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INFLUENCE OF REGIMES ELECTROLYTE--PLASMA PROCESSING ON PHASE STRUCTURE, MECHANICAL PROPERTIES AND WEAR RESISTANCE OF STEEL 30CrMnSi

WPŁYW WARUNKÓW OBRÓBKI ELEKTROLITYCZNO--PLAZMOWEJ NA BUDOWĘ STRUKTURALNĄ, WŁASNOŚCI MECHANICZNE I ODPORNOŚĆ NA ZUŻUWANIE STALI 30CrMnSi

Key words:

electrolytic-plasma cementation; microhardness; wear resistance; modified surface coating

Słowa kluczowe:

obróbka elektrolityczno-plazmowa, mikrotwardość, odporność na zużywanie, modyfikowanie powierzchni

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Summary

The present work is research on the influence of various modes of electrolytic-plasma cementation on changes in structurally-phase conditions and hardening of constructional steel 30CrMnSi. This process has been chosen for investigation because of its economical use of power, the formation of stable ferrite-perlite structures, and higher mechanical properties. The cementation process was carried by selecting different modes of electrolytic-plasma processing in the electrolyte containing a water solution of 10% sodium carbonate and 10 % glycerine.

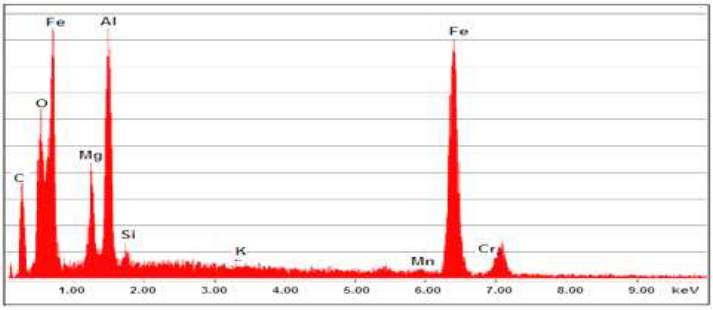
INTRODUCTION

It is known that in modern applied materials technology, the power saving technologies promote an increase in productivity and working capacity and plays very important role in scientific and technical progress in mechanical engineering. The urgency of this problem is especially obvious to the manufacture of automotive parts made of κ-constructional alloyed steels that are intensively exposed to temperature influences that cause the deterioration of surface layers. Various methods and modes of electrolyte-plasma processing leads to the reduction of energy and labour cost and an increase in mechanical qualities. Therefore, wide application of technologies of processing in electrolyte plasma is the perspective direction in machine manufacture **[L. 1].** From this point of view, there is a huge increase in the study of wear resistance related to methods of electrolyte-plasma processing.

MATERIAL AND METHODS

The purpose of this research is to determine the optimum mode of electrolyte-plasma cementation of constructional steel 30CrMnSi and to define the related mechanical properties. As a research material, 30CrMnSi steel in initial condition and after various modes of electrolyte-plasma cementation was used. The chemical composition of the steel is as follows: 0.3% C, 0.8 – 1.1% Cr, 0.8 – 1.1% Mn, 0.8-1.1% Si, 0.025% P, and 0,025% S, and iron in accordance with GOST 4543-71.

Figure 1 presents the chemical compound and distribution of elements in the sample of the investigated steel, received experimentally using a scanning microscope in the laboratories of University of Otto von Guericke (Magdeburg, Germany, November, 2011).



C, %	Si, %	Mn, %	Cr, %	Al, %	O, %	Fe, %
0,3109	0,941	0,966	0,933	0,0255	0,0426	96,36

Fig. 1. The chemical compound and distribution of elements in the sample of the investigated steel

Rys. 1. Skład chemiczny i rozkład składników w próbce badanej stali

Structural research of samples of 30CrMnSi steel were conducted at The Institute of Nanotechnology and New Materials, D. Serikbaev East Kazakhstan State Technical University and in the scientific laboratories of the Institute of Materials Technology and Connecting Technologies of the University of Otto von Guericke (Magdeburg, Germany) by X-Ray analysis on diffractometer X'Pert PRO in monochromatic CrK_α - radiation (λ = 2.2897 Å), optical microscopy on NEOPHOT-21. Mechanical tests for microhardness were conducted on a PMT-3 in accordance with GOST 9450-76 and by the measurement of wear resistance by friction against loosely fixed abrasive particles in accordance with GOST 23.208-79. Samples after mechanical polishing were exposed an electrolytic containing 100 cm^3 of the distilled water, 10 g chromic anhydrite at room temperature, with a working voltage of 6-20 V and a density of current 0.1 A/cm^2.

