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Microstructure and corrosion properties of the laser treated SUPERSTON alloy

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ABSTRACT

Purpose: Results of laser treatment at cryogenic conditions and its influence on microstructure, microhardness and properties of the SUPERSTON alloy are presented in this article.
Design/methodology/approach: New method of the laser remelting specimens diped in liquid nitrogen made by the CO_2 laser with 6000W laser beam power and scanning velocity 1.0 m/min was employed. Observation microstructure was carried out by scanning electron microscope. Hardness of cross-section of the surface layer has been measured by the Vickers microhardness under load 0.49 N. Corrosion investigation in 3% NaCl by the Atlas 9131 equipment conected with computer PC was done.
Findings: Laser remelting lets obtain fine microstructure in surface layer and increase of microhardness and corrosion properties, compared with base material.
Research limitations/implications: The future investigations connected with aplication conditions should be extend of cavitation tests in the magnetostriction stand.
Practical implications: Obtained results point at possibility of the increase hardness, corrosion and cavitation resistance of the parts worked in marine conditions.
Originality/value: The proposed laser treatment at cryogenic conditions could be used for surface consolidation of the copper alloys applied for ship propellers.
Keywords: Surface treatment; Laser remelting; Copper alloys; Corrosion

1. Introduction

The ship propellers made of copper alloys (e.g. SUPERSTON) [1-3] during exploit action can corrode and undergo the cavitation. One of the method of reducing the action effects of mentioned wear types of ship propellers can be the laser surface remelting at cryogenic conditions [4-9].

On the grounds of previous researches concerning the Al-Si alloys it could be infered that increasing of hardness, wear and corrosion resistance is possible. [10-13].

In that aspect carried out an experiment of the laser treatment at cryogenic conditions SUPERSTON alloy applied for ship propellers [14,15].

The purpose of this article is to show the method of the laser remelting mentioned alloy which let obtain to change of its microstructure, hardness and corrosion characteristics.

2. Methodology and materials for research

In the research the SUPERSTON alloy was used. Chemical composition of investigated material is shown in Table 1. Laser remelting was done by the TRUMPF laser TLF 6000 turbo. The laser beam dimension 1x20 mm, power 6000 W, scanning velocity 1.0 m/min were used in this process. During of the laser remelting process the specimens were immersed in liquid nitrogen.

After laser treatment the microstructure of the surface and cross-section the SUPERSTON alloy was observed by scanning electron microscope.

Corrosion test was made by potentiodynamic method in 3% NaCl at 25±1°C mixed with magnetic stirrer. Speciments potential was changed with the speed of 10 mV/min. Reference electrode was saturated calomel electrode but the auxiliary Ti electrode coated by the platinum layer. Corrosion test was carried out for specimens made of: base material, laser remelted material, laser remelted and grinded material.

Table 1.
Chemical composition of the SUPERSTON alloy (wt. %)

Cu	Al	Mn	Fe	Ni	Zn
rest	7.5	17	3.0	2.5	-

3. Test results

3.1. Microstructure of the SUPERSTON alloy

Microstructure of the SUPERSTON alloy contains α phase, eutectoid mixture, manganese-iron phase (Fig. 1a). After laser remalting fine microstructure in surface layer was obtained (Fig. 1b). Image of the laser surface remelted with laser beam 6000 W power and scanning velocity 1.0 m/min is presented in Fig. 2.

It was found that in observed microstructure of the laser surface remelted layer the SUPERSTON alloy there are phases with different microstructure (Fig. 3) and hardess (Fig. 5) in comparison unprocessed surface layer.

a)

b)

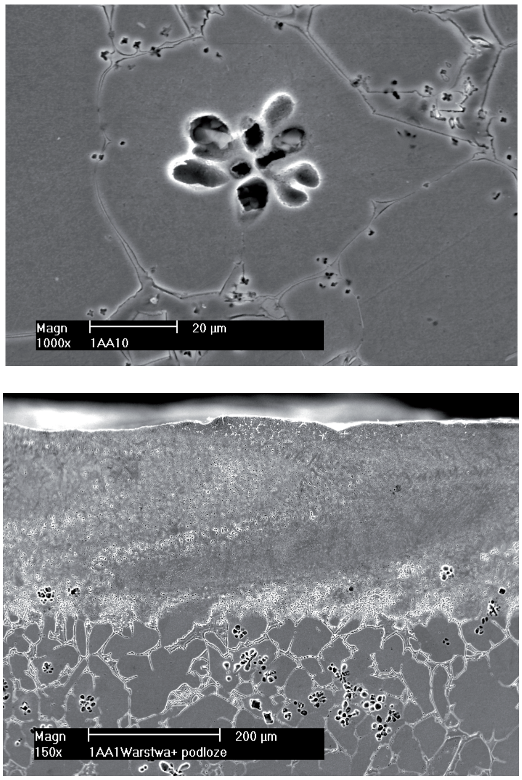

Fig. 1. Microstructure of the SUPERSTON alloy: a – base material, b – cross-section of the laser remelted layer

