Achievements in Mechanical and Materials Engineering

COMMENT Worldwide Congress on Materials and Manufacturing Engineering and Technology

16th - 19th May 2005
Gliwice-Wisla, Poland

COMMITTEE OF MATERIALS SCIENCE OF THE POLISH ACADEMY OF SCIENCES, KATOWICE, POLAND
INSTITUTE OF ENGINEERING MATERIALS AND BIOMATERIALS OF THE SILESIAN UNIVERSITY OF TECHNOLOGY, GLIWICE, POLAND
ASSOCIATION OF THE ALUMNI OF THE SILESIAN UNIVERSITY OF TECHNOLOGY, MATERIALS ENGINEERING CIRCLE, GLIWICE, POLAND

13th INTERNATIONAL SCIENTIFIC CONFERENCE
ON ACHIEVEMENTS IN MECHANICAL AND MATERIALS ENGINEERING

Laser treatment of surface layer over choosen hot work tool steels

L.A. Dobrzański[a], M. Piec[a], K. Labisz[a], M. Bonek[a], A. Lisiecki[b], A. Klimpel[b]

[a]Division of Materials Processing Technology and Computer Techniques in Materials Science, Institute of Engineering Materials and Biomaterials, Silesian University of Technology, Konarskiego 18a, 44-100, Gliwice, Poland, email: marek.piec@polsl.pl

[b]Department of Welding, Faculty of Mechanical Engineering, Silesian University of Technology, Konarskiego 18a, 44-100 Gliwice, Poland

Abstract: This paper presents the results of laser remelting influence on structure and properties of the surface of the 32CrMoV12-28 and X38CrMoV5-3 hot work steel, carried out using the high power diode laser (HPDL). Selection of laser operating conditions is discussed, beam face quality after remelting, as well as hardness tests and X-ray microanalysis results.

Keywords: Laser, Hot work tool steel, Laser melting, Niobium and tantalum carbides

1. INTRODUCTION

The material behavior for the HPDL processing has been found to be different from the other high-power lasers in the following aspects: fewer cracks and less spallation for surface glazing/sealing, more uniform melt/heating zones, smoother surface, better beam absorption for metallic materials, more consistent and repeatable [3-6].

This study was conducted to make clear an effect of NbC and TaC powders addition and the solidification rate on structure and properties in the laser melted metal surface of the hot work tool steel 32CrMoV12-28 and X38CrMoV5-3. On the other hand, the solidification mode in the weld metal was changed from the primary ferrite to the primary austenite, as the solidification rate was raised.

2. EXPERIMENTAL PROCEDURE

Hot work X38CrMoV5-3 and 32CrMoV12-28 steels was used as material for investigation, cubicoid shaped specimens 70 x 25 x 5 mm were taken.

Table 1.
Chemical composition of the X38CrMoV5-3 and 32CrMoV12-28hot work tool steels

Average mass concentration of elements, %								
Steel type	C	Si	Mn	P	S	Cr	Mo	V
X38CrMoV5-3	0,372	0,42	0,43	0,022	0,002	4,95	2,72	0,420
32CrMoV12-28	0.308	0.25	0.37	0.020	0.002	2.95	2.70	5.35

Specimens were subjected to heat treatment consisting in quenching and tempering twice. Austenitizing was carried out in the vacuum furnace at the temperature of 1040ºC, with the soaking time of 0.5h for both of steels. Two isothermal holds were used during heating up to the austenitizing temperature, the first at the temperature of 585ºC and the second one at 850ºC. The specimens were tempered twice after quenching, each time for 2 hours, at the temperature of 550ºC and next at 510ºC for steel of 32CrMoV12-28, and temperature of 575°C and next at 560ºC for steel X38CrMoV5-3. It was found out in the preliminary investigations made using the HPDL Rofin DL 020 high power diode laser that the maximum feed rate at which the process is stable is v=0.5 m/min.

3. INVESTIGATION RESULTS

Preliminary investigations of the remelted hot work tool steel 32CrMoV12-28 show a clear effect of the laser power respectively 1,2; 1,6; 2,0 and 2,3 kW on the shape and thickness of the remelted material (figure 1 and 2).

