

# Cavitation behaviour of the SUPERSTON alloy after laser treatment

**B. Majkowska\*, W. Serbiński**

Department of Materials Science and Engineering,  
Gdansk University of Technology,  
ul. Narutowicza 11/12, 80-952 Gdansk, Poland

\* Corresponding author: E-mail address: bmajkows@mech.pg.gda.pl

Received 07.01.2008; published in revised form 01.02.2008

## Manufacturing and processing

### ABSTRACT

**Purpose:** Results of laser treatment at cryogenic conditions and its influence on microstructure, microhardness and cavitation resistance of the SUPERSTON alloy are presented in this paper.

**Design/methodology/approach:** New method of the laser remelting specimens dipped in liquid nitrogen made by the CO<sub>2</sub> laser with 4000 W laser beam power and scanning velocity 0.5 and 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. Cavitation test in the water using rotating disc facility was done.

**Findings:** Laser remelting let obtain fine microstructure in surface layer and increase of microhardness and cavitation resistance, compared to casting the SUPERSTON alloy.

**Research limitations/implications:** The future investigations connected with environment conditions should be extend of internal stresses in the SUPERSTON alloy after laser remelting at cryogenic conditions.

**Practical implications:** Obtained results point at possibility of the increase hardness and cavitation resistance of the parts worked in cavitation conditions.

**Originality/value:** The propose 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; Cavitation

## 1. Introduction

The purpose of this article is to show the method of the laser remelting at cryogenic conditions of the SUPERSTON alloy and its influence on microstructure, hardness and cavitation resistance [1-8].

The SUPERSTON alloy is used for marine propellers which can undergo cavitation during exploitation. The laser remelting in liquid nitrogen is one of the method of reducing cavitation wearing of the copper alloys used for the ship propellers [9-15].

## 2. Methodology and materials for research

Chemical composition of the SUPERSTON alloy used for marine propellers, as the 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 4000 W, scanning velocity: 0.5 and 1.0 m/min were used in this process. The laser treatment of the SUPERSTON alloy was made after immersion specimens in liquid nitrogen (temperature -195°C).

Table 1.

Chemical composition of the SUPERSTON alloy (wt. %)

Cu	Al	Mn	Fe	Ni	Zn	Sn	Pb
76.6	7.1	10.4	3.8	2.0	0.1	0.05	0.01

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

Cavitation test in the water (average temperature 20°C) was performed at rotating disc facility (Fig. 7). During the cavitation process the kinetics of the mass loss was determined.

### 3. Test results

#### 3.1. Microstructure of the SUPERSTON alloy

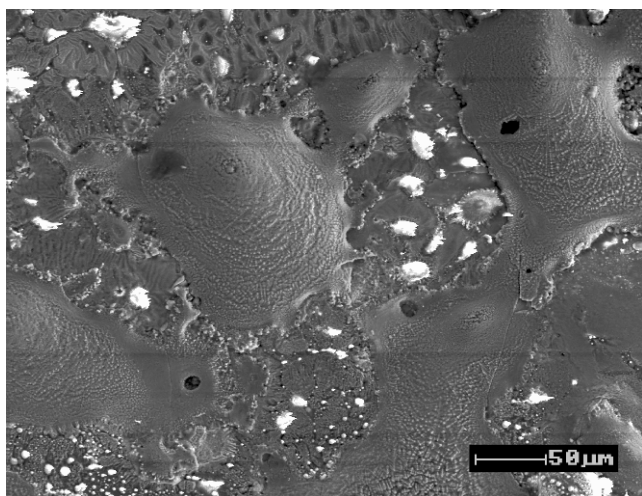


Fig. 1. Surface microstructure of laser remelted the SUPERSTON alloy (4000W, 0.5m/min)

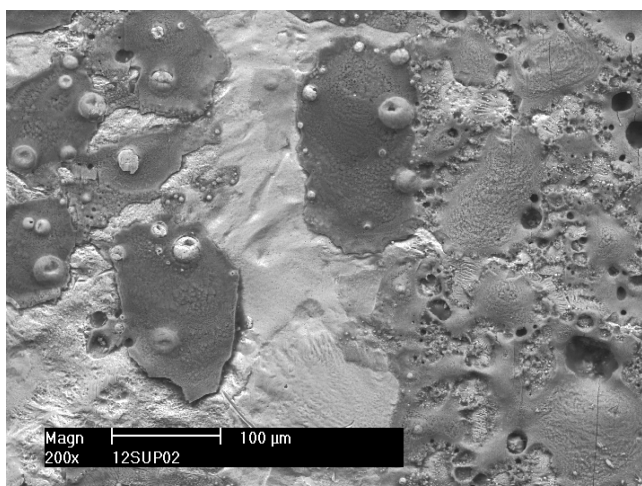


Fig. 2. Surface microstructure of laser remelted the SUPERSTON alloy (4000W, 1.0m/min)

Surface morphology of the SUPERSTON alloy remelted with 4000 W power, scanning velocity 0.5 and 1.0 m/min is presented in Figs 1 and 2.

