THE STUDY OF THE PROCESS OF COMPLEX DIFFUSION SATURATION WITH BORON AND VANADIUM ON THE CARBON STEELS

ИССЛЕДОВАНИЕ ПРОЦЕССА ДИФФУЗИОННОГО КОМПЛЕКСНОГО НАСЫЩЕНИЯ УГЛЕРОДИСТЫХ СТАЛЕЙ БОРОМ И ВАНАДИЕМ

East Siberian State University of Technology and Management – Ulan-Ude, Russian Federation1, Altai State Technical University – Barnaul, Russian Federation2, Textile University – Wuhan, China3
E-mail: lygenov59@mail.ru, gurievam@mail.ru, meishunqi@vip.sina.com, butuhanov_vyacheslav@mail.ru

Abstract/Резюме: The study investigates the formation of the diffusion layers and their properties on carbon steels after saturation with boron and vanadium in pastes. Metallographic analysis was performed with the use of the optical microscope “Neophot -21”. Microhardness was determined by tester PMT-3M. X-ray spectral analysis was carried out by the electron scan microscope JSM-6510LV JEOL with microanalysis system INCA Energy 350.

KEYWORDS:

1. Introduction/Введение
One of the effective methods of increasing the durability of machine parts and tools operating in conditions of wear-down, high temperatures, alternating-sign loads is thermochemical treatment. Heating and exposing materials to high temperatures and chemically active media allow to change the chemical and phase composition of the product’s surface layer, and hence the material properties. The existing methods of thermochemical treatment fall into three groups: saturation in solid, liquid and gaseous phases [1]. Industrially used methods of thermochemical treatment have an essential disadvantage: as a rule, they are unsuitable for processing bulky parts. In this case the process of diffusion saturation by means of pasting is used [2]. To the advantages of the method we can attribute less mixture consumption, technological effectiveness, strengthening of component sections as well as the possibility of combining it with thermal treatment and that of concentrated energy currents [3].

Depending on the saturating element the following processes of thermochemical treatment are recognized: single-component (carbonization, nitration, alumining, borating, chroming, cilarification) and multi-component (carbonitriding, chrome-caraloring, borocilicification and so on) [4]. The study investigates the formation of the diffusion layers and their properties on carbon steels after saturation with boron and vanadium in pastes.

2. Materials and methods of research/Материалы и методы исследования
The steel with 0.8 percent of carbon (steel analogue, W 108 AISI) for saturation with boron and vanadium was used as the test material. Previously the authors found the optimal relationship between the paste components for isothermal borochromizing: 60% B4C + 35% V2O3 + 5% NaF.
Paste components were thoroughly stirred in water to the required consistency and applied layer-by-layer to the samples which were then dried at 50 – 100°C for 0.5 – 1.0 hour in a chamber drier. The paste thickness was 4 – 5mm.
Thermochemical treatment was conducted in two modes: 1 – diffusion saturation at the temperature 950°C for 4 hours; 2 – quenching from 780 - 800°C to obtain a high hardness of the matrix and tempering at the temperature 200 – 250°C for stress relief (fig.1).

Metallographic analysis was performed with the use of the optical microscope “Neophot -21”. Microhardness was determined by tester PMT-3M. X-ray spectral analysis was carried out by the electron scan microscope JSM-6510LV JEOL with microanalysis system INCA Energy 350.

3. Results and discussion/Результаты и обсуждение
After processing the layer has thickness about 80 – 85 µm (fig.2) with microhardness of 20000 MPa a transitional zone 1400 -1500 µm deep. Microhardness of crystals did not exceed that of the main layer, for the transitional zone being 5000 MPa.

Microhardness of the borochromized zone is close to Fe2B microhardness value (fig. 3).
Fig. 3. Distribution of microhardness in the depth of the diffusion layer

X-ray spectral analysis shows that there are iron borides (table 1).

### TABLE I. The layer composition on steel W 108 after borochromizing (content/wt-%)

<table>
<thead>
<tr>
<th>Spectrum</th>
<th>V</th>
<th>Si</th>
<th>B</th>
<th>Fe</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spectrum 1</td>
<td>2.75</td>
<td>0.82</td>
<td>96.43</td>
<td>100.00</td>
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</tr>
<tr>
<td>Spectrum 2</td>
<td>1.72</td>
<td>0.32</td>
<td>97.97</td>
<td>100.00</td>
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</tr>
<tr>
<td>Spectrum 3</td>
<td>0.84</td>
<td>0.10</td>
<td>98.6</td>
<td>100.00</td>
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</tr>
<tr>
<td>Spectrum 4</td>
<td>1.76</td>
<td>0.11</td>
<td>0.42</td>
<td>97.71</td>
<td>100.00</td>
</tr>
<tr>
<td>Spectrum 5</td>
<td>1.51</td>
<td>0.42</td>
<td>98.07</td>
<td>100.00</td>
<td></td>
</tr>
<tr>
<td>Spectrum 6</td>
<td>0.43</td>
<td>99.57</td>
<td>100.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spectrum 7</td>
<td>0.30</td>
<td>99.70</td>
<td>100.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

X-ray phase analysis revealed that the thin strip in the layer it is vanadium carbide $V_8C_7$

Fig. 4. X-ray phase picture

4. Conclusion/Заключение

It is shown that there are vanadium carbide and iron boride after complex diffusion saturation in pastes. Diffusion saturation of carbon steel in a B-V mixture allows to increase hardness to 60 HRC at insignificant decrease in impact strength. It causes possibility of receiving diffusion layers with an optimum combination of the increased hardness and acceptable impact strength.

5. Literature/Литература