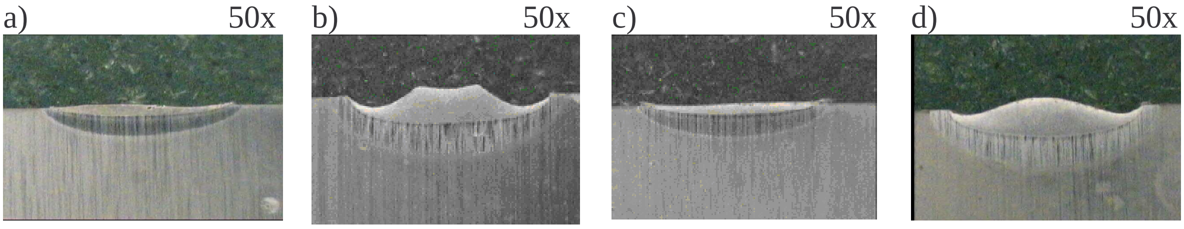

Figure 1 Run face shapes and remelting depths of the 32CrMoV12-28 steel a) NbC laser power values 1,2 kW b) NbC 2,3 kW, c) TaC 1,2 kW, d) TaC 2,3 kW

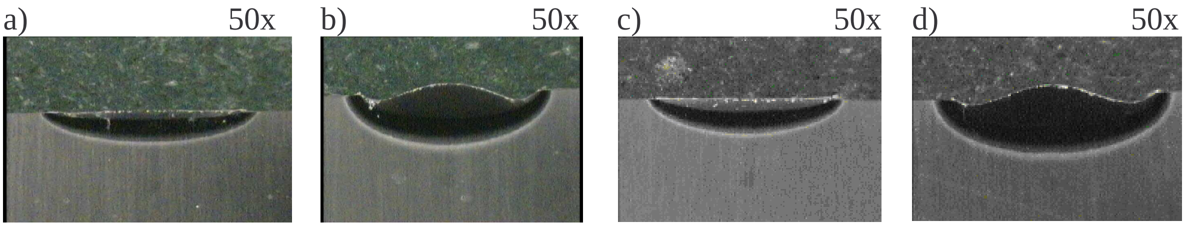

Figure 2 Run face shapes and remelting depths of the X38CrMoV5-3 steel a) NbC laser power values 1,2 kW b) NbC 2,3 kW, c) TaC 1,2 kW, d) TaC 2,3 kW

Table 2.
Descriptive statistics of the hardness tests for the remelted layer - 32CrMoV12-28

Statistical analysis	TaC				NbC			
Power laser, kW	1,2	1,6	2,0	2,3	1,2	1,6	2,0	2,3
Average, HRC	63,83	64,43	64,3	66,33	55,53	57,16	59,36	60,33
Standard eviation	0,30	0,51	0,8	0,15	0,66	0,76	0,63	0,57
Variance	0,09	0,26	0,64	0,02	0,44	0,58	0,40	0,33

Table 3.
Descriptive statistics of the hardness tests for the remelted layer - X38CrMoV5-3

Statistical analysis	TaC				NbC			
Power laser, kW	1,2	1,2	1,2	1,2	1,2	1,6	2,0	2,3
Average, HRC	64,97	61,46	61,46	61,46	61,46	63,03	63,26	63,96
Standard deviation	0,15	0,42	0,42	0,42	0,42	0,25	0,21	0,15
Variance	0,02	0,17	0,17	0,17	0,17	0,06	0,04	0,02

