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The influence of remelting parameters of the electric arc and conventional tempering on the tribological resistance of high speed steel HS 6-5-2

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Abstract

The present thesis depicts the results of the research of tribological high speed steel HS 6-5-2 remelted with the electric arc. Steel was remelted with different parameters. The amperage of electric arc was changed, the scanning speed was changed and the single, overlapping remeltings were used. There was also the influence of conventional tempering defined, which was conducted after remelting on the tribological resistance of hardened steel. For the previously mentioned processing variants, the intensity of tribological wear was defined and the linear wear were presented, and the friction coefficients. The type of tribological wear was also given, present during the friction, technically dry, of the hardened steel. The lower intensity of tribological wear was received for the single remelting by electric arc of 50 and 70A. Using the overlapping remeltings for the strengening of the surface layer of the high speed steel HS 6-5-2 causes the increase of the intensity of tribological wear in comparison to the steel with the single remelting. The conventional tempering leads to the decrease of the intensity of tribological wear.

Keywords: Heat Treatment – Mechanical Features – Metallography, High Speed Steel, Remelting, Intensity Of Tribological Wear

1. Introduction

Remelting (partial melting) by the electric arc of the high speed steel is a comparatively cheap method of the consolidation surface layer [1÷3]. For hardening small areas of the tools' blade, the single remeltings are applied, and for hardening bigger areas, the remelting ovelappings are used, which can cause the decrease of microhardness in the area of heat influence of the alternately overlapping tracks [4, 5]. As it results from the research of the author, the unfavourable decreases of microhardness, are reflected in the increase of the tribological wear of the hardened surface layer of the high speed steel [6, 7].

The proper selection of parameters of the remelting by the electric arc, that is the amperage of electric arc, scanning speed and temperature and time conventional tempering after remelting can be provided by:

a) the increase of hardness and tribological resistance of the surface layer of the steel in case of single remeltings,

b) leveling the microhardness decrease, and at the same time contribute to the increase of the tribological resistance of the surface layer of steel in case of overlapping remeltings.

The aim of that thesis was the optimization of electric arc remelting parameters and conventional tempering of the surface layer of the steel HS6-5-2 due to the increase of the tribological resistance.

2. Material and test methodology

The test material was the HS 6-5-2 high-speed steel in annealed condition. The surface layer of the steel was remelted with the electric arc using the FALTIG 315AC/DC device, used for welding with the GTAW method. Argon was used as a plasma-generating gas. Parameters of the device work were selected in such a way as to remelting the surface layer of the steel. There were the single and overlapping remeltings (40% coverage) used. The process has been conducted at the Rzeszow Technical University, Founding and Welding Department. After the remelting the conventional tempering was conducted 2x2 hours in the temperature of 560^0C.

The tribological research in the dry technical friction was done on the testing machine of the pin-on-disc T-01M. The following parameters have been used: the disc made of sintered carbides of the hardness about 1500HV, friction unit load - 49N, friction track 2000m (7000 seconds).

The metallographic research - SEM was done on the Tesla BS-340 microscope.

3. Results

The samples from the high speed steel HS 6-5-2 of the size 10x10x25 were remelted with the electric arc using the GTAW method. There were the single and overlapping remeltings used. The treatment variants used were presented in Table 1. Toughened samples were also studied for the comparison.

The intensity of tribological wear was counted according to the formula (1):

$$I = \frac{m_1 - m_2}{s \cdot P} \qquad (1)$$

I – intensity of tribological wear, mg/m^3; m_1 – mass of the sample before the tribological test, mg; m_2 – mass of the sample after the tribological test, mg; s – distance of the friction, m; P - surface of the friction, m^2

The Fig. 2 presents the graph of the friction coefficient and linear wear in the friction time function for the steel with the single remelting with the amperage of 50A before and after tempering in the temperature of 560^0C.

Table 1.
Treatment variants the surface layer of HS 6-5-2 steel remelted with the electric arc

Treatment variants	Amperage of the electric arc, A	Scanning speed, mm/min
Single remelting	50	300
Overlapping remeltings	50	300
Single remelting	70	400
Overlapping remeltings	70	400
Single remelting	100	200
Overlapping remeltings	100	200
Single remelting	120	300
Overlapping remeltings	120	300

After the remelting the conventional tempering was conducted 2x2 hours in the temperature of 560^0C. Next as in the Fig. 1, the samples were cut of the size 4x4x25 for the tribological research.