Microstructure of casted and remelted the SUPERSTON alloy is shown in Figs 3 and 4. Microstructure of the SUPERSTON alloy as coating consist of  $\alpha$  phase, eutectoid mixture and manganese-iron phase (Fig. 3). After laser remelting fine microstructure without cracks in the surface layer is observed. (Fig. 4).

Average thickness of the remelted layer is about 300 $\mu$ m and demonstrate a structural connection with base material (Fig. 4).

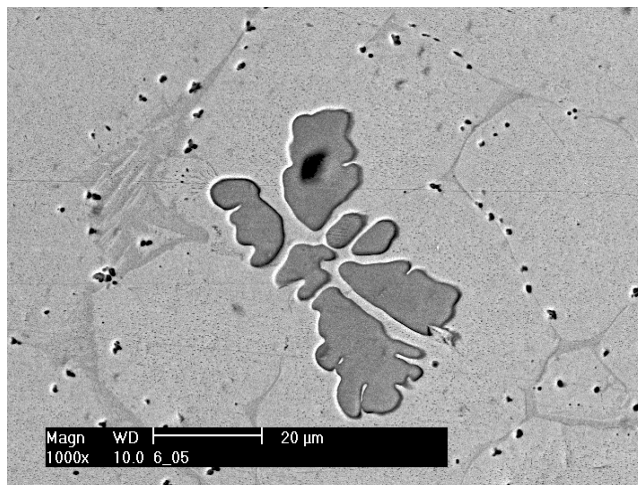


Fig. 3. Microstructure of the casted the SUPERSTON alloy

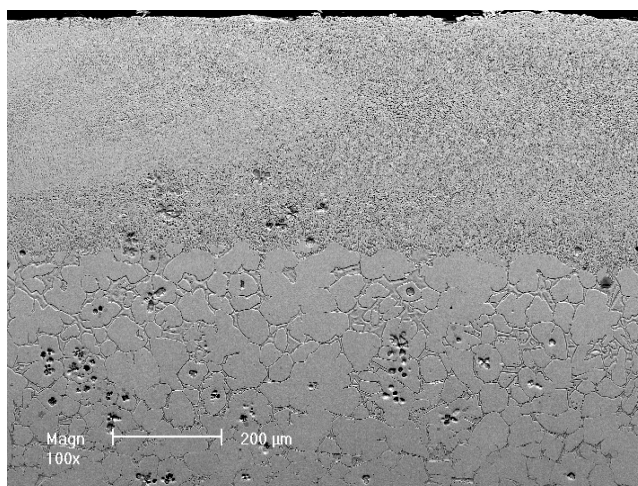


Fig. 4. Cross section microstructure of remelted the SUPERSTON alloy

#### 3.2. Microhardness of the SUPERSTON alloy

Microhardness in the remelted layer of the SUPERSTON alloy made by the Vickers method under load 0.49 N.

Results of the microhardness measurements are presented in Figs 5 and 6.

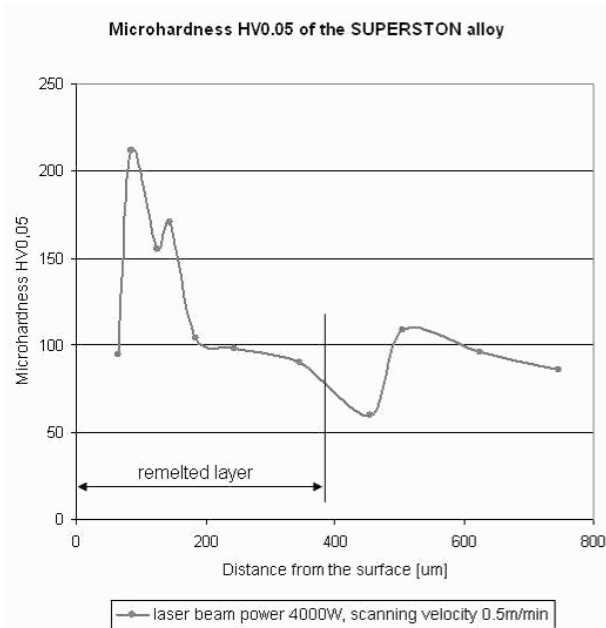


Fig. 5. Microhardness in cross-section of laser remelted layer of the SUPERSTON alloy (4000W, 0.5m/min)

