STUDIES ON THE BEHAVIOUR TO THE EROSION TO CAVITATION OF THE STAINLESS STEEL - 39Cr13

Lavinia Mădălina MICU*, C. GHERA**

** „Banat University of Agricultural Sciences and Veterinary Medicine "Regele Mihai I al Romaniei " from Timisoara, Romania, lavimicu@yahoo.com*
*** „Polytechnica" Universty of Timisoara, Mihai Viteazul No.1, 300222, Timisoara, Romania*

Abstract: *The 39Cr13 stainless steel has an increased hardness due to the high enough carbon content, which is recommended in the construction of condensed evacuators, valves or valve seats, which are subject to cavitation attack because of frequent changes of liquid-vapor phase. This paper highlights the behavior of this type of erosion to cavitation to this steel, improved variants and untreated. Tests conducted on the device of vibrator show that the heat treatment at the improvement by high values of mechanical properties created, substantially increases resistance to erosion caused by microjets resulted from the implosion of cavitation bubbles.*

Keywords: *39Cr13 stainless steel, cavitation, curves mediation erosion rate*

INTRODUCTION

As the thermodynamic steam outlets function based on the difference in pressure at the input and output, respectively of the temperature difference between steam and the condensation water, they are subject to pronounced cavitation attack, especially at the valve and valve seat [2, 11, and 15]. Frequent failure is due to materials they are made of. Therefore, various researchers tested several materials with different hardness to identify those suitable to increase their lifetime. This study shows cavitation erosion behavior of the X39Cr13 stainless steel in heat untreated variant (annealed) and after the hardness followed by tempering, which substantially improves the mechanical characteristics that lead to increasing resistance to the erosion.

MATERIALS AND METHOD

The material to study is the X39Cr13 stainless steel (EN 10088-1 European standard) having a martensitic structure. Due to its structure the steel, characterized by elevated hardness and tensile strength values [1, 9, 10, 12] to use it in the construction of steam outlets, the research was conducted without and with improvement heat treatment ensuring increased toughness, having the coresponding mechanical characteristics. Results were compared with the standard OH12NDL steel, used in making Kaplan turbine blades from the Romania Iron Gates hydro power plant. The chemical composition and mechanical properties of both steels, determined in laboratories of the University Politehnica Timisoara [4, 5, 6, 7, and 8] are shown in Tables 1 and 2.

Table 1

Chemical composition of X39Cr13 and OH12NDL steels [13,14,16]

Reference	C [%]	Mn [%]	P [%]	S [%]	Si [%]	Cr [%]	Fe [%]
EN 10088-1	0.35-0.42	1.0	0.045	0.03	1.0	12.5-14.5	rest
Determined in laboratory	0.38	0.95	0.036	0.024	0.85	13.7	rest
OH12NDL	0.1	0.4	0.09	0.03	0.3	12.8	rest

Table 2

Mechanical characteristics of X39Cr13 and OH12NDL steels [13,14,16]

Material type	**Hardness HB [daN/mm^2] max**	**Tensile strength Rm [daN/mm^2]**	**Fracture resistance Rp $_{0,2}$ [daN/mm^2]**
X39Cr13 - Annealed	245	800	-
OH12NDL	225	650	400

Cyclogram of the improvement heat treatment – oil hardening to 1050^{o}C and tempering to 300^{o}C applied to the samples tested on cavitation is shown in Figure 1.

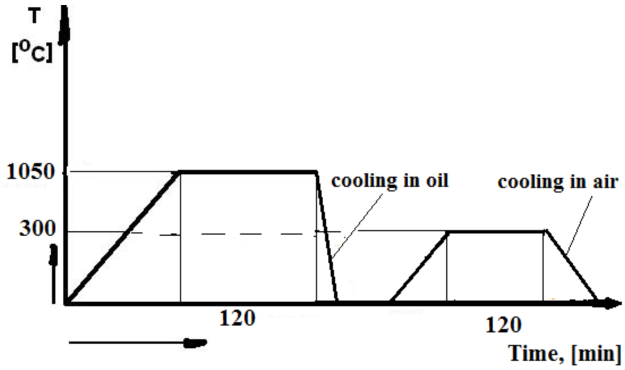

Figure 1.Cyclograma of improvement treatment applied to samples

Cavitation tests were conducted in the Laboratory of the University Politehnica Timisoara on the standard vibrating device with piezoelectric crystal T2 [4, 5, 6, and 7]. To highlight the vibrating cavitation resistance created by the device, several attempts have been made (in two periods of 5 minutes and 10 minutes each and 10 periods of 15 minutes each). After each test period, samples were weighed on a high precision analytical balance ZATCŁCADY, thereby achieving gravimetric losses that led to the construction of characteristic curves, used to assess behavior and resistance to cavitation erosion vibrators.

RESULTS AND DISCUSSIONS

Results were averaged for all the samples tested during the study (three in each set), and the average values obtained as the characteristic curves have been plotted in Figures 2 and 3.