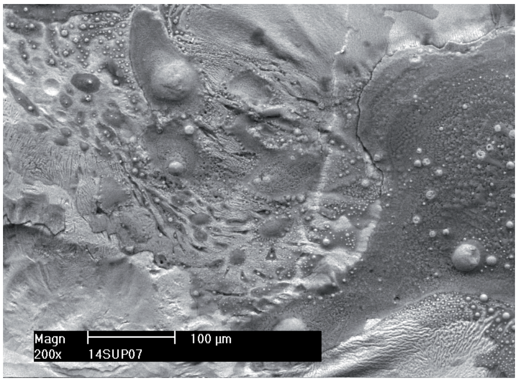

Fig. 2. Microstructure of the laser surface remelted the SUPERSTON alloy

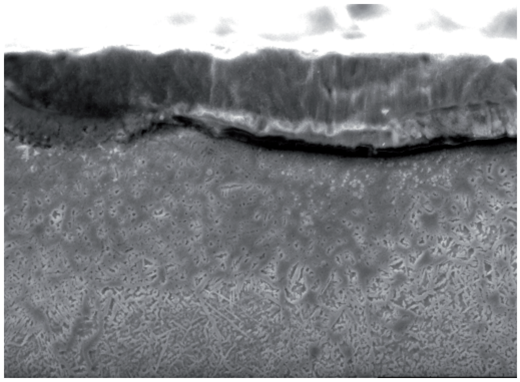

Fig. 3. Detail from Fig.1b

3.2. Microhardness of the SUPERSTON alloy

Microhardness measurements by the Vickers method on the cross-section of the laser surface remelted layer under load 0.49 N are presented in Figs 4 and 5.

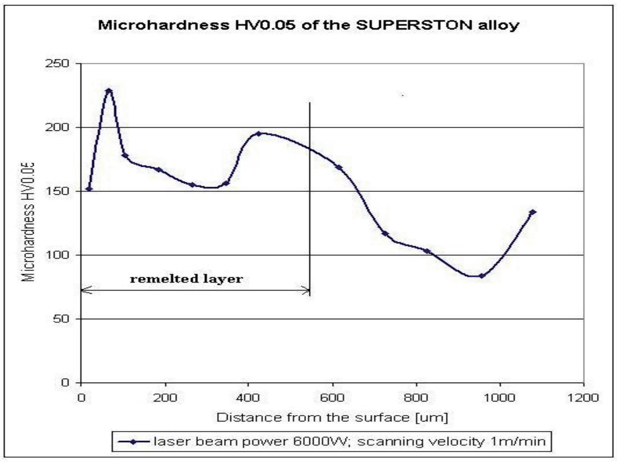

Fig. 4. Microhardness in cross-section of laser remelted layer of the SUPERSTON alloy

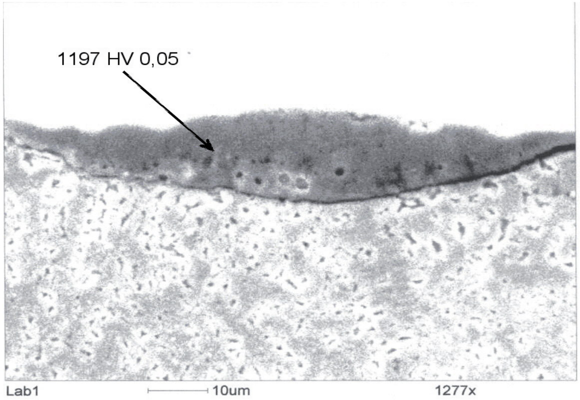

Fig. 5. Microhardness of the phase precipitated in the surface remelted layer the SUPERSTON alloy

3.3. Corrosion test

Corrosion investigations the SUPERSTON alloy were carried out after laser remelting with 6000 W power and scanning velocity 1 m/min. During the potentiodynamic tests corrosion potential (E_c), resistance polarization (R_p) and corrosion current (J_{kor}) were determined. The electrochemical measurements were achieved by the Atlas 9131 set, connected with the computer. Results of those investigations are given in Table 2 and Fig. 6.

