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Different Aspects of Cavitation Damages in Some Stainless Steels

Cavitation is an important factor in many areas of science and engineering, including acoustics, chemistry and hydraulics. In this paper the authors analyze the manner of cavitation damages in different samples of stainless steels. Cavitation destruction was performed in a magnetostrictive vibrating apparatus in Laboratory of Polytechnic University of Timisoara, Romania. Cavitation erosion behaviour was appreciated considering macrostructural analysis (both quantitative and qualitative) made at stereomicroscope type OLYMPUS equipped with QuickMicrophoto 2.2 software and structural analysis at scaning electron microscope (SEM) at Philips SEM microscope. Finally conclusions regarding specific structural features of cavitation at stainless steels were revealed.

Keywords: *cavitation-erosion, damages, stainless steels, chemical element*

1. Introduction

Cavitation erosion is a complex phenomenon that involves the interaction of hydrodynamic, mechanical, metallurgical and chemical factors. The pressure wave and cumulative liquid jet generated by collapsing bubbles interact with adjacent solid surface leading to compressive residual stresses [1].

Cavitation is known as a repeated formation and violent collapse of bubbles in a liquid, which generates very large hydrodynamic stresses. The collapse of a spherical bubble of initial radius R is a source of a pressure shock wave of □103 MPa magnitude [2] and 103 K temperature [3], but this pressure is attenuated within some distance r. Moreover, it is known that a bubble adjacent to a solid boundary does not collapse spherically, forming instead a jet of liquid that impinges the solid [4].

Cavitation can be divided into three types: traveling cavitation, fixed cavitation and vortex cavitation. Fixed cavitation only occurs on a solid wall. Traveling cavitation is the phenomenon that the cavitation bubbles will produce, expand and collapse during flowing. The time needed for the whole process is about 3–4 ms. Vortex cavitation is induced by the bubbles that are generated by obstacles in the flow [5].

Cavitation damage is a dynamic phenomenon caused by repeating action of imploding cavitation bubbles. The bubble collapse causes the origin of an impacting microjet.

The aim present paper reveals structural aspects concerning cavitation behaviour of some stainless steels.

2. Materials and methods

In this paper are analyzed different aspects of cavitation damages in some samples of stainless steel.

Chemical composition for different stainless steel made by spectrometry is given in table 1.

Table 1.

Alloy	**Chemical composition,%**						
	Si	**Cr**	**Mn**	**Ni**	**Cu**	**Mo**	**Fe**
A	1.02	23.58	3.43	3.32	2.12	-	Bal
B	0.68	1.69	0.86	1.57	-	-	Bal
C	1.97	19.27	2.07	9.2	-	3	bal

Cavitation destruction was performed in a magnetostrictive vibrating apparatus in the Laboratory "Cavitation testing", Polytehnic University of Timisoara, Romania.

Cavitation erosion behaviour was appreciated considering macrostructural analysis (both quantitative and qualitative) made at stereomicroscope type OLYMPUS equipped with QuickMicrophoto 2.2 software and scaning electron microscopy type Philips SEM.

3. Results and disscusion

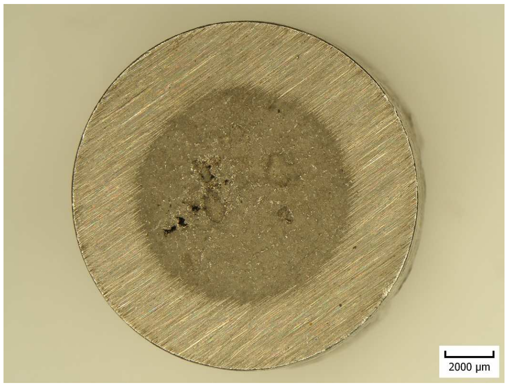
Results concerning structural investigation of cavitation behaviour of some stainless steel are given in figures 1, 2 and 3.

Stereomacrostructural aspects of the experimental test samples are given in figure 1.

