INFLUENTIAL FACTORS IN THE SURFACE-HARDNESS TESTING OF A NITRIDED LAYER

VPLIVNI FAKTORJI PRI PREIZKUŠANJU TRDOTE POVRŠINE NITIRIRANE PLASTI

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Nitrocarburizing is one of the frequently applied processes that significantly improve the service life of steel parts in the complex activities of mechanical loads, wear and corrosion damages. Characterization and confirmation of the quality of a nitrided/nitrocarburized layer is a prescribed norm including a determination of the surface hardness, nitriding hardening depth, compound-zone thickness and its porosity. In the testing of the surface hardness, in spite of determined conditions, there are additional factors that can affect the obtained result and can lead to a misunderstanding between a customer and a provider of the service of nitriding. Here, the inaccuracies and imprecision of a surface-hardness testing are of special importance. The results of a nitrocarburized-layer surface hardness testing are of special importance. The ISO 15787:2001(E) standard prescribes the hardness of the nitrocarburized layer was tested with the Vickers hardness test method under three different loads: 4.9 N, 9.81 N, and 49.03 N (HV0.5, HV1, and HV5). The nitriding hardness depth (NHD) was determined on a cross-section of a metallographic test sample (the treatments marked as: A, B, C). The aim of the polishing was to reduce or remove the porous part of the compound layer in order to reduce the adverse effect of the porosity on the hardness test results. The hardness of the nitrocarburized layer was tested with the Vickers hardness test method under three different loads: 4.9 N, 9.81 N, and 49.03 N (HV0.5, HV1, and HV5). The nitriding hardness depth (NHD) was determined on a cross-section of a metallographic test sample.
with the Vickers test under the load of 4.9 N (HV0.5) according to the ISO 15787:2001(E) standard. Optical microscopy was applied to the same sample to determine the thickness of the compound layer and its porosity.

Table 1: Preparation of the test sample surface for hardness testing

<table>
<thead>
<tr>
<th>Sample</th>
<th>Sandpaper grain size/duration (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>P1000/10</td>
</tr>
<tr>
<td>B</td>
<td>P1000/10 + P2000/5</td>
</tr>
<tr>
<td>C</td>
<td>P600/5 + P1000/5 + P2000/5</td>
</tr>
</tbody>
</table>

3 RESULTS

The surface-hardness test results for the nitrocarburized samples prepared with three different surface treatments and with three different loads applied are presented in Figure 1. The nitriding hardness depth (Figure 2) is 0.22 mm. From the same figure one can see that the hardness decreases sharply with an increased distance from a sample edge. An analysis of variance (ANOVA) was carried out to determine the significance of the surface preparation and scale loading on the results of the hardness tests conducted on a sample surface. The ANOVA results (Figure 3) confirmed the significant influence of the surface pre-treatment and the selection of the indentation load of the indenter on the results of hardness tests.

Generally, lower hardness values were measured when a larger amount of the material was removed from the surface of a nitrocarburized sample, i.e., when sand paper with larger grains was used before the testing. The nitrocarburized layer is thin and the hardness decreases sharply with an increased distance from a sample edge.
finer grade sandpaper, exhibited a better reflection of the light, which made the measurement of diagonals easier, while the hardness of the surface remained almost the same. Accordingly, the surface preparation of sample B could be considered optimal (as it shows a good reflection of the light along with the preserved good properties of the nitrocarburized layer).

If we consider the change in the surface hardness in dependence on the indentation load of the indenter, we can notice that higher values of hardness are obtained when higher loads are applied. This is in line with the expectations that the hardness measured under low loads will depend greatly on the applied force due to the short diagonals of indentations, which can hardly be measured accurately. This phenomenon, known as the Indentation Size Effect (ISE), is of significance at low loads. The compound-layer thickness (CLT) of sample A was approximately 16 μm, with a porous part of approximately 8 μm. The mean CST of sample B was approximately 15 μm and it was reduced to only 5 μm on the damaged spots produced by rough grinding. If the ground surfaces of samples A, B, and C are compared using a light microscope, one can notice that a part of a compound layer has been removed in the process of surface preparation. The rougher surface of sample C after the surface preparation (the surface is damaged, more material has been removed) is the most probable cause for the values of the surface hardness that are lower than those of sample B.

4 CONCLUSION

The following conclusions can be drawn from the investigation into the effect of a surface treatment and indentation load of the indenter on the test results for the nitrocarburized EN 21CrMo5-7 steel surface hardness:

- A nitried layer with the compound-layer thickness (CLT) of 16 μm and with the porosity of 8 μm was obtained. The nitried hardness depth (NHD) was 0.22 mm.
- The values of the surface hardness (according to the Vickers test) greatly depend on the quality of the surface and the applied load. By using sandpaper with larger grains to grind the spot to be measured, the porous part of the compound layer is removed, the layer becomes thinner and the measured values of the surface hardness are lower. When the loads of 0.981 N and 4.89 N were applied, higher values of the surface hardness were obtained for the same measurement spot with the load of 0.981 N than those obtained in the test with the load of 0.489 N.
- During the preparation of the hardness testing of the compound-layer porous part, a compromise between grinding and polishing has to be made in order to obtain a good light reflection and to preserve a sufficient thickness of the surface layer.

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5 REFERENCES

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