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ABOUT INFLUENCE OF STRUCTURAL STATE ON CAVITATIONAL EROSION RESISTANCE OF AUSTENITIC STAINLESS STEEL THERMALLY TREATED

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ABSTRACT

Samples of the austenitic stainless steel have been thermally treated and tested under cavitation erosion. There have been obtained modifications of the cavitation resistance according to the thermal treatment. By use of structural analyses and micro hardness tests, the influence of microstructure on the steel cavitation resistance was emphasisied. The thermal treatment of solution treatment, sand-blasting and nitriding increases cavitational erosion resistance to GX5CrNi19-10 austenitic stainless steel.

KEYWORDS

Cavitation erosion, structural analyses, micro hardness, solution treatment, microstructure, sand-blasting, nitriding.

INTRODUCTION

The erosion intensity depends on a great variety of factors, such as: structural state, the blade material, the suction height, the duration of the phenomenon and the local conditions [1], [2], [3], [4]. Papers [2], [4] for the GX5CrNi19-10 austenitic stainless steel showed:

- Composition characteristic [5], [6], [7];
- The various thermal treatment by solution heat treatment, sandblasting and nitriding;
- The cavitation eroded masses and the erosion velocity for each variant of thermal treatment determined in a vibratory magnetostrictive test facility with nickel tube [4], [12].

In the previous works it was analyzed the cavitation erosion resistance of the austenitic stainless steel GX5CrNi19-10 subjected to solution heat treatment. The analysis and comparisons was made using the characteristic values and curves obtained in a vibratory test facility with nickel tube [2], [4], [12].

HEAT TREATING

- *Solution treatment* - (1050 ^{o}C degrees/30 min/water cooling) and the mechanical characteristics were determined at ambient temperature. Also the metallographic analysis established that, after this treatment, the steel has austenitic structure with macles in some grains and a granulation G=8, according with ASTM [12].

- *Gaseous nitriding* - as in the complex cyclograma, Figure 1, with the nitrating temperatures: step I-500 ^oC degrees/25 h and step II-520 ^oC degrees/28 h nitriding atmosphere and cooling up to 170 ^oC degrees and continued in air.
- *Sand-blasting and nitrating*. A sand-blasting installation was used. The sand-blasting was done at a pressure of 4-6 bars, for 75 s, at an attack angle of β = 450 degrees and sand granulation of G = 50µm.

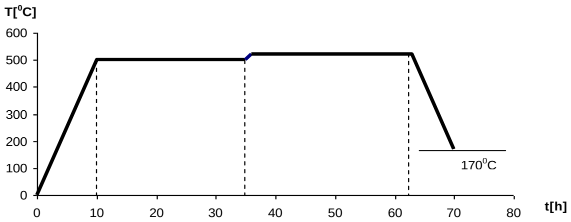


Figure 1 Nitration Cyclogram

The results have been compared with those of the steel 40Cr10 with good but not excellent cavitation erosions and with the steels used for hydraulic turbines: GX4CrNi13-4, GX5CrNiMo13-6-1T07CuMoMnNiCr165-Nb and T09CuMoMnNi Cr185-Ti. For comparisons have been used the characteristic cavitation erosion curves [2], [4] and it resulted that GX5CrNi19-10 has excellent cavitation erosion qualities.

In Table 1 there are made comparisons between the eroded masses after 165 minutes of cavitation attack and the steady state erosion velocities for many steels used in the manufacturing of hydraulic machinery [2], [4].

Table 1

Steel mark	Erosion velocity V_s x105 <g/min>	Eroded mass m_a x103 <g>
GX5CrNi19-10 [solution treatment/sand-blasting/nitriding]	8.10	11.74
40Cr10	35.00	45.00
GX5CrNiMo13-6-1	22.00	32.00
T07 CuMoNiCr 165-Nb	13.60	14.50
T09 CuMoMnNiCr 185-Ti	15.00	15.00
GX4CrNi13-4 [Quenching and tempering]	12.50	17.63
GX5CrNi19-10 [solution treatment]	13.20	15.50

MICRO STRUCTURAL ANALYSES

The specimens from the GX5CrNi19-10 stainless steel, after the cavitation tests, were sectioned on the generatrix, prepared metallographic examined [8], [9], [10]. The attack was made with the reactive CR 12361 / 1999 [11]. Areas A and B were metallographic examined, Figure 2.