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

In figure 1b which is from steel B the cavitation attack is also found approximately in a concentric circle and the surface has general corrosion.

a b



c

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

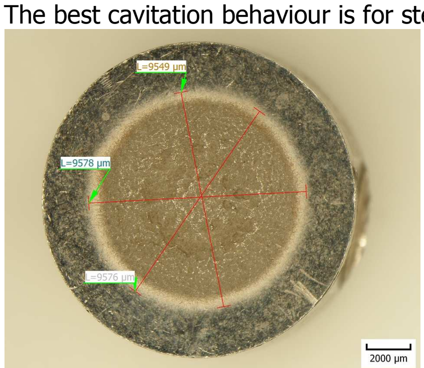
In the steel C from figure 1c the surface degraded through cavitation is well delimitated and it presents a huge cavitation gap in the left side of the cavitation.

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

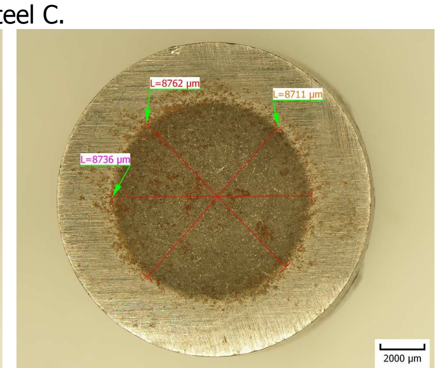
Table 2.

Alloy	Sample diameter, µm	Extension of cavitation, µm	Surface affected by cavitation, %
A	13694.7	9567.7	48.81
B	13692.3	8736.3	40.71
C	13789.3	8566.7	38.60

So only 48.81 % of surface in steel A is affected by cavitation (figure 2 a), about 40.71 % of surface is affected by cavitation in steel B (figure 2 b) and, respectively about 38.60 % of surface is affected by cavitation in steel C (figure 2 c). The best cavitation behaviour is for steel C.



a



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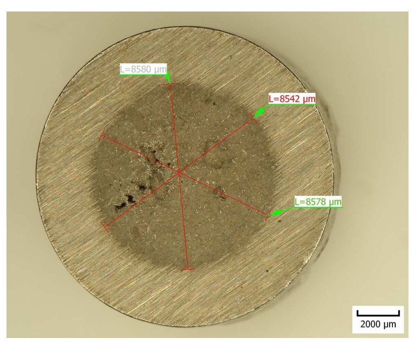

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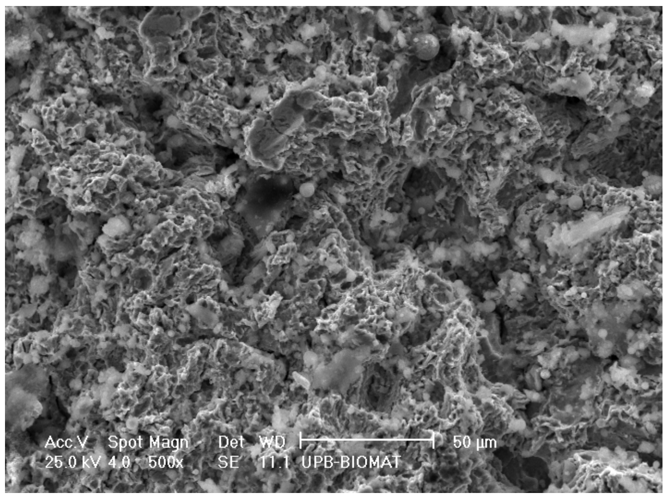
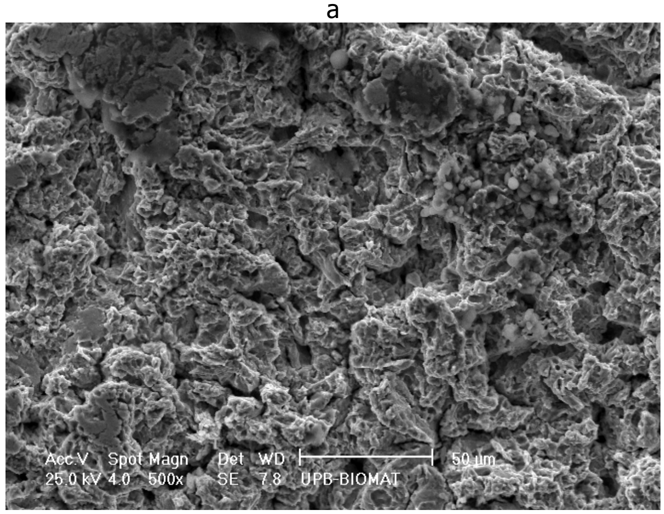
Figure 2. Stereomacrostructural aspect of stainless steel samples after measuring cavitation affected zone: a – steel A, b- steel B, c- steel C

