INFLUENCE OF STRUCTURAL STATE UPON THE CAVITATION EROSION OF GX5CrNi19-10 AUSTENITIC STAINLESS STEEL SUBJECTED TO SOLUTION TREATMENT

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The paper continues the previous researches of the authors, on the same topic-cavitation erosion- researches which ended with a Ph.D. thesis and through other works. Samples of the austenitic stainless steel GX5CrNi19-10 have been heat 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 emhasized. The thermal treatment of solution treatment increses cavitational erosion resistance to GX5CrNi19-10 austenitic stainless steel.

1. 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 stainless steel showed:

- Composition characteristic [5, 6, 7],
- The various of thermal treatment by solution heat treatment,
- 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 GX5CrNi19-10 austenitic stainless steel 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 heat treatment: (1 050 ^{o}C /30 min/water cooling).
- 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].

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- 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 T09CuMoMnNiCr185-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

Steady state erosion velocity and eroded mass

Steel mark	Erosion velocity $V_s \times 10^5$ [g/min]	Eroded mass $m_a \times 103$ [g]
GX5CrNi19-10(solution heat tretment)	**13.50**	**13.20**
40Cr10	35.00	45.00
GX4CrNi13-4	12.50	17.63
GX5CrNiMo13-6-1	22.00	32.00
T07 CuMoNiCr 165-Nb	13.60	14.50
T09 CuMoMnNiCr 185-Ti	15.00	15.00

In the present work the influence of structural state on cavitational erosion of GX5CrNi19-10 austenitic stainless steel, subjected solution treatment will be analyzed.

2. MICRO STRUCTURAL ANALYSES

The specimens from the GX5CrNi19-10 stainless steel, after the cavitation tests, were sectioned on the generatrix, prepared and metallographic examined [8, 9, 10].The attack was made with the reactive CR 12361/1999 [11]. Areas *A* and *B* (Fig. 1) were metallographic examined.

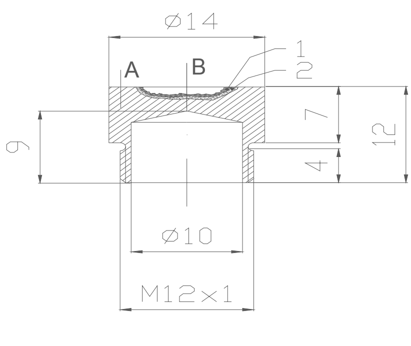


Fig. 1

3. THE STRUCTURE OF THE CAVITATION EROSION TESTED SPECIMENS MANUFACTURED FROM THE AUSTENITIC STEEL HEAT TREATED

The metallographic examination was done with an optical microscope having a photo camera. The structure of the specimens is presented in Figs. 2, 3, 4, 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 (Figs. 2, 3, 4, 5).

STATE: solution treatment (Figs. 2, 3, 4, 5)

Fig. 2 – A zone OM 100×.

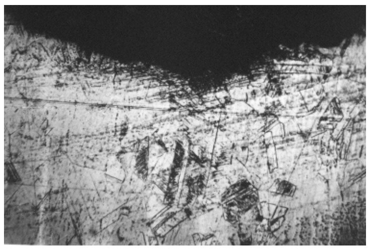


Fig. 3 – B zone OM 100×.

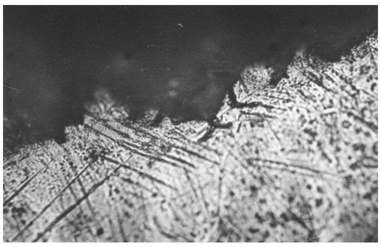


Fig. 4 – B zone OM 500×.

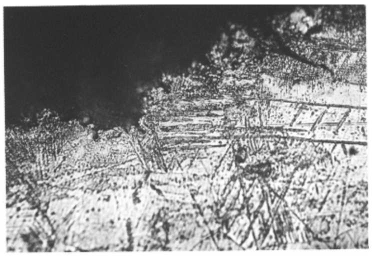


Fig. 5 – B zone OM 500×.

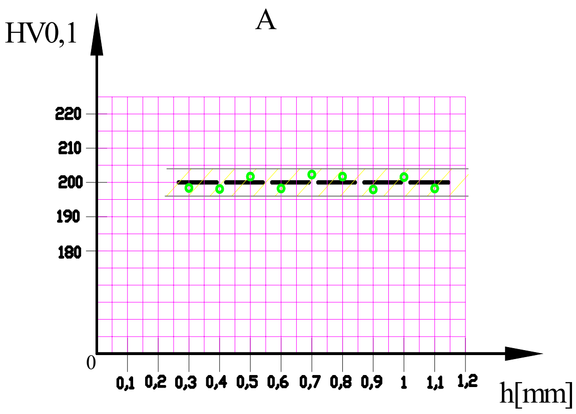
The metallographic analysis of the samples exposed to cavitation erosion tests put into evidence the following aspects for samples with solution treatment:

- *for the area unaffected by cavitations*:
  – a homogenous austenitic,
  – structure with macles in some grains, with G = 8 [12],
  – this structure is coresponding to the solution treatment applied to the austenitic stainless steel;
- *for the areas affected by cavitations appear structure changes*:
  – in the areas affected by cavitations appear microcracks on a intergranular layer, detachments and grain expulsions (Figs. 3, 4),
  – crystalline refinement and carbides precipitation (Fig. 5).

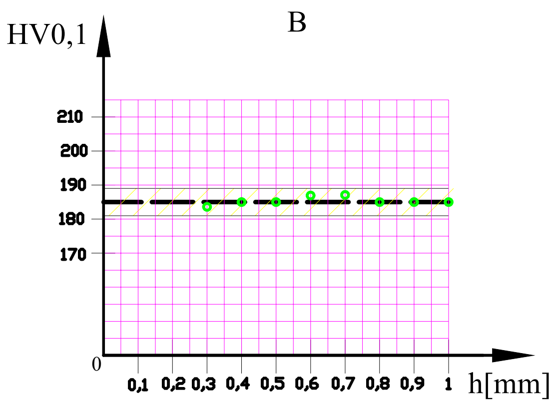
The mechanism of cavitational erosion consists in a melted area, micro-cracks, structural modifications with a smaller intensity that in the case of the solution heat treatment.

4. MICRO HARDNESS MEASUREMENTS

For the austenitic steel, after the solution tempering, there appears a decrease of the hardening from 200 to 185 HV0.2 in the area affected by the cavitations; this situation is in total conformity [2, 4] with the metallographic investigation (Fig. 6).



a



b

Fig. 6 – The hardness HV0.2; state: solution heat treatment.

The microhardness tests show the following aspects according to the variant of thermal treatment:

- increased hardness in structure obtained by solution treatment,
- by solution treatment obtaining the highest hardness values,
- the cavitational erosion resistance is the best in structure of austenitic stainless steel.

5. 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

It is appreciated that the solution treatment variant should have greater opportunities to be industrially applied.

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