Table 2.
Corrosion test results of the laser remelted SUPERSTON alloy at cryogenic conditions

Parameters of the laser remelting	E_c [mV]	R_p [Ωcm^2]	J_{kor} [$\mu A/cm^2$]
Base material	-229	385	51.95
6000 W	-232	643	31.13
6000 W and next grinding	-216	421	47.50

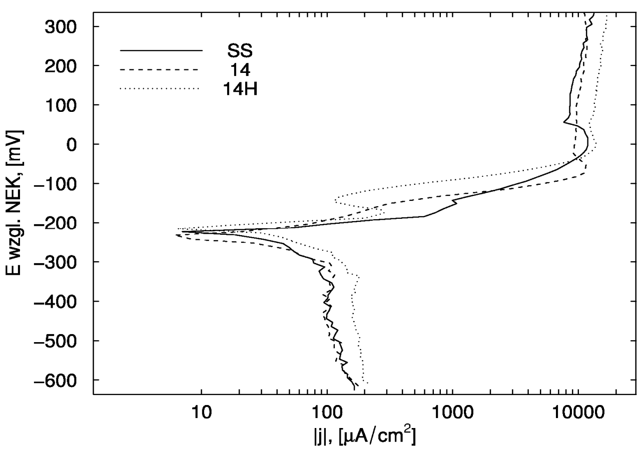

Fig. 6. Potentiodynamic curves of SUPERSTON alloy (6000 W, 1.0 m/min): SS – base material, 14 – after laser remelting, 14H – after laser remelting and grinding process

It was fund that corrosion potential and current density were lower for laser remelted material as well as laser remelted and grinded material of the SUPERSTON alloy.

Microstructure of the surface base material (Fig. 7a), after laser remelting (Fig. 7b) and after laser remelting and grinding (Fig. 7c) up to corrosion process are presented in Fig. 7.

a)
b)
c)

