, coatings, powders, metals and alloys, etc.

Micro and X ray and fluorescenceanalysis is the best method of non-destructive elemental analysis from sodium (11) to uranium (92) of heterogeneous samples, irregular shape samples or small particles in the sample with high sensitivity. To focus the exciting radiation tests on local fields is used ray capillary optics, which allows to quickly analyzing with high spatial resolution. Almost all kinds of materials can be analyzed with minimal or no sample preparation at all.

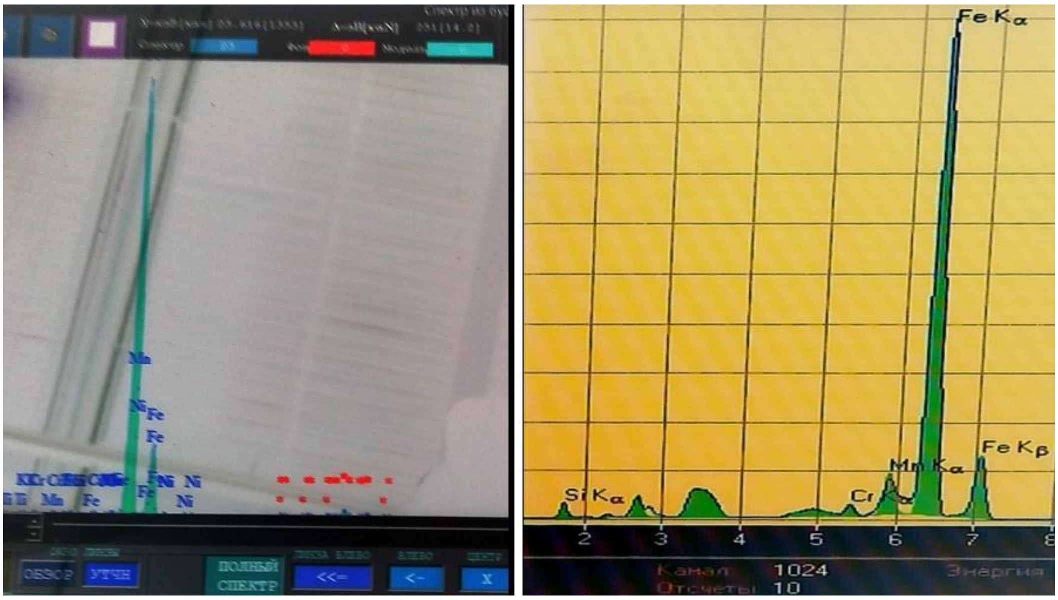
Micro and X ray and fluorescence spectrometers M1 MISTRAL and M4 TORNADO are stationary multipurpose, automated instruments that provide the measurement, processing and registration of initial information (Figure 1 and 2).

Figure 1. General view of the spectrometer micro X-ray fluorescence M1 MISTRAL

Figure 2. General view of the spectrometer micro X-ray fluorescence M4 TORNADO

Research results. Metallographic, microdurometric and phase X-ray analysis showed that in the TCT boron coating of alloyed with chromium, silicon, and titanium containboth the main phase Fe and alloy phase Fe_2B – (FeCr Al Ti Si.)2B.

The distribution of elements on coating thickness indicates the presence of two areas: transitional – boridingzone and base layer zone. Figure №3 shows the type of display to the distribution of chemical elements of steel 30 after boron coating.



M1 MISTRAL M4 TORNADO

Figure 3. Display with the distribution of chemical elements made by micro X-ray fluorescence spectrometers M1 MISTRAL and M4 TORNADO

Table №3 presents the chemical composition of steel 30 in percentages received after boron coating by micro X-ray fluorescence spectrometers M1 MISTRAL and M4 TORNADO.

As seen from the obtained figures they are not significantly different from each other. So one can consider that modern metallographic, microdurometric and X-ray phase analysis may be used to testand ensure accurate performance of strengthened details element that will predict the durability of machine parts and determine to the quality of parts processing and condition of the surface layer [4].