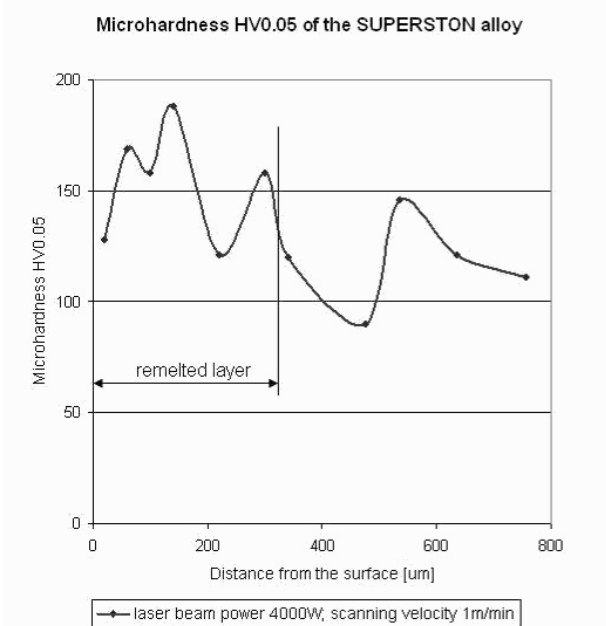


Fig. 6. Microhardness in cross-section of laser remelted layer of the SUPERSTON alloy (4000W, 1.0 m/min)

### 3.3. Cavitation test

The cavitation resistance test of the SUPERSTON alloy after laser remelting at cryogenic conditions was performed at the rotating disc facility Fig. 7.

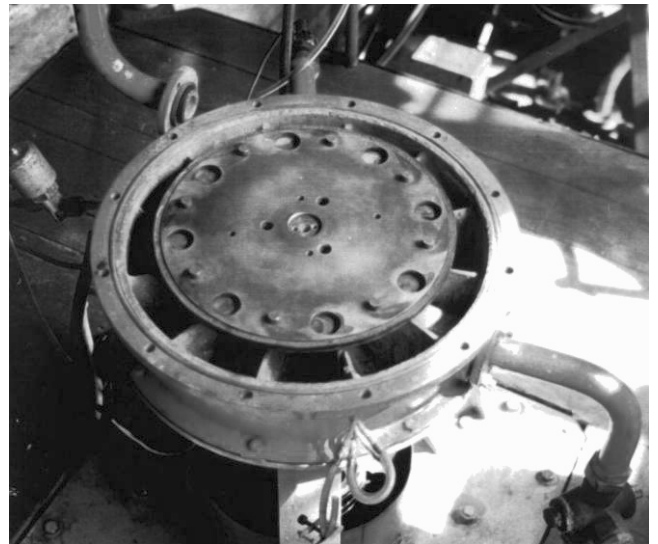


Fig. 7. The rotating disc facility for measurements of cavitation resistance

Average mass loss of the specimens after 5.25h of the cavitation test is presented in Fig. 8.

View of the base material and laser remelted specimens made of the SUEPRESTON alloy after cavitation test is shown in Fig. 9.

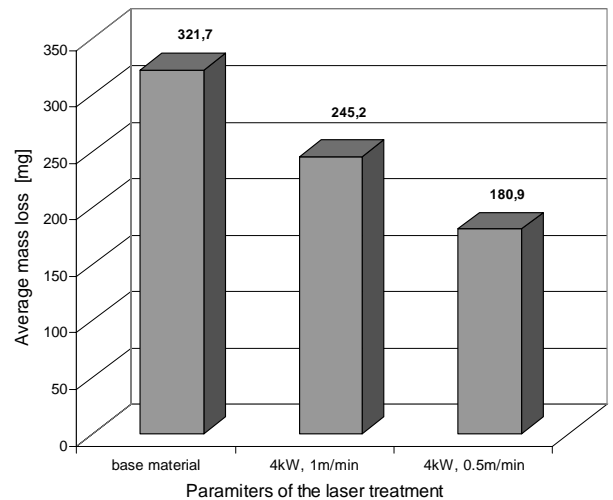


Fig. 8. Average mass loss of the SUPESTON alloy remelted in the different conditions

### 4. Conclusions

Microstructure of the SUPERSTON alloy after laser remelting at cryogenic conditions is fine-crystalline without cracks and manganese-iron phase.