RESULTS AND DISCUSSION

Metallographic research of the initial sample of 30CrMnSi has shown that the steel possesses a ferrite-perlite structure of a random distribution (**Fig. 2a**).

Approximately ~ 60 % of basic volumes on the investigated steel are occupied by grains of perlite. The average sizes of the grains of perlite are about 12.7 microns, and the average sizes of the grains of ferrite are about 9.4 microns. **Figure 2b** is the image of the X-ray diffractogramme and line ruling x-ray. Peaks shown in the diffractogramme correspond to the α - Fe phase **[L. 2]**.

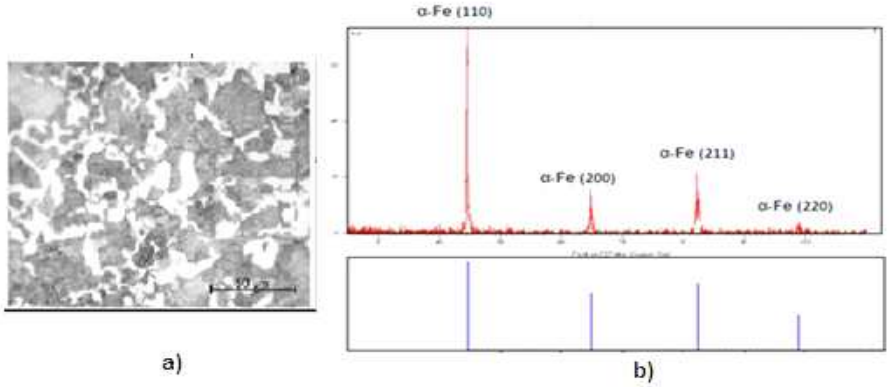


Fig. 2. Microstructure (a) and diffractogramme, line ruling x-ray (b) an initial condition of steel

Rys. 2. Mikrostruktura (a) i dyfraktogram rentgenowski (b) dla stali wyjściowej

Research was then conducted on the influence of various modes of the formation process of diffused layers produced by the electrolyte-plasma process. Investigation of the general kinetics and formation mechanisms during electrolyte-plasma processing with use of various electrolytes was then carried out to optimise the process to improve the quality of the processed steel and stabilise its physic-mechanical properties and increase operational characteristics **[L. 1–4].**

Installation of electrolyte-plasma processing includes a strengthened cathode, a stainless steel anode, a drip pan, a pump, a heat exchanger, a power supply, and a personal computer.

Processing is carried out in glow-discharge plasma at 850-950°C for 5-10 minutes with various electrolytes, depending on the source of heat (cathode or anode), the chemical compound of the processed steel, and the intended goal of the chemical-thermal treatment (cementation, nitrating, nitro-cementation, carbon-nitration).

Electrolyte-plasma cementation was carried out in a water solution of 10% sodium carbonate and 10% glycerine at the following regimes: a) 850°C, 180 sec, 320-180 V; b) 850°C, 360 sec, 320-180 V; c) 950°C, 180 sec, 320-180 V; d) 950°C, 360 sec, 320- 180 V. **Figure 3** shows the borders of the grains of ferrite of iron carbides and oxides.

Figure 4 presents the microstructure and diffractogramma of 30CrMnSi from the X-ray diffractometer, X'Pert PRO, after electrolyte-plasma cementations. The processing mode was 850°C for 180 sec at 320-180 V in a water solution of sodium carbonate and glycerine. Research has shown the location of the borders of the grains of ferrite iron carbides (Fe_5C_3).

