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LASER CLADDING BY *TRU LASER CELL* OF *SSAB BORON B27* STEEL APPLIED IN AGRICULTURE

Summary

The article presents the effect of conventional heat treatment applied after overlaying welding with laser on properties of SSAB BORON B27 STEEL used in agriculture. In order to select the optimum parameters of laser processing and heat treatment for the best tribological properties of strength microhardness tests were carried out as well as observation of microstructures.
Key words*: laser cladding, microstructure, microhardness, SSAB BORON B27 steel*

NAPAWANIE LASEREM *TRU LASER CELL* STALI *SSAB BORON B27* STOSOWANEJ W ROLNICTWIE

Streszczenie

W artykule przedstawiono wpływ konwencjonalnej obróbki cieplnej zastosowanej po napawaniu laserowym na właściwości stali SSAB BORON B27 stosowanej w rolnictwie. W celu wytypowania optymalnych parametrów obróbki laserowej i cieplnej dla uzyskania najlepszych właściwości tribologicznych i wytrzymałościowych przeprowadzono badania mikrotwardości oraz obserwację mikrostruktur.
Słowa kluczowe*: napawanie laserowe, mikrostruktura, mikrotwardość, stal SSAB BORON B27*

1. Introduction

In recent years, boron steel has been increasingly popular on the European and global market. The main producer of boron steel is a company SSAB from Sweden, which has in its range species SSAB BORON B13, B24, B27, B36, B38 and B42.

Species of boron steel are used for hardening and tempering. Mechanical and structural properties of these steels (after suitable heat treatment) control an extraordinary wear resistance, particularly in structural applications that requires increased toughness. These steels are provided after hot rolling in the form of cut lengths and heavy plates.

The most popular and used in the industry in Europe is the steel SSAB BORON B27.The steel is able to ensure a ferritic - pearlitic structure and to obtain the required mechanical and tribological properties the appropriate heat treatment is necessary.

From the point of view of use in agriculture operating elements working in the soil, during heat treatment the steel requires the corresponding grain structure associated to the phase transitions (martensite or bainite), and to achieve appropriate hardness. An interesting solution consists also in optimized combination of heat treatment with the laser deposition of alloys that guarantee to increase the service life of the surface layers, which in many tribological applications can be very necessary.

2. Research methodology

The investigated material constituted SSAB BORON B27 STEELwhose chemical composition is given in Table 1. The chemical composition was determined on the spectrometer SOLARIS CCD PLUS.

Prior to the deposition process of SSAB BORON B27 steel a heat treatment was performed in order to select the best processing conditions for obtaining high hardness. The process consisted of heating to the austenitizing temperature of 880^{0}C, 900^{0}C, 920^{0}C and 950^{0}C, subsequently rapid cooling in water and low tempering at 200^{0}C during 1.5 hours. The results were selected for the best heat treatment of SSAB BORON B27 steel.

Preparation of abrasion resistant layers consisted of a laser-surfacing by TRU LASER CELL 3008 properly prepared samples of SSAB BORON B27 steel using a mixture of powders of 50% by mass. Inconel 625 and 50% by mass. WC (Fig. 1 and Table 2-3). Welded overlay layer was produced as a result of the imposition of several paths.

Table 1. Chemical composition of SSAB BORON B27 steel
Tab. 1. Skład chemiczny stali SSAB BORON B27

Materiał	**% C**	**% Mn**	**% Si**	**% P**	**% S**	**% Cr**	**% Mo**	**% B**	**% Ti**

Source: own work / Źródło: opracowanie własne

Table 2. Chemical composition (wt.%) of TMC – 340 – Inconel 625
Tab. 2. Skład chemiczny (wt.%) TMC – 340 – Inconel 625

%C	%Mn	%Si	%Cr	%Fe	%N	%Co	%Mo	%Ni	%P	%Nb
0,029	0,36	0,62	20,5	4,53	0,14	0,23	8,74	Bal	<0,010	3,04

Source: own work / Źródło: opracowanie własne

Table 3. Chemical composition (wt.%) of TML – 200C – W_2C + WC
Tab. 3. Skład chemiczny (wt.%) TML – 200C – W_2C + WC