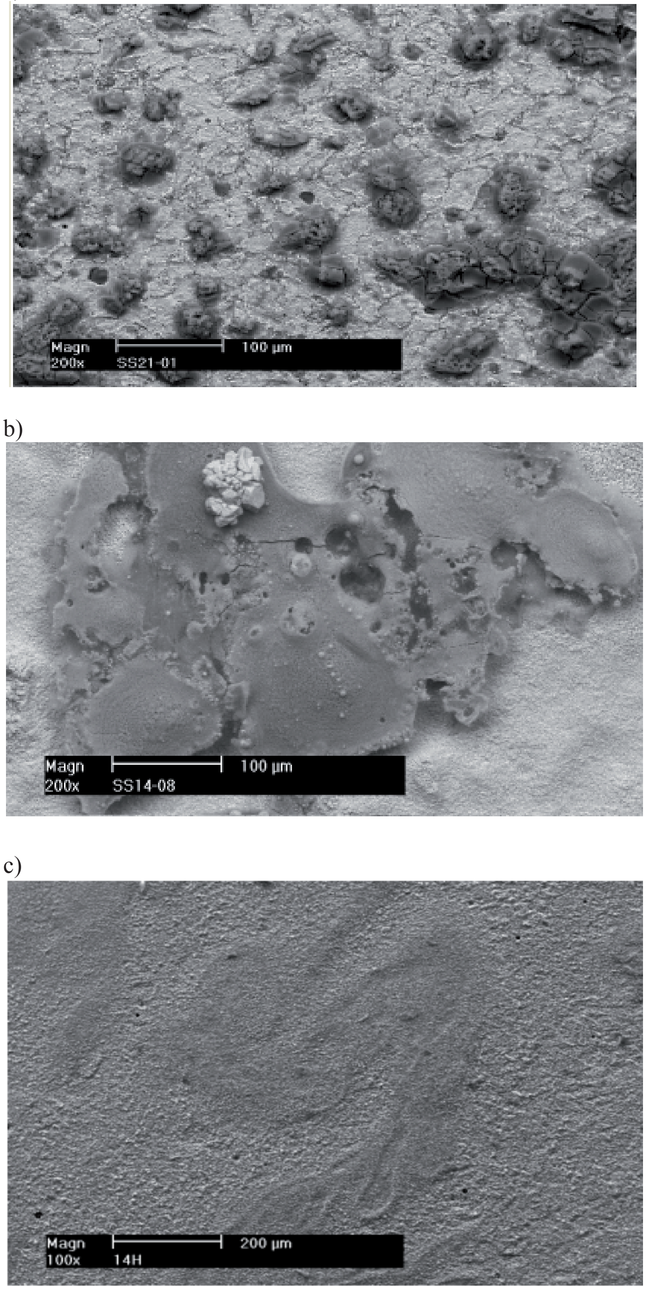

Fig. 7. Image of the microstructure the SUPERSTON alloy: a – base material after corrosion process, b – remelted material by 6000 W after corrosion process, c – remelted material by 6000 W after grinding and corrosion process

4. Conclusions

Fine microstructure in surface layer in comparison to the base material after laser remelting at cryogenic conditions of the SUPERSTON alloy were obtained.

Laser remelting caused the increase hardness and corrosion resistance of the laser remelted layer the SUPERSTON alloy.

Grinding of the laser remelted layer the SUPERSTON alloy reduced its corrosion resistance but it is still the higher then corrosion resistance of the base material.

References

[1] W. Serbiński, B. Majkowska, I. Skalski, Stress corrosion cracking of regenerated ship propellers blades, Polish J. Materiały i Technologie , nr. 2(2) (2004) 141-144 (in Polish).

[2] W. Serbiński, B. Majkowska, I. Skalski, Corrosion properties of the MM55 alloy laser melted at cryogenic conditions, Polish J. Materiały i Technologie, nr. 3 (3) (2005) 197-200 (in Polish).

[3] W. Serbiński, B. Majkowska, I. Skalski, Microstructure and corrosion properties of the laser remelted of selected coppers alloy, Polish J. Inżynieria Materiałowa nr 5, (2005) 379-380 (in Polish).

[4] C.H. Tang, F. T. Cheng, H.C. Man, Improvement In cavitation erosion resistance of a copper-based propeller alloy by laser surface melting, Surface and Technology 182 (2004) 300-307.

[5] C.H. Tang, F. T. Cheng, H.C. Man, Effect of surface melting on the corrosion and cavitation erosion behaviors of manganese-nickel-aluminium bronze, Materials Science and Engineering A 373 (2004) 195-203.

[6] Sen Yang, Yunpeng Su, Weidong Huang, Yaohe Zhou, Microstructure characteristics of Cu-Mn alloys during laser serface remelting, Materials Science and Engineering A 386 (2004) 367-374.

[7] Al-Hashem, W. Riad, The role of microstructure of nickel-aluminium-bronze alloy on its cavitation corrosion behavior in natural seawater, Materials Characterization 48 (2002) 37-41.

[8] C.H. Tang, F.T. Cheng, H.C. Man, Laser surface alloying of marine propeller bronze using aluminum powder, Surface & Coating Technology 200 (2006) 2602-2609.

[9] ASTM Standard G32-92, Standard Method of Vibratory Cavitation Erosion Test, ASTM Standards, Philadelphia 1995.

[10] W. Serbiński, J.M. Olive, J.P. Frayret, D. Desjardins, Morphology and corrosion characteristics of laser surface remelted Al-Si alloy at cryogenic conditions, Materials and Corosion 53 (2002) 335-340.

[11] W. Serbiński, The method and results of the laser surface treatment of aluminium alloys at cryogenic temperature, Polish J. Inżynieria Materiałowa, nr 6, (119) (2000) 434-437 (in Polish).

[12] W. Serbinski, J.M. Olive, T. Wierzchoń, J. Rudnicki, Study of the surface layers created on aluminium-silicon alloy by laser treatment under cryogenic conditions, 3rd International Conference on Surface Engineering, Chengdu, P. R. China (2002) 403-406.

[13] W. Serbiński, A. Zieliński, T. Wierzchoń, Laser assisted forming of the surface layer of Al.-Si alloy at cryogenic conditions, Polish J. Inżynieria Materiałowa, nr 3 (140) 656-658.

[14] K. Krzysztofowicz, T. Krzysztofowicz, L. Nadolny, Materials used for marine propellers, Marine Technology transactions Vol. 11 (2000) 163-179.

[15] B. Majkowska, W. Serbiński, I. Skalski, Corrosion characteristic of the copper alloys applied for ships propellers after laser treatment at cryogenic conditions, (in press) (in Polish).