Table № 3

The chemical composition of steel 30 after boron coating

	M1 MISTRAL	**M4 TORNADO**
C	0,30±0,043	0,30±0,049
Si	0,425±0,049	0,560±0,010
Mn	0,249±0,015	0,390±0,005
Ni	0,090±0,009	0,078±0,022
S	0,046±0,005	0,025±0,002
Cr	0,148±0,009	0,160±0,034
Fe	96,123±0,139	97,010±0,043
Al	0,121±0,020	0,099±0,019
Ti	0,210±0,020	0,195±0,030

Conclusions. Micro X-ray fluorescence spectrometers M1 MISTRAL and M4 TORNADO are nondestructive express method of determining the elemental composition of materials. It is especially important when dealing with expensive and new experimental models as they allow for a minimum period of time to get the most complete and reliable information on the elemental composition of complex samples regardless of their physical state and origin.

Thegrowthof atomic element number is followed bysensitivity growth, and error in quantitative determination of element composition decreases. Quantitative X-ray fluorescence analysis is characterized by high reproducibility of the results when sample is represented and very good sensitivity. Excellent stability of modern tools eliminates the need for frequent repeat measurements or gauging. This guarantees high precision at low cost in the analysis. The basis of quantitative analysis is the dependence of the characteristic radiation on wavelength. The nature of this relationship is established experimentally based oncalibration that is measurements of characteristic fluorescence intensity in several standard (reference) samples - samples with known concentrations of accurately determined element. Conversion of the measured intensities of the elements of the unknown sample concentration per unit is based on the ongoing calibration which is described mathematically by using the calibration function.

The combination of all the above advantages of the method favorably distinguishes it from most modern methods.

References

1. Panasiuk V.V., Andreykyn A.E. Mechanics razrushenyya and prochnosty materials: Ref. Posobye: In 4 t. Under Global Ed. Panasyuk V.V. Kiev: Science. Thought, 1988. Vol. 1. Fundamentals of mechanics razrushenyya. Parton VZ. 1988. 488 p. [In Russian].
2. Hrachëv S.V., Baraz V.R., Bogatov A.A., Shveykyn V.P. Physical metallovedenye. Textbook for Universities. Ekaterinburg. Ed. 2, ext. And Corr. Izdatel'stvo USTU-UPY. 2001, P. 534. [In Russian].
3. Termycheskaya obrabotku in mashinostroeniya: Directory ed. Yu.M. Lahtyna, A.H. Rahshtadta. M.: Engineering, 1980. 783 p. [In Russian].
4. Lahtin Y.N. Method mykrotverdosty the study of superficial layers of metal. Bryansk: BYTM, 1984. 11 p. [In Russian].

Список використаної літератури:

1. Панасюк, В.В. Механика разрушения и прочности материалов [Текст] / В.В. Панасюк, А.Е. Андрейкин, В.З. Партон; под общей ред. Панасюка В.В. // Справ. Пособие: В 4 т. – Киев: Наук. Думка, 1988 – Т. 1: Основы механики разрушения, 1988. – 488 с.
2. Физическое металловедение: учебник для вузов [Текст] / С.В. Грачёв, В.Р. Бараз, А.А. Богатов, В.П. Швейкин. – Екатеринбург. Изд. 2, доп. и испр. – Изд-во УГТУ-УПИ, 2001. – С. 534.
3. Термическая обработка в машиностроении: справочник [Текст] / под ред. Ю.М. Лахтина, А.Г. Рахштадта. – М.: Машиностроение, 1980. – 783 с.
4. Лахтин Ю.Н. Методика исследования микротвердости поверхностных слоев металла [Текст] / Брянск: БИТМ, 1984. – 11 с.

УДК 621.74

НЕРУЙНІВНИЙ ЕЛЕМЕНТАРНИЙ АНАЛІЗ СТАЛІ 30 ПІСЛЯ БОРУВАННЯ, СУЧАСНИМ ОБЛАДНАННЯМ ДЛЯ КОНТРОЛЮ ЯКОСТІ МАТЕРІАЛУ

Олег Чернета; Роман Волощук; Борис Середа; Олександр Лаврик

Дніпродзержинський державний технічний університет, Кам’янське, Україна

Резюме. *Мікрорентгенофлуоресцентний аналіз набув значного поширення як у промисловості, так і науці завдяки своїй універсальності, точності й швидкості вимірювань, а також простоті експлуатації.*

Метод заснований на залежності інтенсивності рентгенівської флуоресценції від концентрації елемента в зразку. При опроміненні зразка потужним потоком випромінювання рентгенівської трубки виникає характеристичне флуоресцентне випромінювання атомів, яке пропорційне їх концентрації в зразку.

Ключові слова: *борування, неруйнівний, матеріал, аналіз, мікрорентгенофлуоресцентний.*

Отримано 01.10.2016