%C	C free	%Fe	%W	%Cr	%V	%Si	%Ti	%Mo	%Co	%Ni
3,99	0,038	0,4	Bal	0,0083	0,001	0,0078	0,0016	0,0058	0,0021	0,0076

Source: own work / Źródło: opracowanie własne

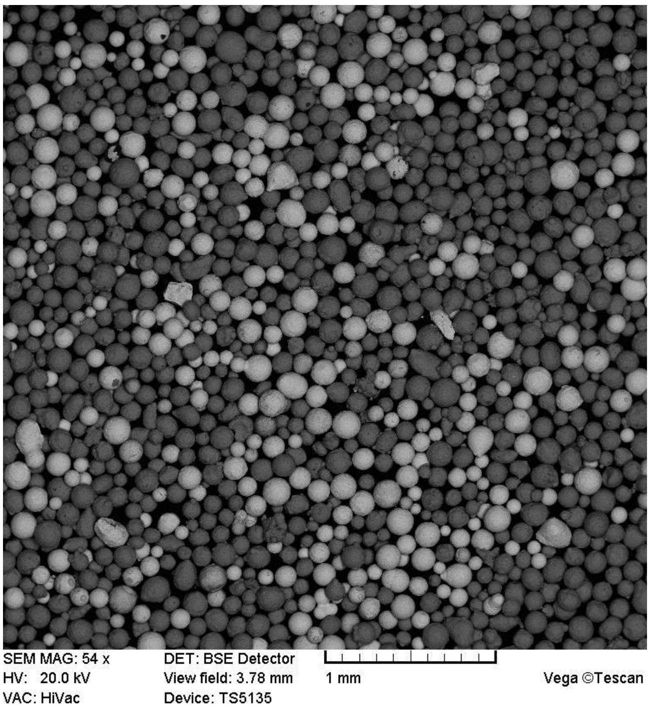

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Fig. 1. Particle morphology and size of powder mixture
Rys. 1. Morfologia i wielkość cząstek mieszaniny proszkowej

Laser cladding of steel boron B27 uses the power of the laser beam P = 800 W. The following parameters of laser cladding were assumed:
- laser power density q = 300 $W \cdot cm^{-2}$,
- feed speed of the laser beam of 500 $mm \cdot min^{-1}$,
- powder feed rate 16 $g \cdot min^{-1}$,
- the distance between the tip and the substrate head 17 mm,
- gas flow rate: the carrier (He) - 8 $l \cdot min^{-1}$, and the casing (Ar) - 10 $l \cdot min^{-1}$.

Microstructure observations were carried out using Metaval Carl Zeiss optical microscope equipped with a camera Moticam.

To determine microhardness profiles Buehler's Micromet II hardness tester was used. Indention load of 50 G, based on the standard PN-EN ISO 6507-1:2007.

3. Results and discussion

Fig. 2 shows the metallographic structure of the SSAB BORON B27 steel samples obtained from austenitizing temperatures 880-950^{0}C, quenching in water and low tempering at 200^{0}C for 1.5 hours.

