RESEARCH OF INTERNAL STRUCTURE INFLUENCE ON THE QUALITY OF THE SURFACE DURING LOADING IN THE CORROSIVE ENVIRONMENT FOR BEARING STEEL

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Abstract. The aim of the work carried out was to assess the internal structure of the material bearing steel 14 109 according to ČSN 42 0002 alloyed by Cr and with the carbon content from 0.9 to 1.1 %. This steel was used in the research of the influence of the machining process on the properties of the surface layer, the surface resistance and changes of the surface in normal and corrosive environment in the frame of the project GA 101/06/0508. Furthermore, under normal loading in ambient environment in a lab environment, on the surface of the test blade surface irregular marks of two different shapes are identified.

Keywords: steel, material structure, carbides, corrosive fumes, surface quality, EDS analysis.

Introduction

Among the most widely used construction materials steels, which are in their use differently exposed and on which the surrounding corrosive environments act, are included. It is mainly about interaction between the surface layer of the material and the surrounding corrosive environment. This process of interaction of the material significantly affects the structure of the material (mainly the metallurgical purity), the quality of the prepared surface, the method and length of the loading surface and the composition of the corrosive environment. Therefore, the aim of this experiment was to determine the mutual relationship between these factors on the possible occurrence of corrosion after the surface loading.

For the experimental investigation [4] bearing steel grade 14 109 (in according ČSN) was used in the form of round bars 80 mm in diameter, from which for the experiment rolls of length 20 mm were cut. The surface of the material of thus prepared samples was subjected to load tests in the current environment surrounding atmosphere (without surface exposure to moisture) and in corrosive environments under the influence of NaCl aqueous solution in the corrosion chamber. On the sample loaded in the chamber corrosion appeared on the surface of the material dark corrosion spots, which were subsequently analyzed by the EDS analysis in a scanning electron microscope to determine their chemical composition and determine the cause of their occurrence. For the experiment, 8 samples were used. For the current environment of ambient air samples were used labeled No. 1 to 4 and for loading in the corrosion chamber samples marked No. 5 to 8 were used. For the samples that were loaded in the corrosion chamber (5 – 8) only for samples No. 7 - 8 on the surface corrosion products were identified.

Evaluation of the internal structure of steel 14 109 (accordance with ČSN)

At the edge of the surface of the loaded sample No. 2 in an ambient atmosphere, which was of the samples No. 1 to 4 loaded longest (250 pm), it is very difficult to see distinct continuous decarburization layer thickness up to 125 to 140 micrometers. This corresponds to the lower values of microhardness in this layer (see Table 1). For other samples, which were loaded in an ambient atmosphere the decarburization layer was not identified.

The structure of the sample No. 2 (Fig. 1 – marked) shows fine carbides near the boundary area, which are evenly spaced with fine martensite needles. After color etching (color etching is performed in order to allow the morphology and color to determine the type of inclusions or structural components, without re-EDX or EDS analysis) of the samples there were found present in the structure rarely light (Fig. 2, 3 – marked) and geometrically regular particles of the size of about 10 μm. These are particles of TiN inclusions (Fig. 2, 3). Furthermore, the presence of small plastic MnS type silicates with uniform distribution of carbides (Fig. 4, 7) was identified. In the central area of the material a larger plastic silicate (Fig. 4 – see marking) of MnS type was identified. For the sample No. 7 there was in the central area in several locations identified typical carbidic networking at the boundaries of former austenitic grains with coarser martensite needles (Fig. 5, 6). The center has

several locations in typical networking carbide at the boundaries of former austenitic grains with coarser needles of martensite and retained austenite. Decarburization area for the sample No. 2 was detected using microhardness and the size of the areas identified in the microstructure.