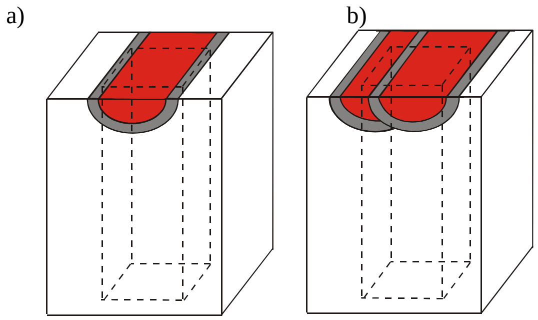


Fig. 1. The way of sample cutting for the tribological research; a) samples from single remelting, b) samples from the overlapping remeltings

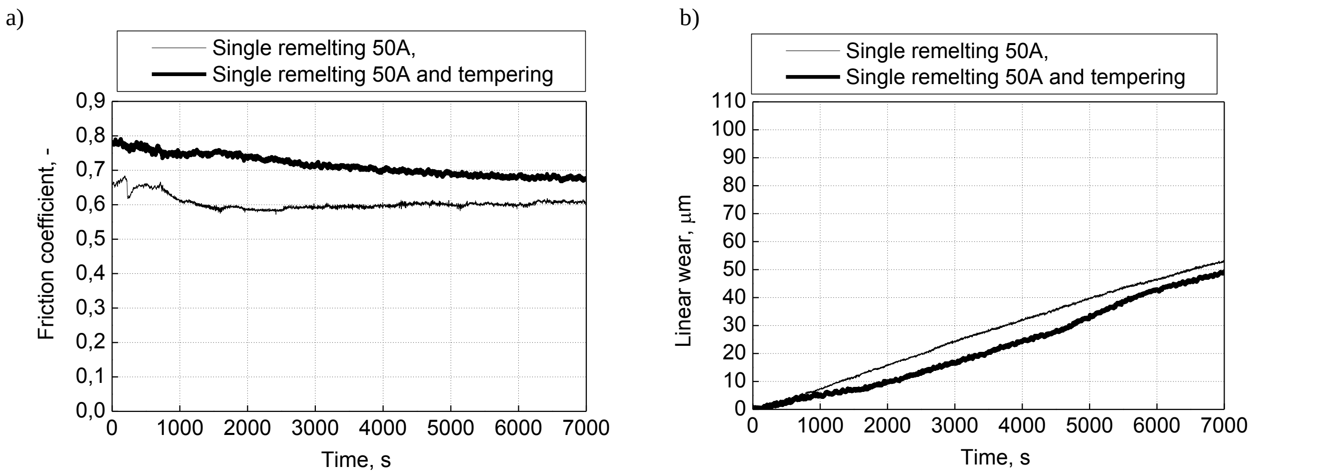


Fig. 2. Friction coefficient graph a) and linear wear b) in friction time function for the steel with single remelting with the amperage of 50A, before and after tempering in the temperature of 560^0C

The Fig. 3 presents the friction coefficient graph and linear wear in the friction time function for the steel with the overlapping remeltings received for the amperage of 50A before and after tempering in the temperature of 560^{0}C. In all processing cases analysed, the use of overlapping remeltings leads to the increase of the liner wear – Fig. 2b and Fig. 3b and the increase of the intensity of tribological wear - Fig. 4. It is the result of microhardness decrease in the areas of heat influence of another overlaping remeltings [4, 5].

The smallest linear wear and the smallest the intensity of tribological wear was shown in steel with the single remelting by the amperage of 50A or 70A (Fig. 4). It is caused by the smallest volume of the melted material and at the same time, as a consequence the highest speed of crystallization leading to the highest structure granularity. The application of the amperage of 50A and the scanning speed of 300mm/min or the increase of amperage up to 70A and the increase of the scanning speed up to 400mm/min leads to the similar effect.