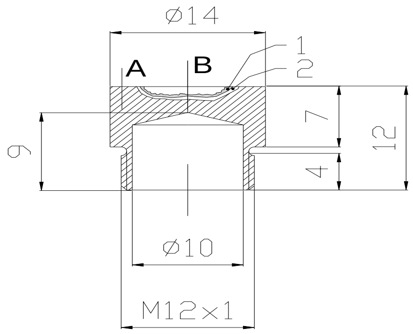


Figure 2 Areas metallographic examined

The metallographic examination was done with an optical microscope having a photo camera. The structure of the specimens manufactured from the GX5CrNi19-10 austenitic steel subjected to solution treatment, sandblasting and gaseous nitration is presented in Figure 3, 4 and 5. Through microscopic analyses it was put into evidence the manner in which the cavitation erosion take place, inclusive the granulation and structural modifications of the layers subjected by cavitation.

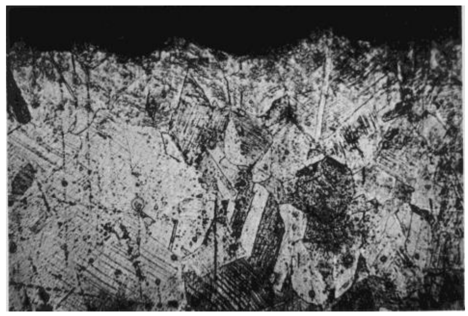


Figure 3 A zone A OM 500X

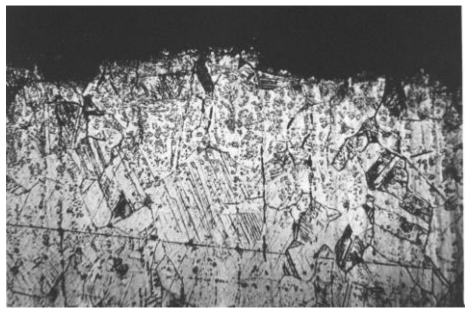


Figure 4 B zone OM 100X

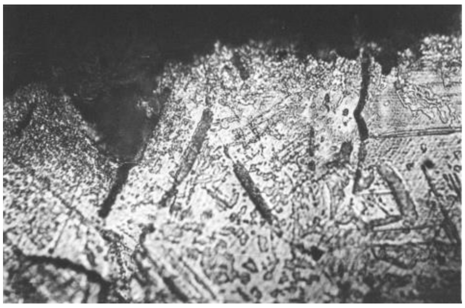


Figure 5 B zone OM 500X

From the metallographic analysis of the specimens tested for 165 minutes to cavitation the following aspects can be noted:

- microdeformations produced by the impact of the sand particles, Figure 3;
- a small depth nitrated layer appear strikingly on the micro asperities created by sandblasting cleaning, Figure 3;
- the depth of the nitrated layer is not uniform and has the thickness of approximately 0.1 mm;
- the structure is austenitic with macles as a result of the solution treatment applied before the sandblast cleaning and gaseous nitration; the cavitation attack is increased on the asperities, Figure 4 and 5;
- the cavitation attack determines microcracks in the nitrated layer, especially at the top of the micro asperities, Figure 4 and 5;
- the cavitation determines high pressures plus a local temperatures raise and apart the microcracks causes also the precipitation of carbides and intermetallic phases in the former austenitic grains, Figure 5.
- it can be remarked an important inter and intra crystalline corrosion.

The mechanisms of cavitation erosion for the tested specimens, in this manufacturing procedure are analogous with those previously described: local melting, micro cracks, and structural modifications in the superficial layers.

The deteriorations evolve with a reduced rate and that is an indicator of the good cavitation resistance.