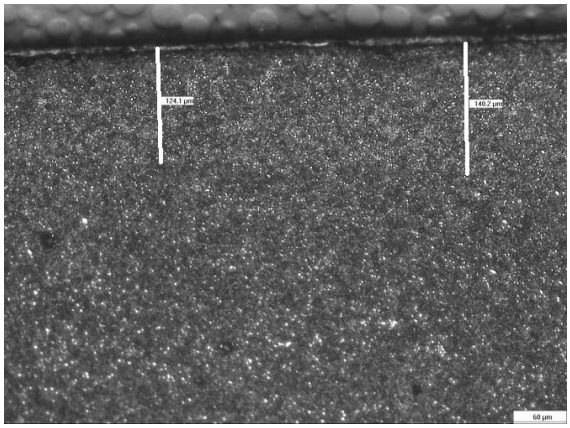

Fig. 1. **Sample No. 2, border, decarburization area**

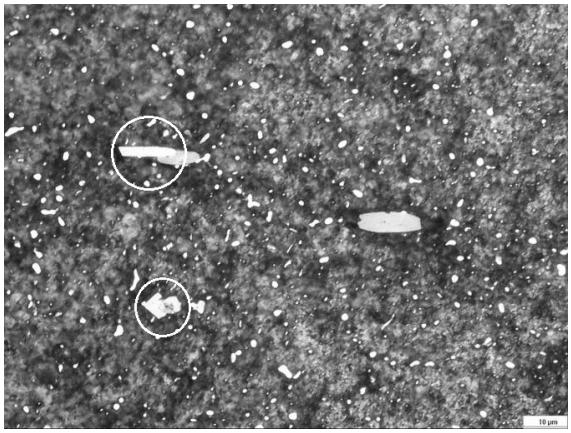

Fig. 2. **Sample No.2, border, inclusions TiN**

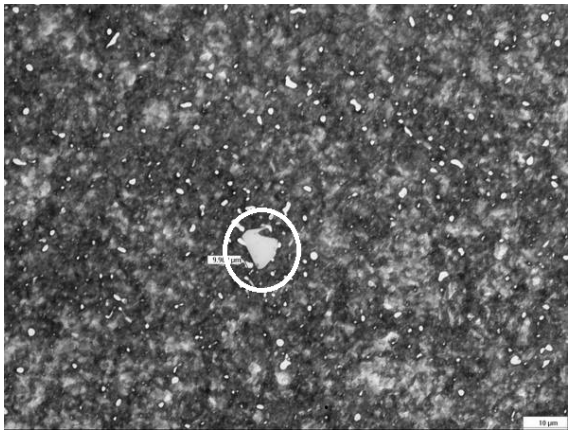

Fig. 3. **Sample No. 2, border, inclusion TiN**

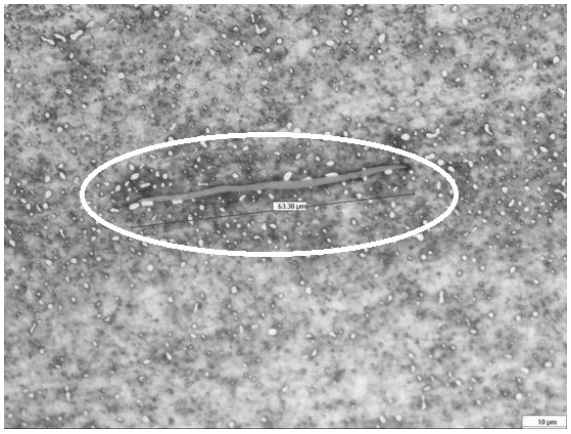

Fig. 4. **Sample No. 2, center, plastic silicate of MnS type**

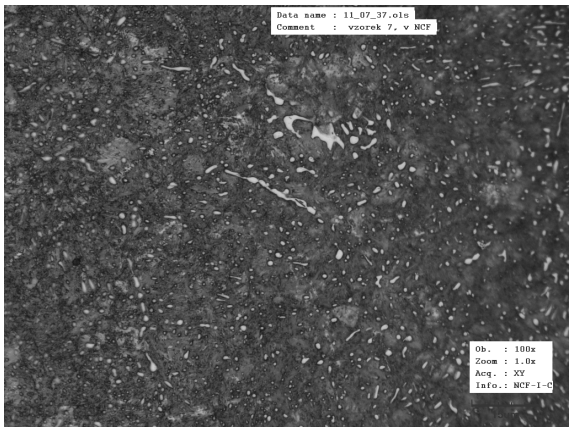

Fig. 5. **Sample No. 7, center, carbidic networking**

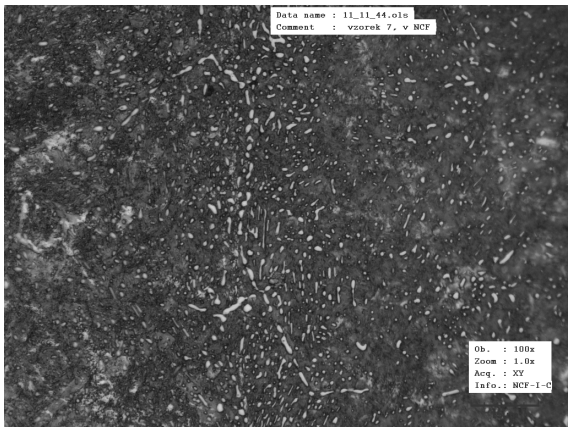

Fig. 6. **Sample No. 7, center, carbidic networking**

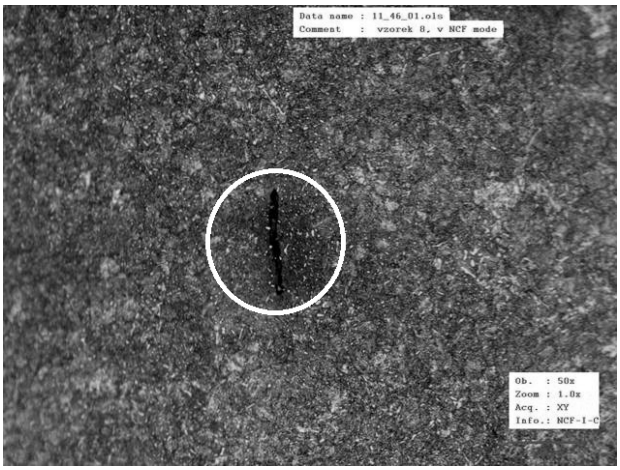

Fig. 7. **Sample No. 8, plastic silicate of MnS type**

Table 1

Microhardness of sample No. 2

Distance from border, μm	Microhardness Vickers HV 0.05	Note
103.5	729.6	decarburization area
120.7	839.1	decarburization area
180.1	874.5	transition
257.7	975.0	base material

Identifying irregular surface spots on the surface of the discs

On the surface of No.7 and No.8 samples that were loaded in a corrosive environment chambers after the load irregular surface smaller spots on the surface of the sample No. 7 were discovered with an orientation in the direction of loading and more irregular surface greater spots without orientation on the sample No.8. These spots were subjected to further research. For the samples No.5, 6 corrosion spots were not identified.

Smaller surface spots with orientation in the direct of loading