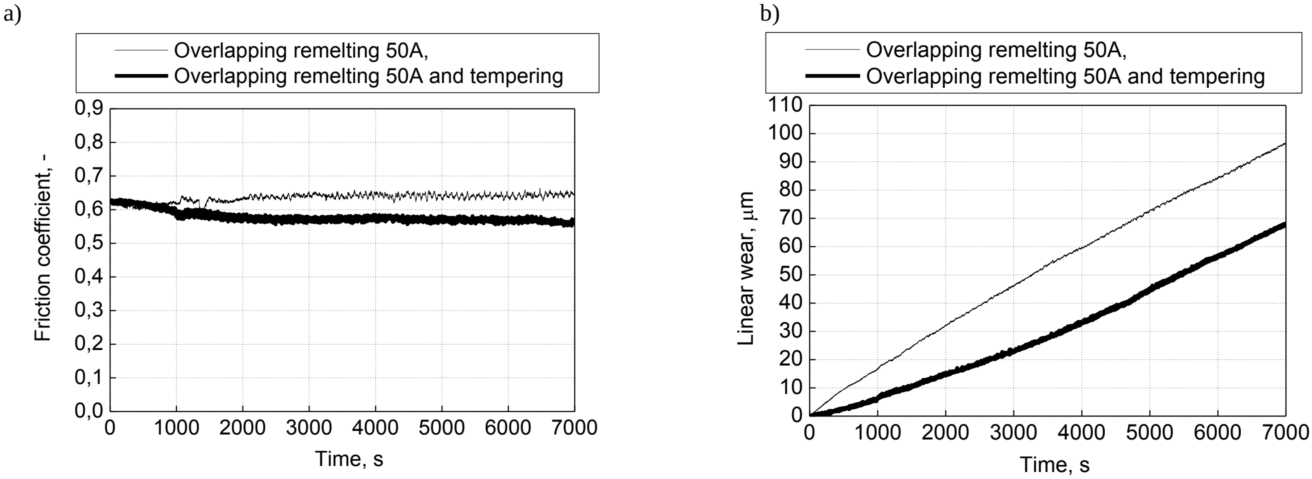


Fig. 3. The graph of friction coefficient a) and linear wear b) in friction time function for the steel with overlapping remeltings received for the amperage of 50A, before and after tempering in the temperature of 560^{0}C

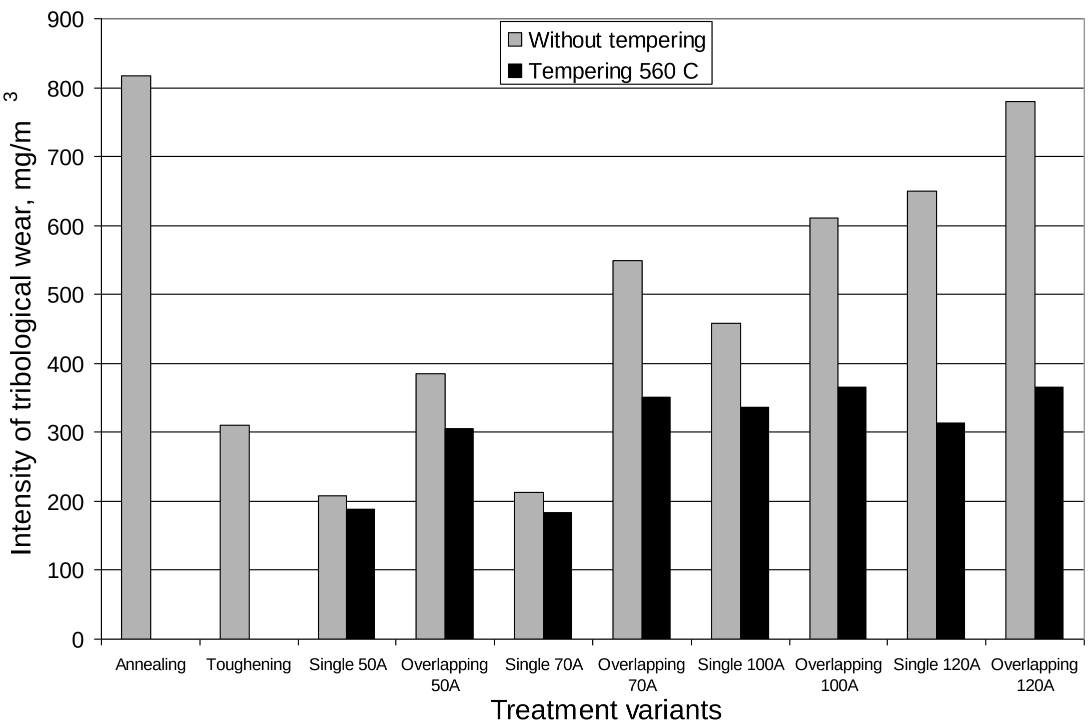
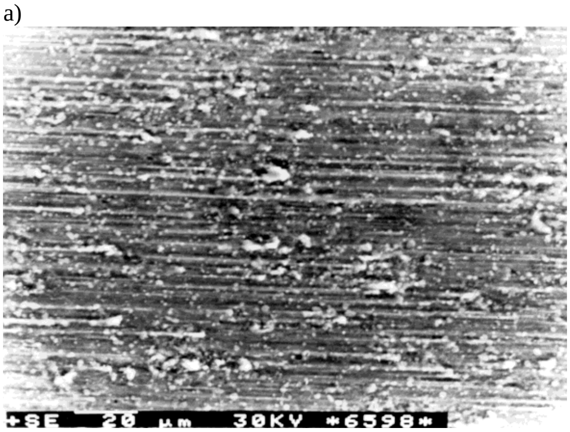