Figure 3 reveals the structural analysis at scaning electron microscope of the experimental stainless steel. So, at steel A there are put in evidence surfaces mixed with fine and big cavitation; surfaces with secondary intergranular cracks; fragile character breaking with propagation intergranular cracks. At steel B is presented fragile breaking with aspect intergranular; surfaces mixed with fine and big cavitation. In steel C is observed surface with very fine cavitation; aspect mixed of cavitation and cleavage planes with very fine intergranular cracks.



a



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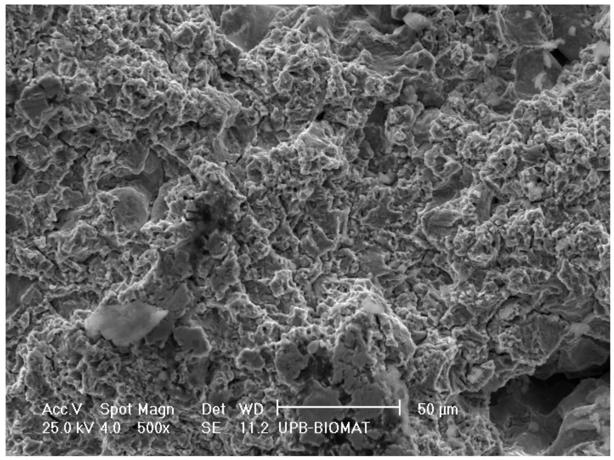

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Figure 3. Structural analysis at scaning electron microscope (SEM), after 165 minutes of cavitation loading (x500):
a- steel A, b- steel B, c- steel C

As is mentioned in literature, cavitation patterns can be divided into three groups: transient isolated bubbles, attached or sheet cavities and cavitating vortices[6].

Finally conclusions regarding specific structural features of cavitation at stainless steels were revealed.

4. Conclusion

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

- The SEM analysis reveals that surfaces contain uniform degradation with fine and very fine intergranular cracks.
- The best cavitation behaviour (between our investigated stainless steels) is for steel C, with about 38.60% surface affected by cavitation in comparison with steel A and steel B, where the surface affected by cavitation is about 48.81% and 40.71%.

Acknowledgements

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References

[1] Krause H., Mathias M., *Investigation of cavitation erosion using Xray residual stress analysis*, Wear 119 (1987) 343–352.
[2] Vyas B., Preece C.M., *Cavitation erosion of face centred cubic metals,* Metall. Trans. 8A (1977) 915–923.
[3] Fedokin I., Yachno O., *Some problems of development of cavitation technologies for industrial applications*, CAV 2001, in: Proceedings of the Fourth International Symposium on Cavitation, California Institute of Technology, Pasadena, CA, USA, June 20–23, 2001.
[4] Brennen Ch.E., *Cavitation and Bubble Dynamics*, Oxford University Press, New York, 1995.
[5] Sun Z. , Kang X.Q., Wang X.H., *Experimental system of cavitation erosion with water-jet*, Materials and Design 26 (2005), 59–63
[6] Ghiban N., Bordeaşu I., Ghiban B, Mânzână M.-E., *Macrostructural Analysis Of Cavitantion For Various Ferrous Materials,* Metalurgia international vol.XVI ISSN 1582-2214, No.4 (2011), Material science research and development.

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