For the sample No. 7 a smaller amount of surface corrosion dark spots was identified, oriented in the direction of loading (disc rotation, Fig. 7, 8). To compare and identify the differences between the areas with the occurrence of corrosion stains and corrosion-free areas the EDS analyzes were carried out in both areas, the results are summarized in Tab. 2 and 3.

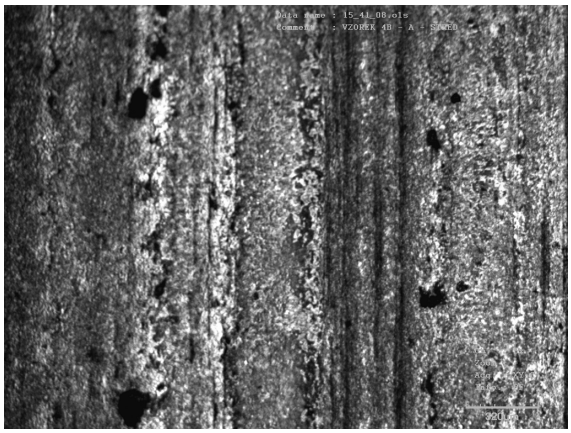

Fig. 7. **Sample No. 7 – Identification of corrosion spots on the laser confocal microscope**

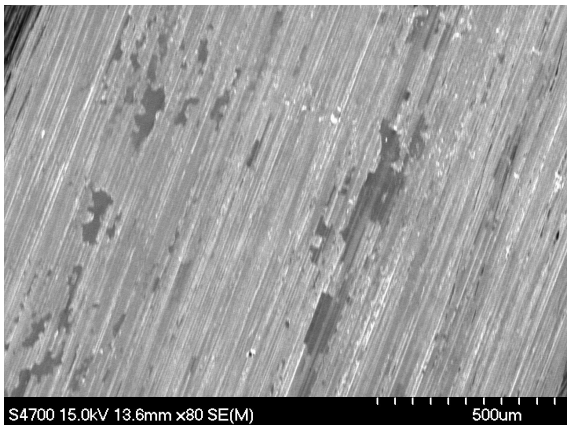

Fig. 8. **Sample No. 7 – The area identified and analyzed on a scanning electron microscope**

Table 2

EDS analysis of the record with the occurrence of corrosion of the sample No. 7

Element Line	Wt. % Formula	Atom % Wt.%
C K	4.00	C 0.90
O K	1.78	O 0.53
Si K	0.28	Si 0.15
Si L	–	–
Cr L	–	–
Cr K	1.20	Cr 1.17
Mn L	–	–
Mn K	0.82	Mn 0.85
Fe K	91.92	Fe 96.39
Fe L	–	–
total	100	100

Table 3

EDS analysis of the record from area free of corrosion for the sample No. 7

Element Line	Wt.% Formula	Atom% Wt.%
C K	5.00	C 1.12
O K	0.00	O 0.00
Si K	0.41	Si 0.22
Si L	–	–
Cr L	–	–
Cr K	1.31	Cr 1.27
Fe K	93.27	Fe 97.39
Fe L	–	–
total	100	100

Larger irregular surface spots without orientation

For the sample No. 8, there were identified more dark irregular spots of surface corrosion without orientation (Fig. 10, 11). To compare and identify the differences between the areas with the occurrence of corrosion stains and corrosion-free areas the EDS analyzes were carried out in both areas, the results are summarized in Tab. 4 and 5.

