THE CAVITATION EROSION RESISTANCE OF THE MARTENSITIC STAINLESS STEEL GX4CrNi 13-4 LASER HARDENED

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Through laser irradiation there had been made superficial 15…20 µm layers on the stainless steel surface martensitic GX4Ni13-4 in the quenched and tempered state. There had been observed an increase of the cavitational erosion rezistance of hardened layers by laser radiation.

1. INTRODUCTION

Cavitation is a complex phenomenon with negative feedback on hydraulic agregates function because of the hydrodynamic characteristics of current was modified, the materials was eroded, as well as of the produced vibrations and noises [1].

Damping cavitation effects can be achieved by design methods of the hydraulic components and using materials with high resistance to cavitation corrosion. This high resistance at cavitation corrosion is given by composition and structural state of the used materials [4, 5].

Arranging and evaluating the resistance under cavitation erosion of different materials needed at manufacturing of hydraulice machinens is made under the following parameters: inclination of mass loss curves and stationary velocity of erosion.

2. MATERIALS, SAMPLES AND TREATMENTS

In papers [1, 2] we are presented researches about cavitational erosion resistance of steel GX4CrNi13-4 treated through quenching, tempering, nitriting and sandblasting. It was observed increase at cavitational erosion of resistance in case they obtained hard superficial layers with a complex microstructure.

Further other superficial layers were obtained through laser hardening.

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The martensitic stainless steel used for tests has the structural and compositional characteristics on Table 1.

Table 1

<table>
<tr><td rowspan="3">Steel Mark</td><td colspan="8">Compositional State %</td></tr>
<tr><td>C</td><td>Si</td><td>Mn</td><td>S</td><td>P</td><td>Cr</td><td>Mo</td><td>Ni</td></tr>
<tr><td>0,04</td><td>1</td><td>1</td><td>0,035</td><td>0,035</td><td>13,2</td><td>0,6</td><td>4,2</td></tr>
<tr><td rowspan="4">GX4CrNi 13-4</td><td colspan="5">Heat Treatment</td><td colspan="3">Structural State</td></tr>
<tr><td colspan="2">PI. – Quenching
1 050 ^{o}C/1h/water</td><td colspan="3">High tempering
650 ^{o}C/3h/air</td><td colspan="3">Martensite + fine carbides, Granulation, G = 5</td></tr>
<tr><td colspan="2">PII. – Quenching with laser – 500W/3mm/7,5 mm/s</td><td colspan="3"></td><td colspan="3">Martensite + fine carbides</td></tr>
<tr><td colspan="2">PIII. – Quenching with laser – 500W/3mm/7,5mm/s</td><td colspan="3">Low Tempering
300 ^{o}C/1h/air</td><td colspan="3">Martensite + fine carbides, uniform distributed, Granulation, G = 7</td></tr>
</table>

NOTE: PI, PII, PIII are the samples I, II, III wich were tested.

The quenching and tempered samples were laser hardened on theier surface at cavitational erosion [3]. There were made succesive passing over with averlapping of layers on 0.5 mm distance. During the laser irradiation the samples have been introduced in a tank with liquid azot up to 4…5 mm of treated surface. The superficial hardening have been accomplished on depth of 15…20 μm. Certain samples have been tempering by use of on electric oven.

3. TESTS AT CAVITATION EROSION

It was used a magnetostrictive vibrator facility and the method described in the paper [1].

The evolution of the eroded mass and the erosion velocity of samples is given on Figs. 1, 2.