MICRO HARDNESS MEASUREMENTS

If before nitration, the surface is sandblasted, in the superficial layer on depth until 0.2 mm the hardness is increased until HV0.2 – 410-450 (Fig.3.50).

In the transition zone, from the layer that suffered both sandblasting and nitration to that subjected only to solution treatment, from 0.2 until 0.45 mm, the HV 0.2 hardness varied from 410 to 340 (Figure 3.5 - zone A) and over 0.6 mm the hardness is stabilized at the level HV 0.2-330.

The measurements carried out in the zones B and C –zones affected by cavitation- the obtained microhardness has the values HV 0.2-270. This increase of hardness is due to the cavitation erosion mechanisms. The present metallographic researches do not allow clarifying intimately the causes of this hardness increase, in order to obtain a correct image of the phenomena it is necessary to use electronic microscopy and X rays analyses.

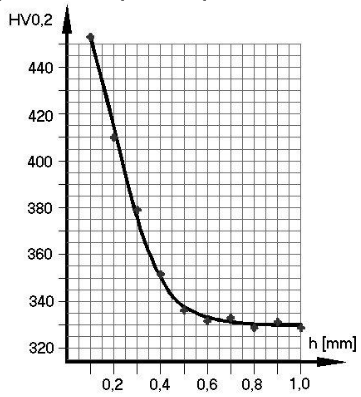
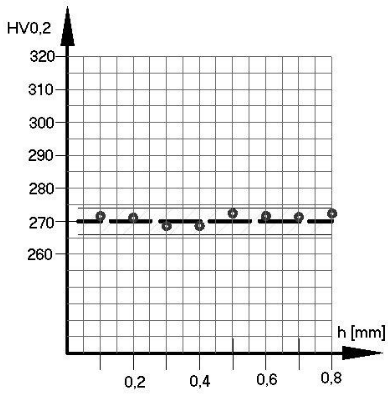


Figure 6 Titlu figura



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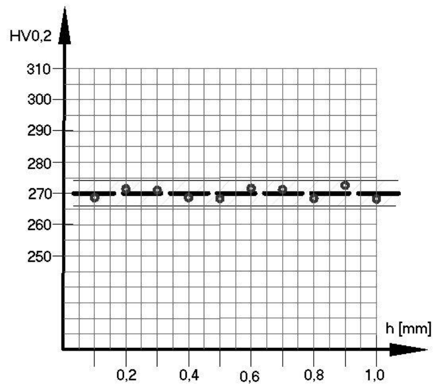

Figure 8 Titlu figura

CONCLUSIONS

The metallographic analyses and the hardness tests have revealed the great role of structural state on the erosion resistance of austenitic stainless steel GX5CrNi19-10.

The technological variants of thermal treatment through which superficial layers of fine grains are obtained with fine and hard structural constituents and compression tension states, are in favour of increasing of the resistance cavitational erosion of austenitic stainless steel.

In the superficial layers obtained by solution treatment there appear tensional states of compression which add to the increase of the cavitatonal erosion resistance.

Sand-blasting and nitrating austenitic steel indicate the appearance of micro asperities on the surface by sand-blasting, a grain finishing of a few microns and a well shaped nitrated level especially on the asperities created by sand-blasting.

The sand-blasting and the gas nitriding produce an increase of hardening in the superficial layers; precisely for:

- austenitic steel in the unaffected area appears hardenings of 450 HV0.2 and in the affected areas there is micro hardening at the level of 270 HV0.2 a little bigger than the one obtained from the chilling by solution treatment in solution (fig. 3.49 A, B, C)
- the thermal solution treatment for the austenitic Gx5CrNi 19-10 steel, followed by treatments of sand-blasting and gas nitrogen gives to steel the biggest resistance at cavitational erosion.
- The mechanisms of cavitation erosion for the tested specimens, in this manufacturing procedure are analogous with those previously described: local melting, micro cracks, and structural modifications in the superficial layers.

It is appreciated that the solution treatment followed by sandblasting and nitriding variant, should have greater opportunities to be industrially applied.

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