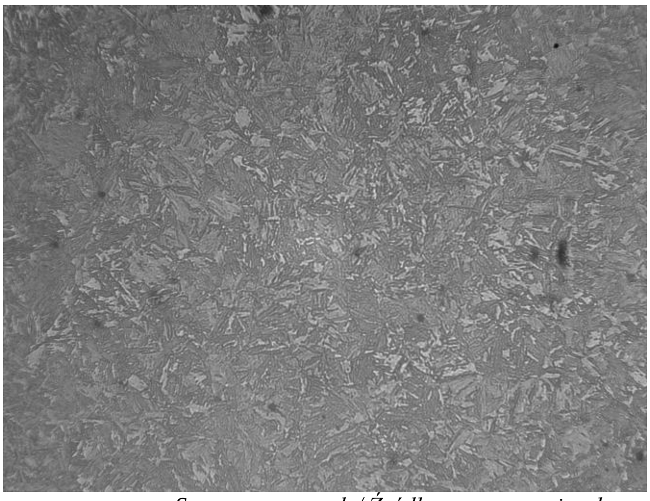

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Fig. 2. Microstructure of SSAB BORON B27 steel after austenitising at temperatures: 880^{0}C – A, 900^{0}C – B, 920^{0}C – C and 950^{0}C – D, quenching in water and low tempering at a temperature of 200^{0}C$\cdot h^{-1}$
Rys. 2. Mikrostruktura stali SSAB BORON B27 po austenityzowaniu w temperaturach: 880^{0}C - A, 900^{0}C - B, 920^{0}C - C oraz 950^{0}C –D, hartowaniu w wodzie i niskiemu odpuszczaniu w temperaturze 200^{0}C$\cdot h^{-1}$

As a result of analysis of the obtained microstructure (Figure 2) and the hardness measurements, the samples of up: A - 47 HRC, B - 46 HRC, C - 52 HRC, D - 48 HRC it has been found that the best performance is achieved for the heat treatment of the sample C (austenitization at 920^{0}C and 200^{0}C tempering). The highest hardness value of sample C was connected with obtaining during the heat treatment a fine acicular tempered martensite structure.

Fig. 3 presents the microstructure of the layer formed from a mixture of powders of WC and Inconel 625 using a laser power of 800 W and a feed rate of 500 $mm \cdot min^{-1}$. It is made of spherical particles of primary tungsten carbide in a nickel alloy matrix. Carbides are present in the whole area of the welded layer. Most of them are uniformly distributed in it which is directly related to the good mixing of the powder mixture and only twice the density matrix of WC. The use of mixtures of a much larger differences in densities of the individual components leads to the formation of agglomerates.

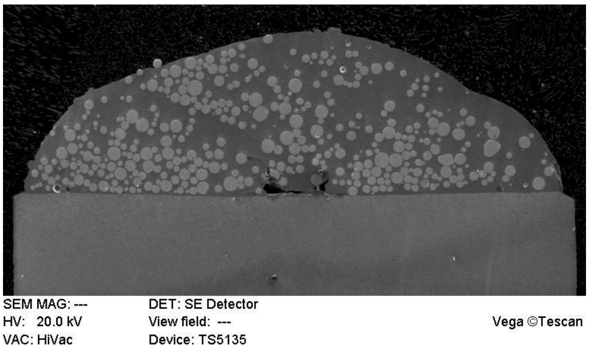

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Fig. 3. The microstructure of the surface layer formed at a power density of 300 $W \cdot cm^{-2}$
Rys. 3. Mikrostruktura warstwy powierzchniowej wytworzonej przy gęstości mocy równej 300 $W \cdot cm^{-2}$

Fig. 4 shows the microstructure of the welded layer of the HAZ (Heat Affected Zone**)** and matrix. The microstructure of the matrix represents the dendritic grains on the border, which reveal the presence of eutectic. The microstructure of the core in the heat-affected zone of weldings directly to the ferrite and pearlite (Fig. 5), while the core is ferrite-pearlite structure with a larger particle size than in the HAZ (Fig. 6).

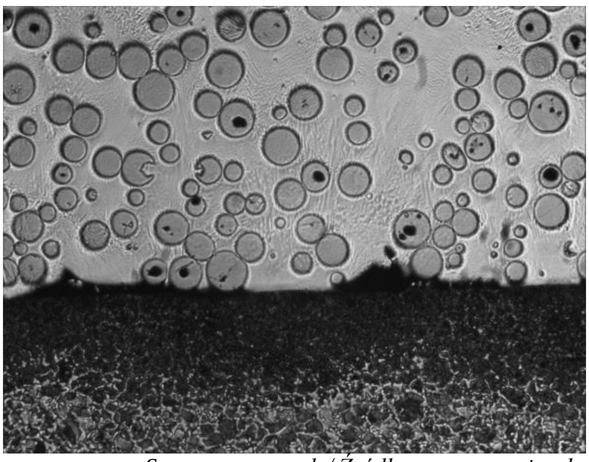

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Fig. 4. The microstructure of welded zone containing dendritic grain boundaries, which is an eutectic – magnification 55x
Rys. 4. Mikrostruktura strefy napawanej zawierającej dendrytyczne ziarna na granicach, których znajduje się eutektyka – pow. 55x