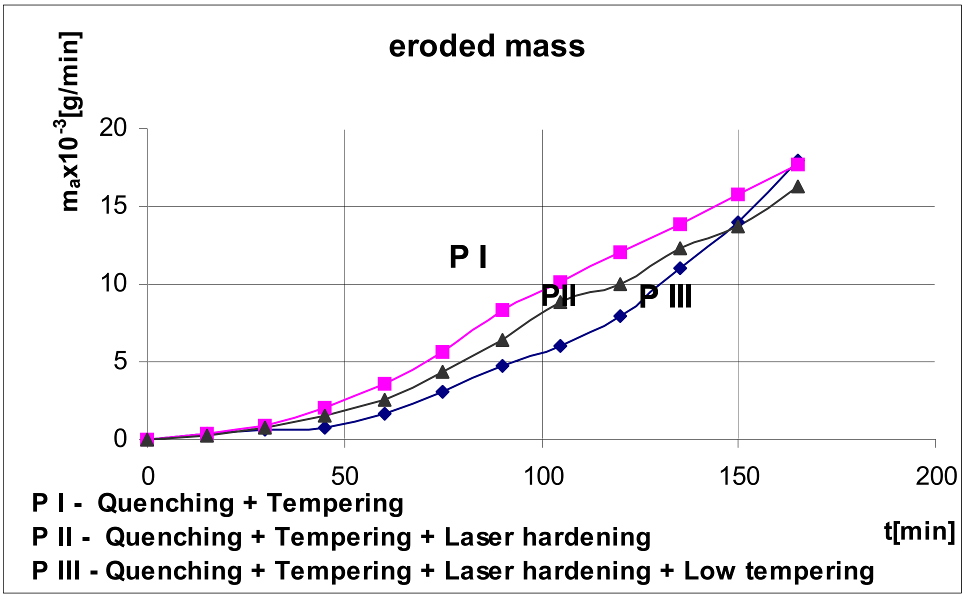


Fig. 1 – Eroded mass.

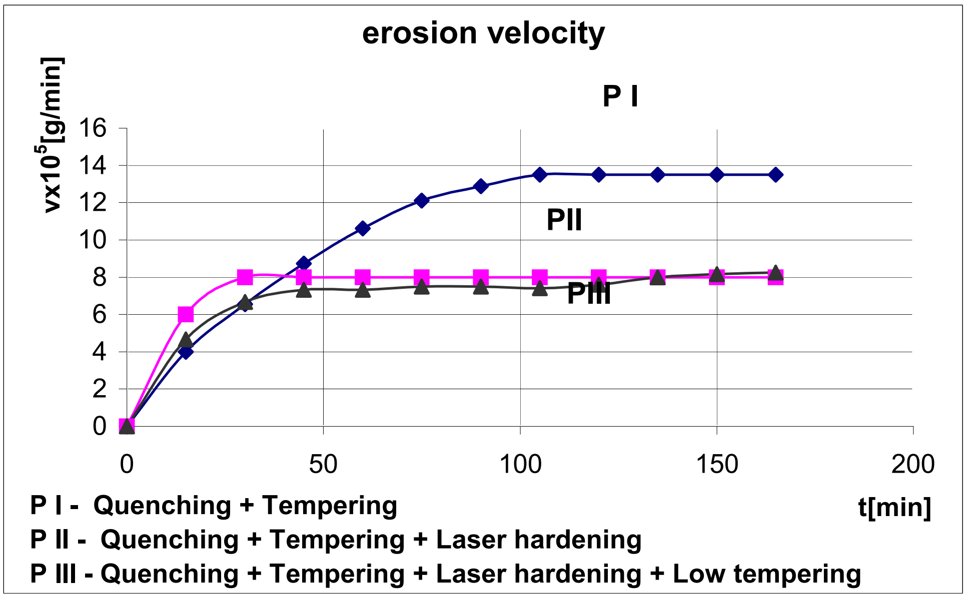


Fig. 2 – Erosion velocity.

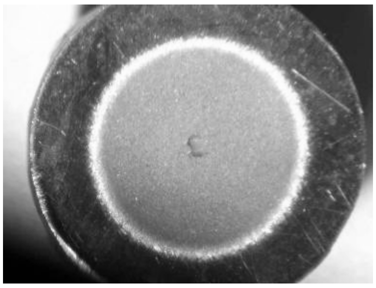
Cavitation curves analyses (Figs. 1,2) shows the following aspects:

- superficial hardening with laser increase the resistance to cavitational erosion;
- the eroded mass curves present a smaller inclination if cooling technological variants are to be used after quenching and tempering. Erosion of superficial layer will be obtained after 100 min;
- the erosin velocity of the laser quenched samples have greater values during the period of 30 minutes after wich they decrease as compared to the quenched and tempered samples.

The cavitational erosion behaviour of the samples wich were superficially quenched with laser is superior and prolonges the life of the active parts of the hydraulic machines.

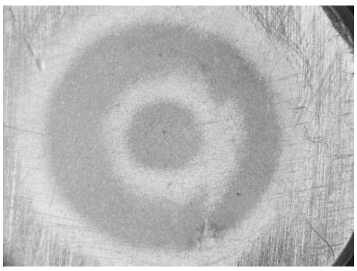
By aplyning the low tempering after laser quenching increases the martensitic stainless steel resistance under cavitational erosion.

The macroscopic analyses of the samples under different structural states is presented in Fig. 3.