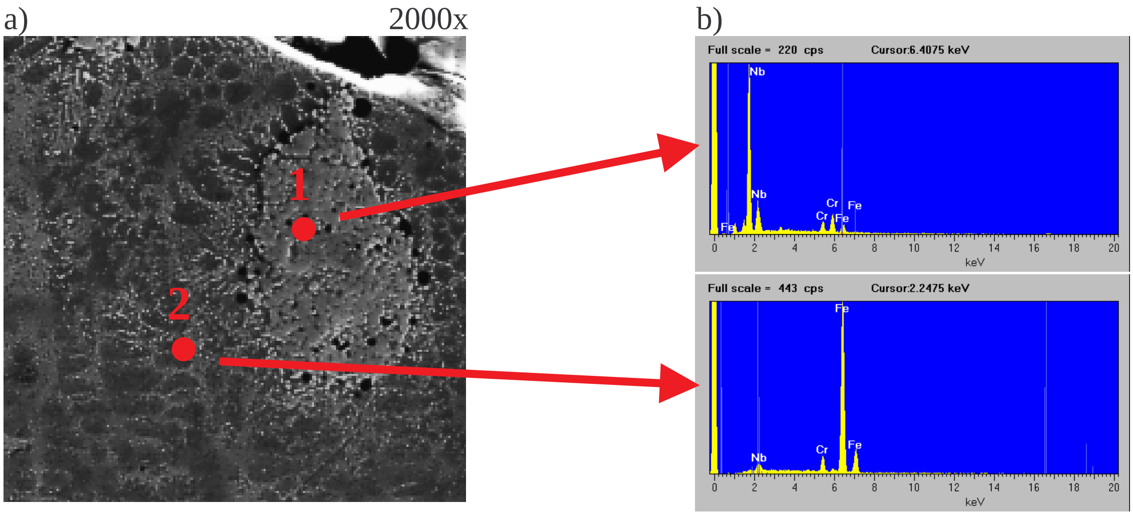

Figure 3. Surface layer of the steel after laser remelting, a) X38CrMoV5-3 steel alloyed with the NbC particles with the scanning rate of 0.5 m/min and laser beam power of 2.3 kW, b) spectrum of the pointwise chemical composition analysis,

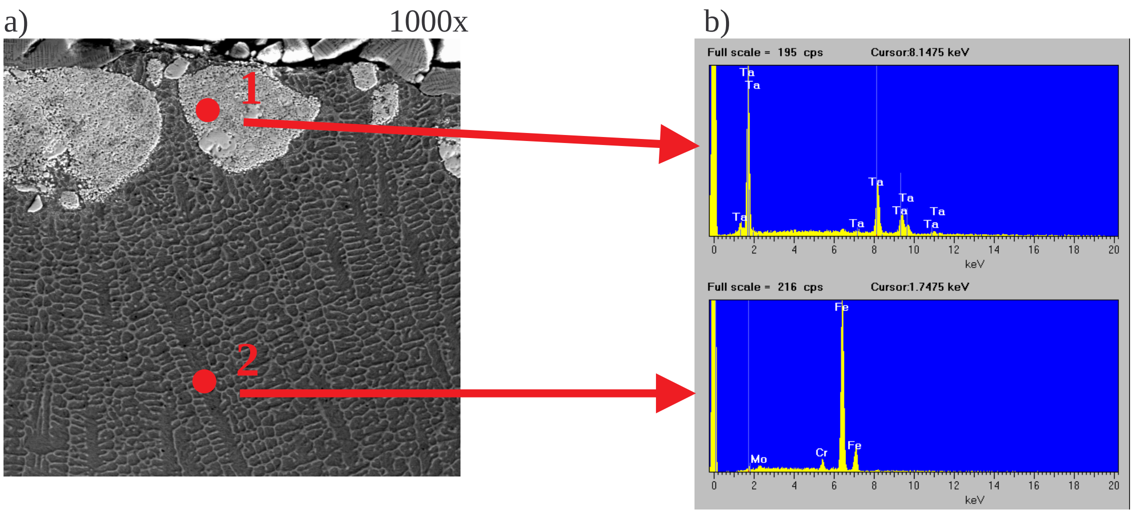

Figure 4. Surface layer of the steel after laser remelting, a) 32CrMoV12-28 steel alloyed with the TaC particles with the scanning rate of 0.5 m/min and laser beam power of 2.3 kW, b) spectrum of the pointwise chemical composition analysis,

It can be seen that with the increasing laser power the roughness of the remelted metal surface increases. The layers are showed on figure 1 and 2.

Microstructures presented on figures 3 to 4 show a dendritic structure in the remelted area. There is a clear relationship between the employed laser power and the dendrite size, namely with increasing laser power the dendrites are larger. On the table 2 and 3 shows the hardness measurements results of the remelted surface for 1.2, 1.6, 2.0 and 2.3 kW laser power.