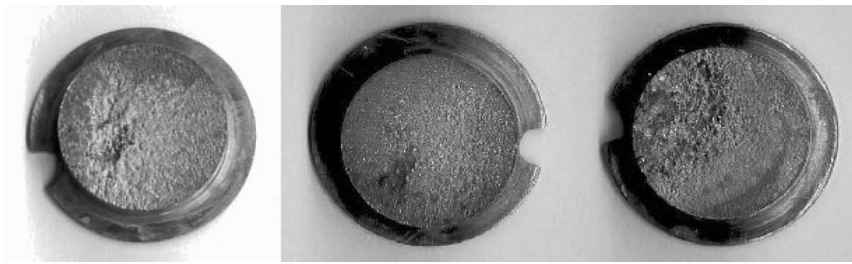


Fig. 9. Surface of the SUPERSTON alloy after cavitation test by 5.25h: a) 4000W, 0.5m/min; b) 4000W, 1.0m/min; c) base material - as casting

Laser remelting caused the increase hardness of the SUPERSTON alloy to 200 HV 0.05.

Most beneficial increase of cavitation resistance (about 30%) obtained for laser remelting the SUPERSTON alloy with 4000 W power and 0.5 m/min scanning velocity.

## Acknowledgements

The financial support by the Polish Ministry of Science and Higher Education under grant No 3859/B/T02/2007/33 is gratefully acknowledged.

## References

- [1] W. Serbiński, B. Majkowska, Microstructure and corrosion properties of the laser treated SUPERSTON alloy, *Journal of Achievements in Materials and Manufacturing Engineering* 18 (2006) 415-418.
- [2] B. Majkowska, W. Serbiński, I. Skalski, Microstructural aspects of corrosion of the SUPERSTON alloy after laser treatment, *Advance in Materials Science* 11 (2007) 141-146.
- [3] W. Serbiński, J.M. Olive, A. Kibitlewski, Influence of the heat treatment on corrosion characteristics of the SUPERSTON alloy, *Advance in Materials Science* 13 (2007) 147-158.
- [4] W. Serbiński, B. Majkowska, I. Skalski, Stress corrosion cracking of regenerated ship propellers blades, *Materials and Technologies* 2/2 (2004) 141-144 (in Polish).
- [5] L. Ciura, J. Stobrawa, W. Malec, K. Joszt, Progress in copper alloys sphere, *Proceedings of the 7<sup>th</sup> International Scientific Conference "Achievements in Mechanical and Materials Engineering"*, AMME 1998, Gliwice – Zakopane 1998, 85-94.
- [6] W. Serbiński, The method and results of the laser surface treatment of aluminium alloys at cryogenic temperature, *Materials Science* 6/119 (2000) 434-437 (in Polish).
- [7] W. Serbiński, A. Zieliński, T. Wierzchoń, Laser assisted forming of the surface layer of Al-Si alloy at cryogenic conditions, *Materials Science* 3 /140 656-658.
- [8] Sen Yang, Yunpeng Su, Weidong Huang, Yaohe Zhou, Microstructure characteristics of Cu-Mn alloys during laser surface remelting, *Materials Science and Engineering A* 386 (2004) 367-374.
- [9] 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.
- [10] 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.
- [11] M. Szkodo, Relationship between microstructure of laser alloyed of C45 steel and its cavitation resistance, *Proceedings of the 13<sup>th</sup> Scientific International Conference „Achievements in Mechanical and Materials Engineering” AMME’2005, Gliwice-Wisła, 2005, 643-646.*
- [12] A. Al-Hashem, W. Riad, The role of microstructure of nickel-aluminium-bronze alloy on its cavitation corrosion behavior in natural seawater, *Materials Characterisation* 48 (2002) 37-41.
- [13] C.H. Tang, F.T. Cheng, H.C. Man, Laser surface alloying of marine propeller bronze using aluminum powder. Part I: Microstructural analysis and cavitation erosion study, *Surface & Coating Technology* 200 (2006) 2602-2609.
- [14] C.H. Tang, F.T. Cheng, H.C. Man, Part II: Corrosion and erosion-corrosion synergism, *Surface & Coating Technology* 200 (2006) 2594-2601.
- [15] ASTM Standard G32-92, Standard Method of Vibratory Cavitation Erosion Test, ASTM Standards, Philadelphia 1995.