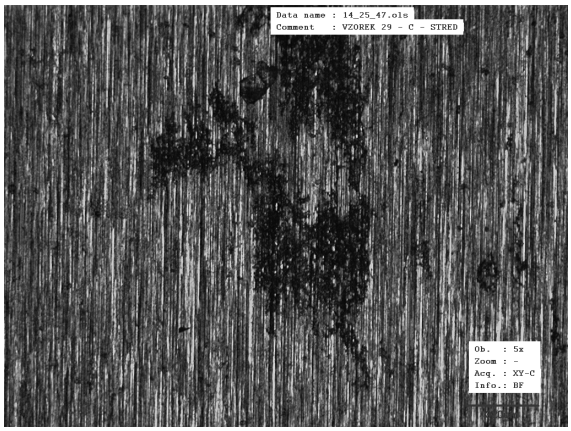

Fig. **10 Sample No. 8 - Identification of corrosion spots on the laser confocal microscope**

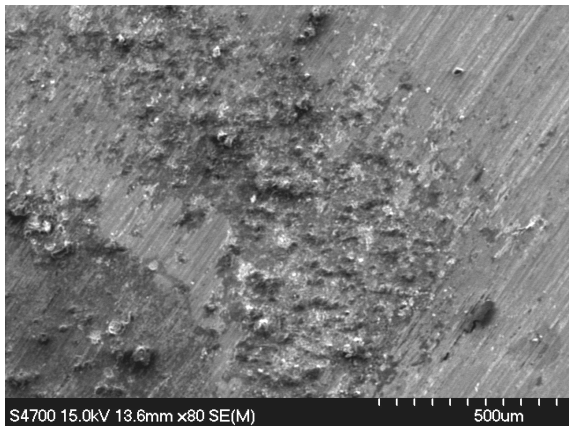

Fig. 11 **Sample No. 8 - The area identified and analyzed on a scanning electron microscope**

Table 4

EDS analysis of the record with the occurrence of corrosion of the sample No. 8

Element Line	Wt. % Formula	Atom % Wt.%
C K	4.00	C 0.90
O K	1.78	O 0.53
Si L	–	–
Si K	0.28	Si 0.15
S L	–	–
S K	–	–
Cl L	–	–
Cl K	–	–
Cr L	–	–
Cr K	1.20	Cr 1.17
Mn L	–	–
Mn K	0.82	Mn 0.85
Fe K	91.92	Fe 96.39
Fe L	–	–
total	100	100

Table 5

EDS analysis of the record from the area free of corrosion for the sample No. 8

Element Line	Wt. % Formula	Atom % Wt.%
C K	5.710	C 1.30
O K	0.48	O 0.48
Cr L	–	–
Cr K	1.37	Cr 1.36
Fe K	91.33	Fe 96.86
Fe L	–	–
total	100	100

Conclusions

On the base of the performed microscopic investigations, EDS analyzes and known in the field of forming technology used, heat treatment and chemical composition of the material [1 – 3; 5; 6], we can say the following:

At the edge of the loading area there is very hardly distinguishable apparent continuous decarburization layer thickness up to 125 to 140 μm. The structure in the peripheral area has a homogeneous structure with finely distributed carbides and fine martensite needles. This structure at the surface can achieve good HRC hardness values (60 – 62). The central area in a few places is showing typical carbidic networking at the boundaries of former austenitic grains with coarser needles of martensite and retained austenite. This points to a lack of material deformation (insufficient balancing the austenitic structure) in this area particularly in relation to larger diameter rods used for the research. But it does not affect the tests carried out, because it was loading bar neighborhoods.

In terms of metallurgical steel the quality is common quality steel with fewer occurring plastic of MnS type and with one large plastic silicate MnS in the central area. In the structure there are rarely presenting geometrically regular particles of inclusions with the size about 10 μm, where in terms of morphology and coloration (after color etching) there is a TiN. Overall, the steel material used in terms of metallurgical grade is possible to be considered as satisfactory.

For the sample No. 7 a smaller amount of surface corrosion dark spots oriented in the direction of loading was identified. The EDS analysis of these dark spots, and its comparison with the EDS analysis of the good area show that this is a superficial corrosion attack at an early stage, as evidenced by a lower amount of present oxygen in the corrosion spots (1.78 %). The surprise is a considerable content of carbon (4 – 12 %) for all analyzes and both samples (7, 8), which is likely to contaminate

the surface during sample preparation. The contents of other elements relate to the composition of the steel (Fe, Cr, Mn).

For the sample No. 8 more dark irregular spots of surface corrosion without orientation are identified. The EDS analysis of these dark spots, and its comparison with EDS analysis of the good area show that this is a superficial corrosion attack in the more developed stage, as evidenced by a higher content of oxygen present in the corrosion spots (8.94%) and more agitated surface of the material that is shown in the image of the scanning electron microscope.

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