The metallographic investigations on light microscope and electron scanning microscope show, that the structure of the coagulated material after laser remelting can be characterized by a differentiation of the structure, which depends on the coagulation speed. In areas, which are between the solid and molten state dendritic structure with large dendrites can be found.

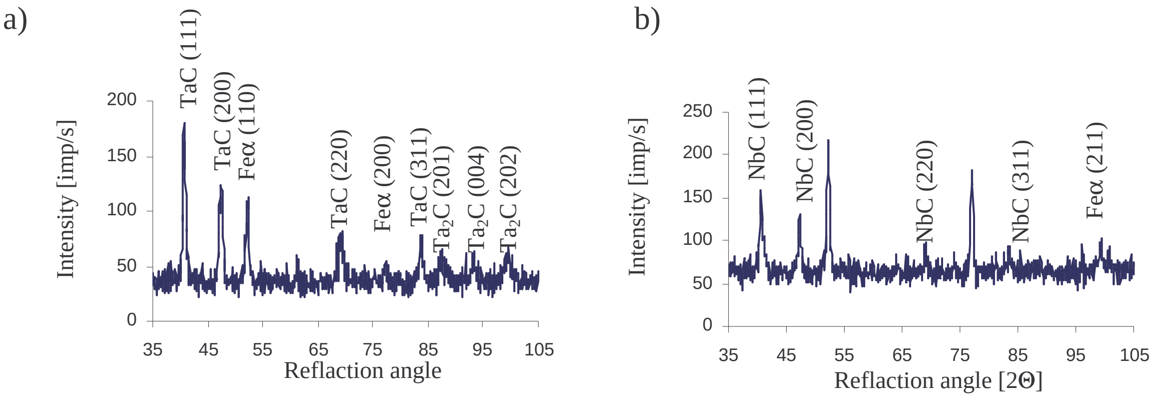

Figure 5. X-ray diffraction pattern of the 32CrMoV12-28 and X38CrMoV5-3 hot work steels, a) alloyed with the TaC ceramic powder , b) alloyed with the NbC ceramic powder

4. CONCLUSIONS

The investigations carried out made it possible to state that due to the heat treatment and remelting of the 32CrMoV12-28 and X38CrMoV5-3 tool steel with the NbC and TaC powders it is possible to obtain the high quality of the surface layer with no cracks and defects and with hardness significantly higher than the substrate metal. Remelting experiments made it possible to demonstrate the effect of the HPDL high power diode laser alloying parameters on properties and structure of the tool steels. Remelting depth grows along with the laser power increase and the remelted run face is more regular, less rough and more flat along with the laser power increase. The higher hardness value was confirmed for the tantalum carbide powder for both kinds of the steels. Metallographic examinations on the scanning microscope with the EDX attachment, and also with the X-ray qualitative phase analysis method confirm the occurrence of the niobium and titanium carbides and also Ta_2C in the surface layer of the investigated steels. It was find the niobium occurs in the remelted layer mainly in the form of conglomerates.

ACKNOWLEDGEMENTS

Finally, I want to express my sincere thanks to all his colleagues who accepted the challenge to spend much of their free time and effort for the author. This work was partially made in the framework of the KBN nr 4 T08C 051 25 project headed by dr E. Hajduczek and also in the appointed project PBZ-100/4/T08/2004 headed by Prof. L.A. Dobrzański

REFERENCES

1. L.A. Dobrzański., M. Bonek., E. Hajduczek., A. Klimpel.: Tribological behaviour of the X40CrMoV5-1 steel alloyed with tungsten carbide using the high power diode laser, International Science Journal, Progressive Technology and Systems in Machine-Building, Donieck, Ukraina, 2004,245-249
2. Klimpel.: Welding application of high power diode laser. Przegląd Spawalnictwa, 6, 2001, 1-6
3. K. Dae-Hwan, H. Seong-Hyeon, K. Byoung-Kee.: Fabrication of ultrafine TaC powders by mechano-chemical process, Materials Letters 58, 2004, 3863-3867