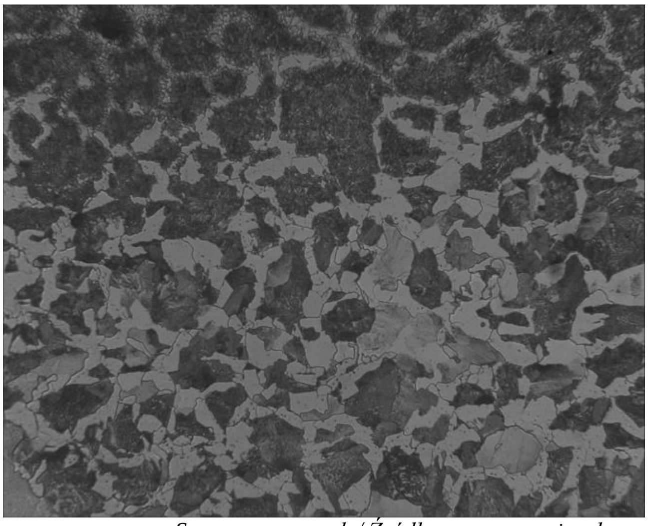

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Fig. 5. The microstructure of ferrite-pearlite (Heat Affected Zone- HAZ) – magnification 250x
Rys. 5. Mikrostruktura ferrytyczno-perlityczna (strefa wpływu ciepła – SWC) – pow. 250x

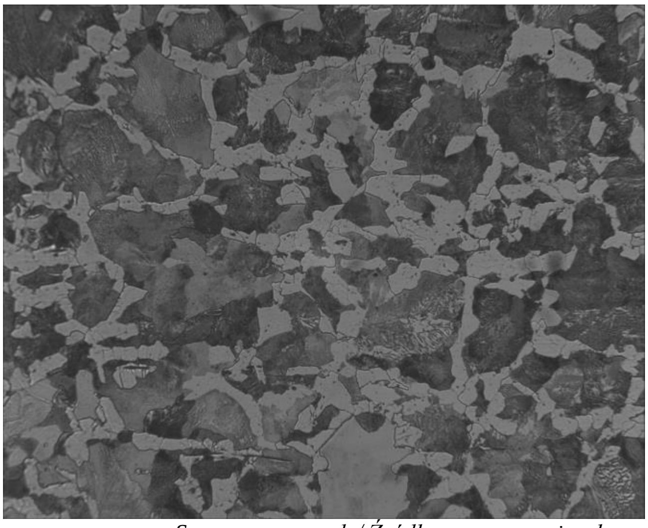

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Fig. 6. The microstructure of ferrite-pearlite (core) – magnification 250x
Rys. 6. Mikrostruktura ferrytyczno-perlityczna (podłoże) – pow. 250x

The hardness of SSAB BORON B27 steel was surfacing to the respective areas:

- deposit is: HV0,05 (479.9, 574.9 ,516.4, 486.9 466.4),
- carbide: HV0,05 (2756.2, 2853.8),
- SWC: HV0,05 (406.6, 410.6),
- core: HV0,05 (220.6, 218.5).

By subjecting SSAB BORON B27 steel to welding process and then the heat treatment (austenitization at 920^{0}C and 200^{0}C tempering) there was achieved in the welded layer structure consisting of primary tungsten carbide in a nickel alloy matrix (Fig. 7), while the heat affected zone including martensite (Fig. 8) and the substrate tempered martensite (Fig. 9).