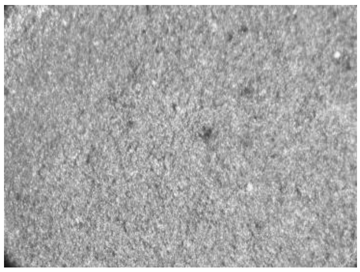


a) OM 10× – quenching and tempering;

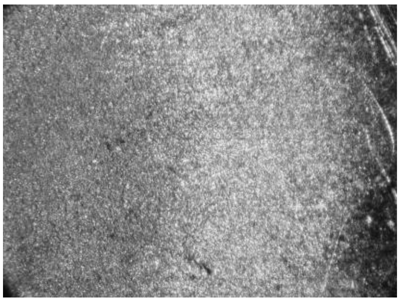
b) OM 20× – cavitated area's center;



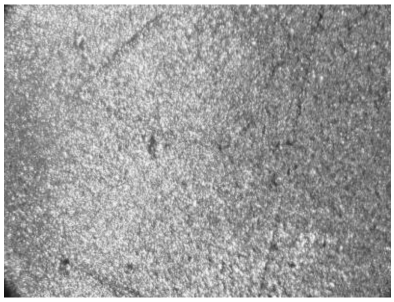
a_1) OM 8× – laser quenched;



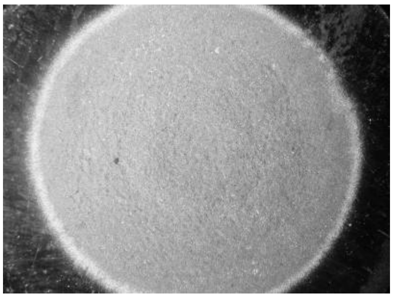
b_1) OM 50× – cavitated area's center;



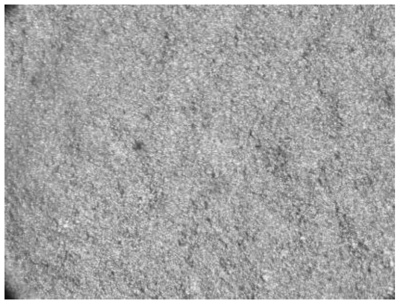
c_1) OM 50× – outer ring of cavitated area;



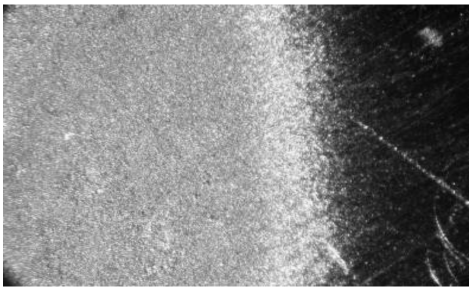
d_1) OM 50× – inner ring of cavitated area;



a_2) OM 8× – laser quenched / low tempered;



b_2) OM 50× – cavitated area's center;



c_2) OM 50× – outer ring of cavitated area.
Fig. 3 – Macroscopic analyses of the samples.
Note: OM – Optical microscope with 8× or 50× increase factor

In the quenched and tempered state (Fig. 3.a,b) there is an eroded area with microcrakes in the central zone and detachments of crystalline grains.

The samples wich were superficially laser quenched have in the eroded area detachaments of crystalline grains (Fig. $3a_1$–d_1), and the edges they present a rough area.

The samples which were subject to laser quenching and low tempering (Fig. $3a_2$–c_2) have two areas of erosion and detachments of grains and on the edges they present a rough area.

The depth of the quenched layer is in the range of 15…20 μm and one structure in bands of 2…3 mm width.

4. CONCLUSIONS AND SUGGESTIONS

The superficial laser quenching of martensitic stainless steel increases the resistance at cavitational erosion. By using a low tempering after laser quenched results in a detensioning which induces an increase of the resistance of steel at cavitational erosion.

We consider that the increase of the resistance of the layers provoques a fines martensite as well as a greater dispersion of carbides.

This situation will be elucidate through microstructural and microhardness analysis.

The cavitation erosion resistance of the quenched layers can be improved by:

- avoiding successive quenching in layers but achieving the simultaneons quenching of the surface at a depth of queneched layer of 50….100 μm;
- aplyng a low tempering in order to reduce the mechanical stress.

We suggest to test "in situ" the laser superficial quenching of steel used at manufacturing hydraulic machine components and establishing reliable technologies.

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