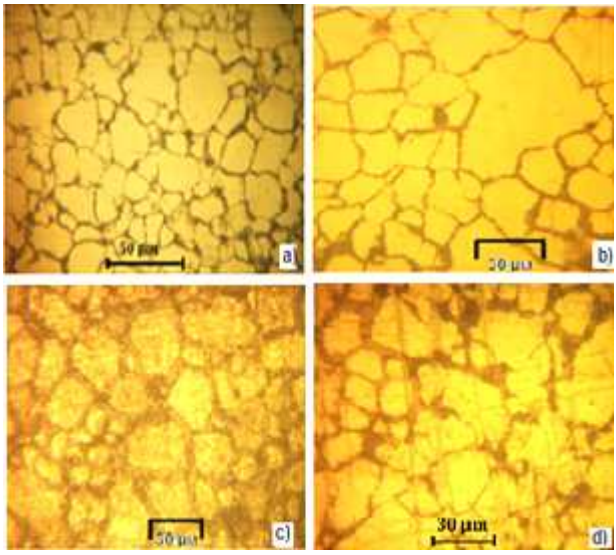


Fig. 3. Microstructure of steel 30CrMnSi after electrolyte-plasma cementation
Rys. 3. Mikrostruktura stali 30CrMnSi po obróbce elektrolityczno-plazmowej

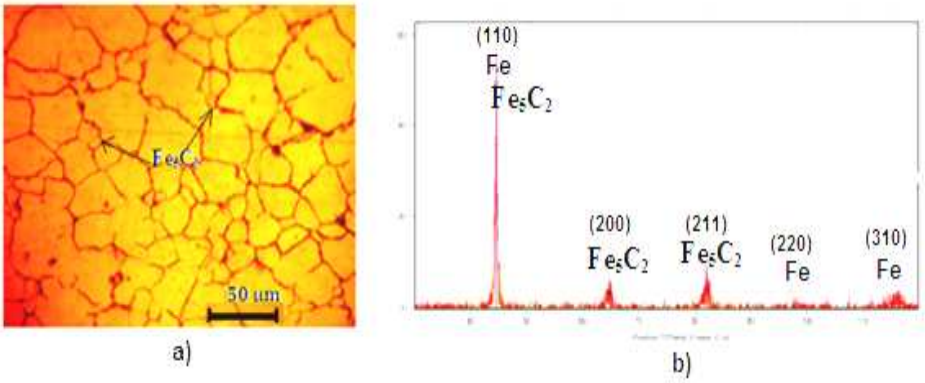
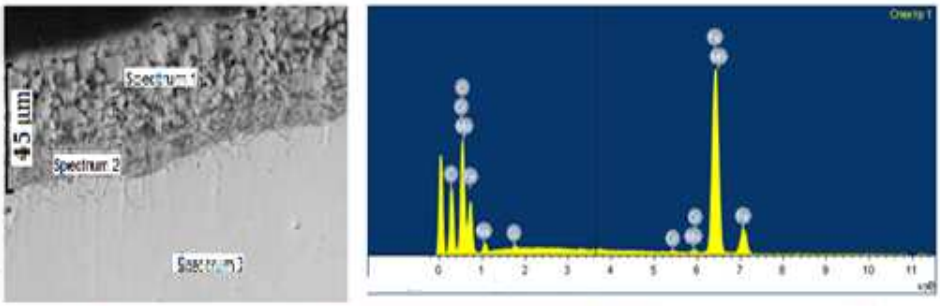


Fig. 4. Microstructure (a) and X-ray graph (b) of steel 30CrMnSi
Rys. 4. Mikrostruktura (a) i wykres rentgenowski (b) stali 30CrMnSi

Cross-section samples after various modes of electrolyte-plasma cementation have been investigated. X-ray scattering electron-microscope indicates that the processing depth of the saturated layer is about 40-50 microns.

