Tribological resistance of high speed steel HS 6-5-2 remelted with electric arc

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Received 09.04.2009; accepted in revised form 24.04.2009

Abstract

The intensity of tribological wear of the high speed steel HS 6-5-2 remelted with the GTAW method has been compared to the heat treatment steel in a conventional way. Moreover, the types of the wear appeared during the friction. The tribiological research were done in the technically dry friction conditions on a testing machine of the pin-on-disc T-01M. The smallest intensity of wear was shown by the high speed steel remelted with the parameters leading to obtain the biggest speed of cooling of the molten metal. The main wear type appearing during the research, was the abrasion and adhesive wear.

Keywords: Heat treatment – mechanical features – metallography, High speed steel, Remelting, Tribological resistance

1. Introduction

One of the methods of strengthening the surface layer of the high speed steel, is its remelting and as a result of cooling, the quick crystallization. This process can be realized with the use of the laser beam, electric arc heat or the electron beam. Each of these methods has advantages and disadvantages. The author of this paper has been writing about the remelting of the surface layer of the steel with the laser beam of continuous or impulse work. But using of this method has been connected with possessing of laser, which is still not available for everybody because of the price. The cheapest solution that can be applied in remelting of the surface layer of the steel is the electric arc used in GTAW method. The lower price of the device for remelting the surface layer of the steel and the lack of absorption layers usage, was the reason for using it in research concerning the strengthening of the tools’ blades from the HS 6-5-2 steel.

At present, the research subject matter of the author concerns the comparison of the strengthening effects of the high speed steel - HS 6-5-2 remelted with the laser for the steel remelted with the electric arc.

2. Material and test methodology

The material for research was the high speed steel - HS 6-5-2 in the annealing 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 remelt 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.

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.

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 (about 40% coverage). The treatment variants used were presented in table 1. Toughened and conventional annealed samples were also studied.

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

<table>
<thead>
<tr>
<th>Treatment variants</th>
<th>Current intensity of the electric arc, A</th>
<th>Scanning speed, mm/min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single remelting</td>
<td>70</td>
<td>400</td>
</tr>
<tr>
<td>Overlapping remeltings</td>
<td>70</td>
<td>400</td>
</tr>
<tr>
<td>Single remelting</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>Overlapping remeltings</td>
<td>100</td>
<td>200</td>
</tr>
</tbody>
</table>

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](image)

There has been a friction coefficient graph presented in fig. 2 and the linear wear in time function for the steel with the single remelting of the current intensity 100A.

![Fig. 2. The friction coefficient graph a) and the linear wear b) in the time function for the steel with the single remelting of the current intensity 100A](image)

The intensity of tribological wear indicated according to the pattern (1) for all examined variants of the treatment was presented in the fig. 3.

\[ I = \frac{m_1 - m_2}{s \cdot P} \] (1)

I – intensity of tribological wear, mg/m²; m₁ – mass of the sample before the tribological test, mg; m₂ – mass of the sample after the tribological test, mg; s – distance of the friction, m; P - surface of the friction, m²

The smallest wear intensity was observed in the high speed steel HS 6-5-2 with the single remelting of the current 70A. It is lower wear intensity about 30% than the wear intensity of the heat toughened steel in a conventional way. It can be caused by the reason that in that case there is the remelting of the smallest material volume, which causes receiving the highest speed of cooling the liquid metal leading to the structure refinement and to gain the solid solution more saturated. It results from the fig. 3 and previous author’s research that with the use of the single remeltings for the surface layer of the steel HS 6-5-2 strengthening, the decisive role plays the speed of cooling. The higher the cooling speed the higher the micro-hardness, and lower tribological wear intensity.
Using the overlapping remeltings of the high speed steel HS 6-5-2 in order to reinforce it causes the increase of the tribological wear intensity. The increase of the steel wear with the overlapping remeltings in comparison to the steel with the single remelting can result from the reason below. From the analysis of the surface layer of the steel remelted with the GTAW method, the micro-hardness for certain processing conditions (the structure of the steel, parameters of the processing with the GTAW method) in the area of heat influence zone of second remelting overlapping on first remelting, there is microhardness lower about approx. 200 HV0,065. Such a significant decrease of the micro-hardness can be the reason of the increase of the tribological wear intensity of the steel with the overlapping remeltings. The reason of the decrease of the micro-hardness has been presented widely in works [1-3].

These are not the final results, because the steel after it has been remelted should be under the tempering process. It is connected with the proper temperature selection of the tempering process for the particular processing variants in order to receive the desired properties.

SEM tests of the friction area of the samples made of the high speed steel remelted with the electric arc using the GTAW method were presented in fig. 4, 5.

Using the terminology concerning the subject from works [5, 6] the 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. 4 a, b. The abrasion wear is not evenly appearing on the whole friction area of the steel as we can see it in the fig. 4a. Supposing that the surface roughness was the same on the friction area, it can signify that there are areas of the structure susceptible to this type of the wear.

**Fig. 3.** Comparison of the tribological wear intensity of the high speed steel HS 6-5-2 for different treatment variants

**Fig. 4.** The SEM view of the friction area of the samples made of the steel remelted with the electric arc, using the GTAW method; micro-machining cutting, scratching or grooving of the areas typical for the abrasion wear
It is possible that this wear takes place in the areas characterized by the lower hardness - in the area of heat influence zone of second remelting (HIZ2) overlapping on first remelting (R1). 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. 5 a-c.

4. Conclusions

Applying the overlapping remeltings for the strengening of the surface layer of high speed steel HS 6-5-2 causes the increase of the tribological wear intensity in comparison to the steel from the single remelting. It can be explained by the heterogeneous decomposition of the micro-hardness value of the surface layer of the steel with the overlapping remeltings. In the area of the heat influence zone of second remelting overlapping of the first remelting, there is a visible decrease of the micro-harness that can be the reason of the tribological wear increase of the steel. The material loss of the surface layer of the steel in the tribological sample was caused by the abrasion and adhesive wear.

Literature


Fig. 5. SEM view of the friction area of the samples made of the high speed steel remelted with the electric arc using the GTAW method; a-b) accretions on the friction area typical for the adhesive wear; c) crater typical for the adhesive wear.