SPECIAL HEAT AND THERMOCHEMICAL TREATMENTS OF HIGH SPEED TOOLS STEEL

Phd. Stud. Nicoleta TORODOC, Prof. Ing. Ioan GIACOMELLI

Transilvania University of Brasov, Romania
Faculty: Materials Science and Engineering, Department: Materials Science
B-dul. Eroilor 29, Brasov
E-mail: nicotorodoc@yahoo.co.uk

Abstract

In this work, the results of experimental studies regarding the improvement of the performance of tools by heat treatments in electromagnetic fields are presented. Samples made of the steels T1 and M2 have been submitted to testing. The results of the experiments reveal the advantages of the heat treatment methods in electromagnetic fields and thermochemical treatments, when compared to the classical ones, by offering a higher mechanical resistance, shock resistance and significantly increased fatigue resistance.

1. INTRODUCTION

We have studied two types of high speed steel, that have a wide usage in the production of tools such as drills. The efficiency of some heat and thermochemical treatments applied to these steels has been determined on eprouvettes as well as helicoidal drills. For the beginning in table 1 the chemical composition of the studied steels are presented.

<table>
<thead>
<tr>
<th>Nr.</th>
<th>Type of steel</th>
<th>C</th>
<th>W</th>
<th>Cr</th>
<th>V</th>
<th>Mo</th>
<th>Si</th>
<th>Mn</th>
<th>Ni</th>
<th>P</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>T1</td>
<td>0.72</td>
<td>17.7</td>
<td>3.9</td>
<td>1.2</td>
<td>0.45</td>
<td>0.35</td>
<td>0.42</td>
<td>0.33</td>
<td>0.025</td>
<td>0.02</td>
</tr>
<tr>
<td>2.</td>
<td>M2</td>
<td>0.80</td>
<td>6.33</td>
<td>4.2</td>
<td>1.9</td>
<td>5.25</td>
<td>0.35</td>
<td>0.37</td>
<td>0.35</td>
<td>0.025</td>
<td>0.02</td>
</tr>
</tbody>
</table>

In order to maintain the characteristics of the basis material constant, the eprouvettes that underwent various chemical and thermochemical treatments, have been made from the same steel rod, having the composition presented in the above table.

2. EXPERIMENTAL PROCEDURE

2.1. Heat treatments

For the beginning, the eprouvettes and tools have been subjected to standard heat treatment, this having the purpose to create a reference base for later experiments, as well as for preparing them for some additional operations of thermochemical treatment.

In table 2 the heat treatment regimes for the two types of steel are presented:

<table>
<thead>
<tr>
<th>Nr.</th>
<th>Type of steel</th>
<th>Quenching</th>
<th>Tempering at 560 deg C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>T1</td>
<td>1265</td>
<td>60</td>
</tr>
<tr>
<td>2.</td>
<td>M2</td>
<td>1190</td>
<td>60</td>
</tr>
</tbody>
</table>

We mention that for samples destined for later application of a surface treatment, only two subsequent consecutive temperings have been carried out at 560 degrees C, for 1 hour each.
2.2. Thermochemical treatments

On heat treated eprouvettes and tools (quenching and two tempering steps), supplementarily the thermochemical treatment of sulphocyanurizing has been carried out in three variations, as it is presented below:

a. standard sulphocyanurizing treatment at 560 deg. C in salt bath;

b. sulphocyanurizing treatment at 560 deg. C with application of a steady-state electromagnetic field;

c. sulphocyanurizing treatment at 560 deg. C with the application of an alternating electromagnetic field;

On the samples thus obtained, measurements have been carried out regarding the thickness of the diffusion layer, conform with the data from table 3, where the values indicated are expressed in mm.

<table>
<thead>
<tr>
<th>Nr.</th>
<th>Type of steel</th>
<th>Standard sulphocyanizing</th>
<th>Sulphocyanizing in steady-state electromagnetic field</th>
<th>Sulphocyanizing in alternative electromagnetic field</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>10 min</td>
<td>20 min</td>
<td>30 min</td>
</tr>
<tr>
<td>1.</td>
<td>T1</td>
<td>0.0093</td>
<td>0.0122</td>
<td>0.0150</td>
</tr>
<tr>
<td>2.</td>
<td>M2</td>
<td>0.0108</td>
<td>0.0133</td>
<td>0.0187</td>
</tr>
</tbody>
</table>

In order to evidence the favourable influence of the electromagnetic field upon the diffusion rate, the data from the above table are presented graphically in figures 1 and 2.

