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Structural Analysis of Cavitation for Different Stainless Steels

The cavitation phenomenon is currently approaching all areas of technology and modern industry, where are fluid in motion.
In this paper cavitational erosion was conducted on different samples of stainless steels. The cavitation were performed in magnetostrictive vibrating apparatus at Cavitation Laboratory (Polytechnic University of Timisoara).
The present paper intends to identify specific structural features in stainless steels. Several investigations were done: macrostructural analysis (Olympus SZX57), scaning electron microscope (Philips SEM) and X-ray diffraction (D8 ADVANCE). After quantitative and qualitative investigations structural features were put in evidence on experimental stainless steels.

Keywords: *cavitation, chemical composition, macrostructural analysis, stainless steels*

1. Introduction

The literature search showed that research on cavitation goes back many years and numerous scientists have studied the cavitation phenomenon [1].

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 [2].

The term cavitation refers to the phenomena of the formation and collapse of gas/vapor bubbles within a liquid. When the pressure in a fluid drops below the vapor pressure, a bubble is formed. Once the liquid pressure recovers, the bubble collapses [3].

Cavitation is caused by rapid vaporization and condensation of a liquid. It originates from voids or tiny bubbles containing gas and vapor which form a nucleus for vaporization.If these bubbles are subjected to vapor pressure, they grow rapidly. The collapse of the cavities causes noise, pressure fluctuations, vibrations, and possible erosion damage [4].

Other authors revealed correlation between structure and properties of different metallic materials in conection with cavitation erosion resistance [5].

The aim present paper is to identify specific cavitation erosion structural features of two stainless steels.

2. Materials and methods

In this paper are analyzed structural analysis of cavitation for two samples of stainless steels.

The local composition determined by EDAX analysis in University Politehnica Bucharest at Center of Expertise of Special Materials (UPB-CEMS) is given in table 1.

Table 1.

Alloy	**Chemical composition, %**								
	Si	**Mo**	**Cr**	**Ca**	**Ni**	**Mn**	**Al**	**K**	**Fe**
A	2.37	2.16	19.89	1.1	14.47	4.49	1.47	-	bal
B	2.55	3.33	20.47	0.81	25.72	1.67	0.93	0.29	bal

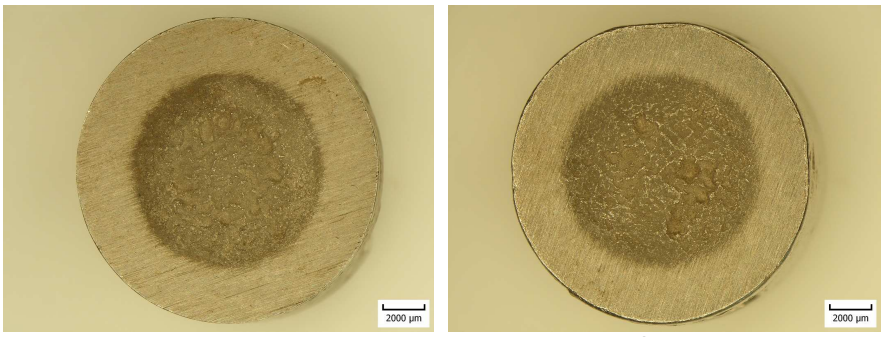
The cavitation erosion tests were carried out in a magnetostrictive facility, in Timisoara Hydraulic Machinery Laboratory, in according with ASTM G32-85 [6]. Stereomicroscopy and SEM analysis was performed after 165 minutes of cavitation erosion at CEMS laboratory. Different investigations were done: macrostructural analysis (Olympus SZX57), scaning electron microscope (Philips SEM) and X-ray diffraction (D8 ADVANCE).

3. Results and Discussion

Structural analysis for two stainless steels produced by cavitation are given in figures 1-4.

In figure 1a where the presented sample is from steel A the surface is highly degraded with many interconnected cavitations with radial disposal without affecting the core of the sample.

In steel B the surface attacked by cavitation is found approximately in a concentric circle (figure 1 b) and also it can be observed huge macroscopic interconnected cavitations.



a b

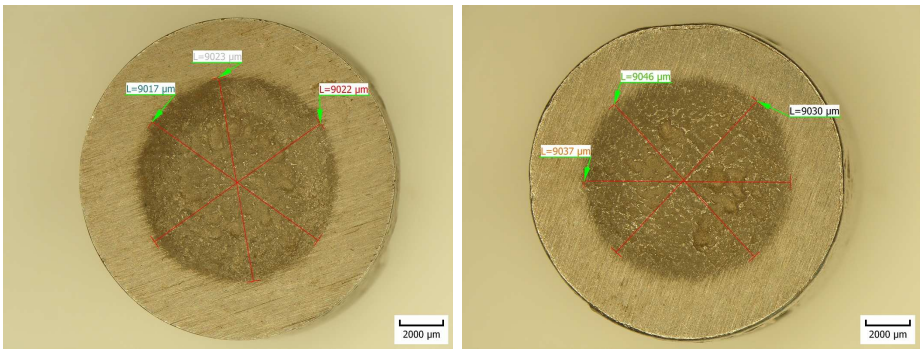
Figure 1. Stereomacroscopic aspect of stainless steel samples:
a – steel A, b- steel B

The extension of cavitation phenomenon is given in figure 2 and table 2.