Fig. 4. Comparison of the intensity of tribological wear of the high speed steel HS 6-5-2 for different treatment variants

a) b)



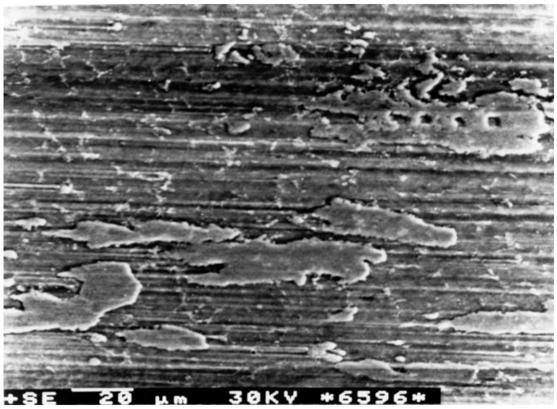


Fig. 5. The SEM view of the friction area of the samples made of the steel HS 6-5-2 remelted with the electric arc and tempered; a) the abrasion wear, b) the abrasion and adhesive wear

There is one fact, very interesting, that applying the conventional tempering after electric arc (except two cases – single partial melting 50 A or 70A) leads to the decrease of the intensity of tribological wear for the particular level 305÷370 mg/m^3 regardless of remelting parameters. The similar intensity of tribological wear was shown in the steel thermally improved in a conventional way (311 mg/m^3).

SEM tests of the friction area of the samples made of the high speed steel remelted with the electric arc using the GTAW method and tempered were presented in Fig. 5. Dominant type of the wear appearing during the test, is the abrasion wear and adhesive wear. The abrasion wear causes the loss of the material in the surface layer by dividing the particles due to the micro-machining cutting, scratching or grooving which is visible in Fig. 5 a,b. The adhesive wear is characterized by the local metal coupling of the friction areas and destruction of these joints together with the metal particles tearing away or its smearing on the friction area can be observed in Fig. 5b.

4. Conclusions

The smallest intensity of tribological wear was received for the single remelting by electric arc with the amperage of 50A or 70A.

The application of overlapping remeltings for the strengening of the surface layer of high speed steel HS 6-5-2 causes the increase the intensity of tribological wear in comparison with the steel with single remelting. The application after remelting the conventional tempering 2x2 hours in the temperature of 560^{0}C (except two cases – single remelting of 50A or 70A) leads to the decrease the intensity of tribological wear to the level responding to the intensity of tribological wear of the steel toughening in a conventional way.

During the tribological research, there was the abrasion and adhesive wear present.

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