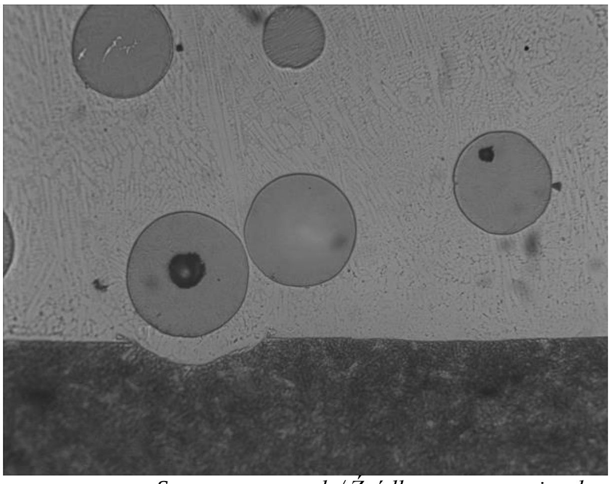

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Fig. 7. The microstructure of welded zone – magnification 250x
Rys. 7. Mikrostruktura strefy napawanej – pow. 250x

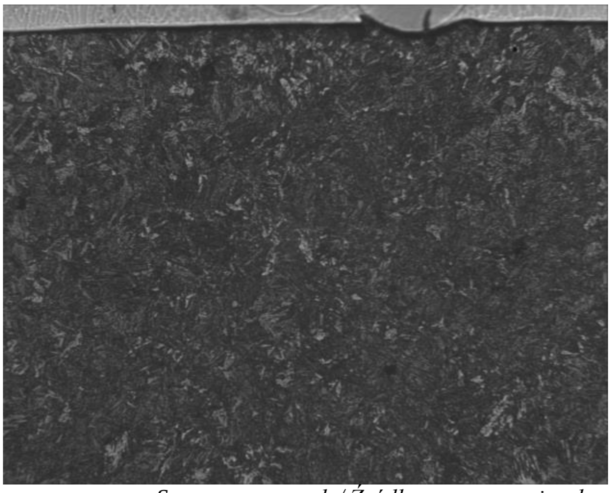

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Fig. 8. The microstructure of martensite (Heat Affected Zone- HAZ) – magnification 250x
Rys. 8. Mikrostruktura martenzytu (strefa wpływu ciepła – SWC) – pow. 250x

Hardness of SSAB BOROB B27 steel after welding and heat treatment was for each zone:

- deposit is: HV0,05 (516.4 ,584.0, 524.2, 494.0, 494.0),
- HAZ: HV0,05 (459.8, 435.0),
- core: HV0,05 (479.9, 521.3).

Comparing the results of hardness of the samples after welding and surfacing heat treatment can be concluded that in the second variant there were obtained a smoother transition between microhardness welding layer and the core and significantly higher hardness values of each zone.

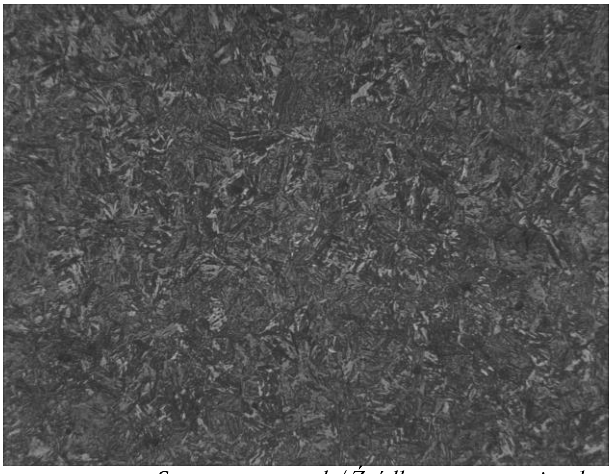

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Fig. 9. The microstructure of tempered martensite (core) – magnification 250x
Rys. 9. Mikrostruktura martenzytu odpuszczonego (podłoże) – pow. 250x

4. Conclusions

1. SSAB BORON B27 steel requires an appropriate precision heat treatment for best wear resistant properties for use in soil.
2. Primary carbides WC are anchored by in the matrix due to diffusion.
3. The hardness of the matrix produced weldings is in the range of 400-550 HV0,05. The hardness of tungsten carbide is approx. 2500 HV0,05.
4. The technology surfacing while optimizing heat treatment process allows to obtain metallographic structures guaranteeing tribological properties and strength.

5. References

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