Tabel 2.

Alloy	Sample diameter, µm	Extension of cavitation, µm	Surface affected by cavitation, %
A	14044	9020.7	41.26
B	13823	9037.7	42.75

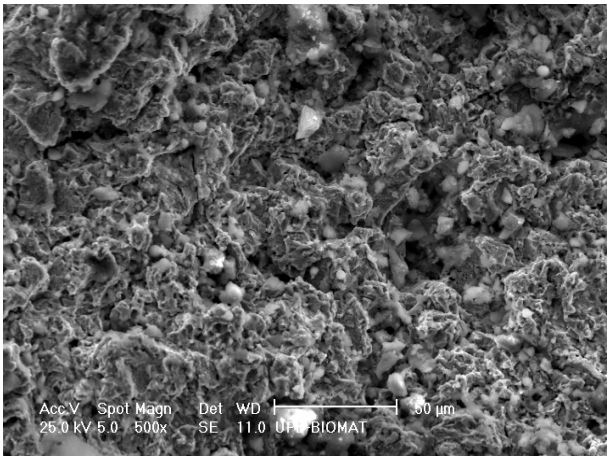
So at steel A only 41.26% of surface is affected by cavitation (figure 2a), but the real affected cavitation surface can be smaller, due to very deep frame cavitations. At steel B a surface about 42.75% is affected by cavitation in figure 2b. The best cavitation behaviour between our two steels is for steel A.



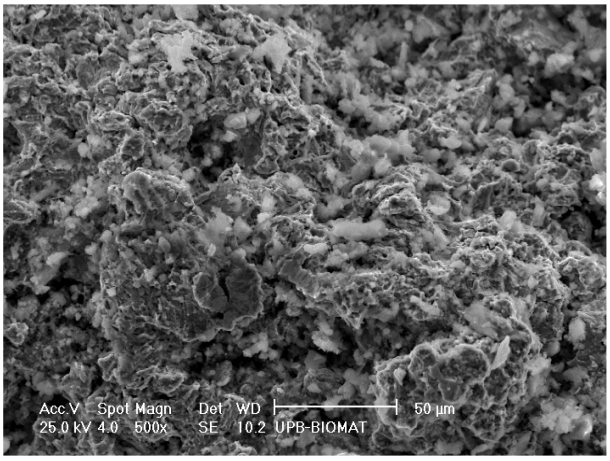
a b

Figure 2. Stereomacrostructural aspect of stainless steel samples after measuring cavitation affected zone:
a – steel A, b- steel B

Figure 3 reveals the structural analysis at scaning electron microscope of the experimental stainless steels. So, at steel A is presented (figure 3a) fragile breaking with aspect intergranular; equal proportions of fine and very fine cavitations; fragile character breaking with propagation intergranular cracks.



a



b

Figure 3. Structural analysis at scaning electron microscope, after 165 minutes of cavitation loading:
a-steel A, b-steel B

At steel B one may reveal (figure 3b) surface with very fine cavitation; aspect mixed of cavitation and cleavage planes with very fine intergranulation cracks. The material shows many inclusions with different sizes.

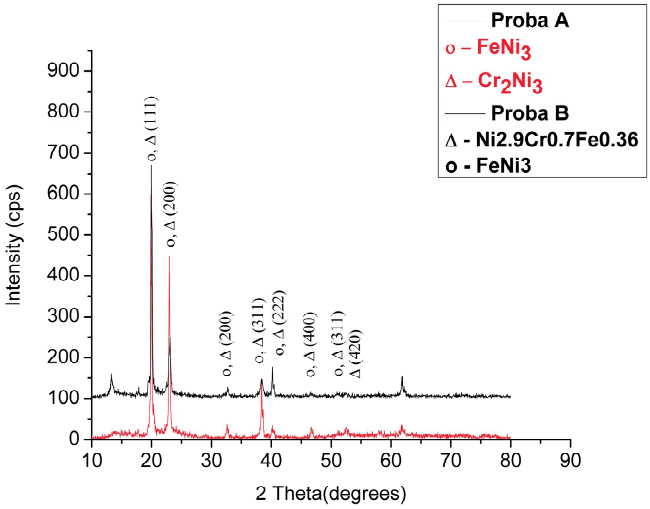


Figure 4. XRD of steel A and B

The spectrometer of the steel XRD (figure 4) was compared with the ASTM international standard and it was found that they correspond. The diffraction also identified the phases of both steel. In steel A two phases were identified: $FeNi_3$ and Cr_2Ni_3. In steel B the phases identified were: $Ni_{2.9}Cr_{0.7}Fe_{0.36}$ and $FeNi_3$.

Our results are in according with those mentioned in literature. As a novelty, we identify specific structural aspects and also, we made quantitative and qualitative investigations.

4. Conclusion

The experiments of cavitation phenomen made on two stainless steels may reveals the following conclusions:

- Due to the big amount of inclusions in structures of steel B the material is more predisposed to the cavitation phenomen.
- The best cavitation behaviour (between our investigated stainless steels) is for steel A, with about 41.26% surface affected by cavitation in comparison with steel B where the surface affected by cavitation is about 42.75%.
- The steels analyzed have austenitic structures with precipitates of $FeNi_3$ and MxNy compound.

Acknowledgements

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