Comparing the two states (heat untreated and heat treated by volume) of the steel studied (Fig. 2 and 3) it is observed that the samples to which one treatment of hardening and tempering have resisted erosion cavitation by 50 % higher than annealed samples and about 81% higher than standard steel OH12NDL, considered a high strength steel cavitation erosion; and the rate of penetration implosion of cavitation in the material surface, hardened and tempered condition showed a decrease of about 46% compared to annealed, and approximately 74% compared to the benchmark. This is due to the hardening martensitic structure in which more and more with the application of the annealing treatment followed by low tempering, as a result of precipitation of fine crystals of carbide steel and change position in the matrix of carbon atoms.

Also, as it originates from the Table 2, the steel X39Cr13 annealed has a higher hardness than standard steel OH12NDL because annealing increases the hardness of the material that leads to the appearance in the crystal lattice of a high density of defects, improved partly by the process the low tempering (keeping the 300 °C for 2 hours).

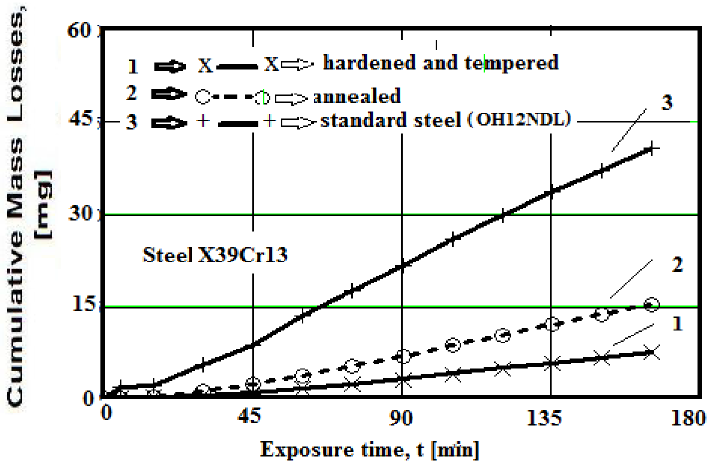

Figure 2. Mass losses for X39Cr13 steel subjected to cavitation erosion for 165 minutes

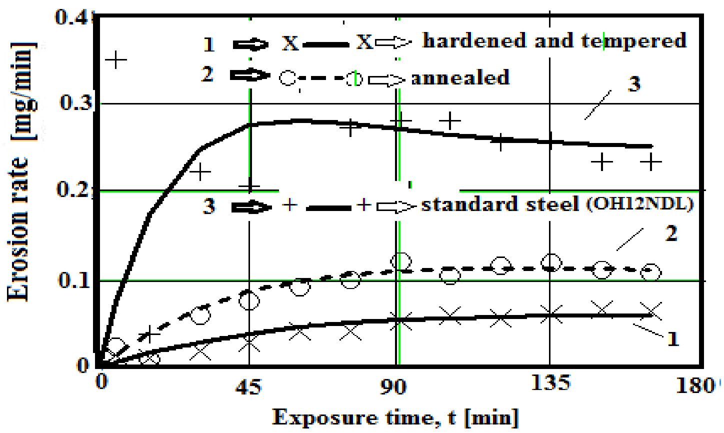

Figure 3. Erosion rate of the cavitation atack depending on the exposure time

In Figure 4 is seen that the tempering temperature favors the growth of 300°C alloy carbides, thereby, enhancing the toughness and ductility of a steel respectively, while decreasing the mechanical strength.

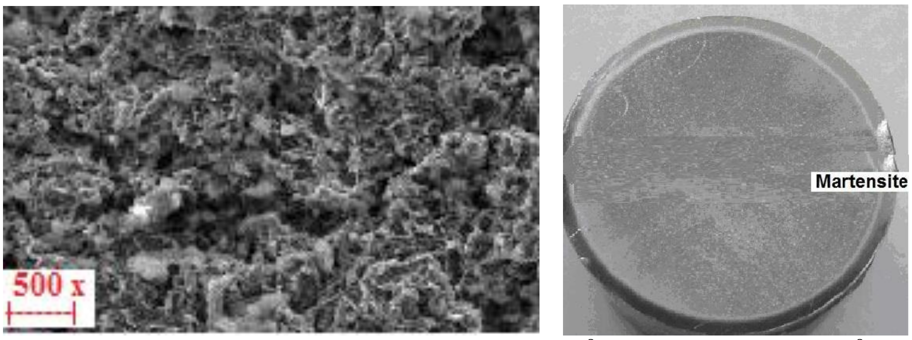

Figure 4. Microstructure of oil hardened samples to 1050 ^{o}C/2 h/oil tempering to 300 ^{o}C

CONCLUSIONS

Following this research it can be said that both alternatives of the X39Cr13 annealed steels and hardened - tempered was in the area of steel good resistance to cavitation.

For valve manufacturing it is recommend as the most erosion-resistant hardned and tempered condition.

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