After electrolyte-plasma processing of samples of steel, tests were conducted for microhardness in accordance with GOST 9450-76 and on abrasive wear resistance in accordance with GOST 23.208-79.



spectrum	C	O	Na	Si	Cr	Mn	Fe	sum
spectrum 1	27.27	25.01	1.68	0.25	0.21	0.66	44.92	100.00
spectrum 2	28.68	21.82	1.48	1.14	0.93	0.45	45.51	100.00
spectrum 3	26.39			0.70	0.74	0.69	71.48	100.00

Fig. 5. Element analysis sample cross-section of steel 30CrMnSi
Rys. 5. Analiza składu przekroju próbki stali 30CrMnSi

Microhardness was measured on a Vickers tester with a loading of 1N. **Figure 6** indicates the increase in microhardness after processing. Abrasive wear resistance of steel was defined based on the loss of mass sample steels after processing (**Figure 7**). Research indicates that the loss of mass decreased at a temperature 850°C, 180–360 sec **[L. 5].**

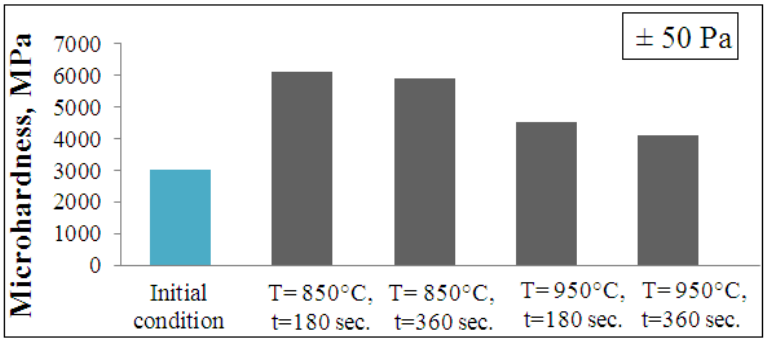


Fig. 6. Tests for microhardness surface coating sample of steel 30CrMnSi
Rys. 6. Mikrotwardość powierzchni próbki stali 30CrMnSi

Tests for microhardness were performed on a PMT-3, Vickers, with a load of 1N. The received diagram indicates that the maximum increase in microhardness is reached at 850°C, 180-360 sec.

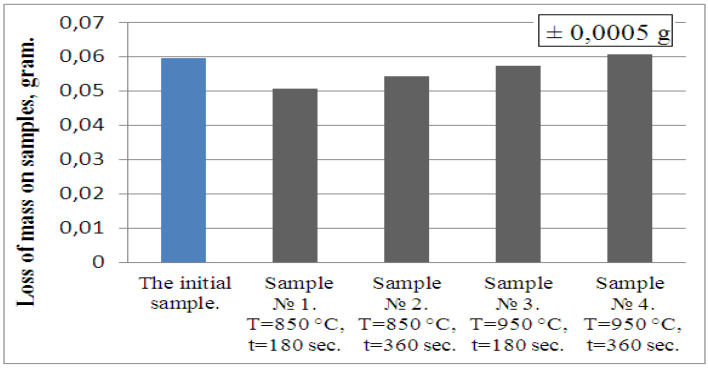


Fig. 7. Tests for abrasive wear resistance surface coating sample of steel
Rys. 7. Odporność na zużywanie powierzchni stali

CONCLUSIONS

Thus, on the basis of the performed analysis of the results received after electrolyte-plasma processing, it is possible to draw the following conclusions:

1. Electrolyte-plasma processing is the most effective and power saving technology of processing.
2. The optimal mode to produce the diffused layer is while electrolyte-plasma cementation takes place at 850°C, 180-360 sec.
3. The microhardness of 30CrMnSi steel after processing is approximately 6100 MPa.
4. Abrasive wear resistance based on loss of mass is approximately 0.050-0.060 grams.
5. The saturated layer which consists of α - Fe, iron carbides (Fe_5C_2) and iron oxides (FeO).
6. The depth of the saturated layer is about 40-50 microns.

Acknowledgments

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Streszczenie

Prezentowana praca poświęcona jest badaniom wpływu różnych sposobów obróbki elektrolityczno-plazmowej na zmianę właściwości strukturalno--fazowych i twardości stali 30CrMnSi. Dokonano wyboru procesów obróbki odznaczających się zapotrzebowaniem na małe moce i zasoby materiałowe, co zostało potwierdzone badaniami naukowymi. Wybrane procesy prowadzą do formowania stabilnej struktury ferrytyczno-perlitycznej oraz podwyższają własności mechaniczne stali. Procesy obróbki przeprowadzono przy wyborze różnych parametrów elektrolityczno-plazmowych w elektrolicie zawierającym wodny roztwór 10-procentowy węglanu sodu i 10% gliceryny.