Fig. 1 Evolution of the diffusion layer thickness at sulphocyanurizing of T1 steel
a. standard sulphocyanurizing treatment;

b. sulphocyanurizing treatment in steady state electromagnetic field;

c. sulphocyanurizing in alternating electromagnetic field;
The microstructure of the diffusion layers is built generally from two zones: at the surface a very thin layer of white colour, also called the “combination zone”, which contains carbides and sulphides. Under this zone a second, darker coloured one, is situated, called the “diffusion zone” with a mass of nitrous martensite, and inclusions of carbides of alloying elements. A few examples are illustrated in the next figures.
3. DURABILITY TESTING

Simultaneously with the heat and thermochemical treatments of the eprouvettes, also helicoidal drills with a diameter of 6.2 mm have been treated, made from M2 steel. On these treated drills, after different regimes, their durability has been tested by using them for drilling non-penetrating holes in laminated steel sheets of type OLC 45 (which has been used as delivered, at a thickness of 45 mm). Wear has been measured after every 30 holes, and has been determined in comparison with a previously treated drill, in parallel with the main cutting surfaces. The determination of the durability has been carried out until fatal wear. In table 4 the results of the durability determination is presented. The exemplified values represent the mean value of 3 measurements carried out on identical treated drills.

<table>
<thead>
<tr>
<th>Nr.</th>
<th>Type of treatment</th>
<th>30</th>
<th>60</th>
<th>90</th>
<th>150</th>
<th>210</th>
<th>270</th>
<th>330</th>
<th>Wear of the sheet after „n“ holes.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Standard heat treatment</td>
<td>0.17</td>
<td>0.24</td>
<td>0.29</td>
<td>0.33</td>
<td>0.36</td>
<td></td>
<td></td>
<td>248</td>
</tr>
<tr>
<td>2.</td>
<td>Heat treatment+sulphocyanurizing 30 min</td>
<td>0.07</td>
<td>0.12</td>
<td>0.14</td>
<td>0.08</td>
<td>0.20</td>
<td>0.23</td>
<td>0.28</td>
<td>490</td>
</tr>
<tr>
<td>3.</td>
<td>Heat treatment+sulphocyanurizing 30 min in steady state electromagnetic field</td>
<td>0.11</td>
<td>0.14</td>
<td>0.16</td>
<td>0.17</td>
<td>0.18</td>
<td>0.19</td>
<td>0.20</td>
<td>681</td>
</tr>
<tr>
<td>4.</td>
<td>Heat treatment+sulphocyanurizing 30 min in alternating electromagnetic field</td>
<td>0.08</td>
<td>0.11</td>
<td>0.13</td>
<td>0.14</td>
<td>0.15</td>
<td>0.16</td>
<td>0.18</td>
<td>755</td>
</tr>
</tbody>
</table>
Considering that the depth of one drilled hole was 40 mm, one can calculate the processing length until reaching a certain level of wear, and until total wear, respectively, as in fig. 8.

![Graph showing wear size vs. characteristic length](#)

Fig 8. Ratio between the wear size and the processing length for helicoidal drills with φ 6.2 mm, heat and thermochemically treated as in table 4.

5. CONCLUSIONS

Following the experimental research carried out, according to the results presented above, the following conclusions can be drawn:

- in comparison with the classical heat treatments, the thermochemical heat treatments bring substantial improvements of the durability of tools from high speed steels
- for the improvement of the productivity of thermochemical treatments, while carrying out these, one can apply an external electrical field (e.g. electromagnetic)
- the steady-state electromagnetic field leads to an increase of the diffusion rate with approximately 20% in comparison with the thermochemical heat treatment in the absence of this field
- the alternating electromagnetic field is more efficient when compared to the steady-state electromagnetic field
- the increase of the thickness of the diffusion layer brings also a plus regarding the durability in the use of the tool.
LITERATURE REFERENCES