Annals of DAAAM for 2010 & Proceedings of the 21st International DAAAM Symposium, Volume 21, No. 1, ISSN 1726-9679
ISBN 978-3-901509-73-5, Editor B. Katalinic, Published by DAAAM International, Vienna, Austria, EU, 2010
Make Harmony Between Technology and Nature, and Your Mind will Fly Free as a Bird
DAAAM Symposium

STRUCTURAL ASPECTS OF CAVITATION FOR DIFFERENT COPPER ALLOYS

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Abstract: *Cavitation is an important factor which may influence either industrial process, or function of materials. Copper alloys have a wide spread of applications, using as naval components being one of them. Present paper intends to identify specific structural features in two copper alloys: brass and bronze. Several investigations were done: macrostructural analysis on Olympus microscope, microstructural analysis at Reichert and Philips SEM. After quantitative and qualitative investigations structural features were put in evidence on experimental brass and bronze.*
Key words: *cavitation, dimple, brass, bronze, stereomicroscopy, copper*

1. INTRODUCTION

Cavitation is an important factor in many areas of science and engineering, including acoustics, chemistry and hydraulics. It occurs in many industrial processes such as cleaning, lubrication, printing and coating. While much of the research effort into cavitation has been stimulated by its occurrence in pumps and other fluid mechanical devices involving high-speed flows, cavitation is also an important factor in the life of plants and animals, including humans, (Brujan, 2009).

Cavitation can be defined as the breakdown of a liquid medium under very low pressures. This makes cavitation relevant to the field of continuum mechanics and it applies to cases in which the liquid is either static or in motion.

The cavitation damage is caused when a bubble collapses in the vicinity of a solid surface. Since then a wide range of studies that deal with problems from bubble dynamics to material testing, have been made all aiming toward deeper understanding of the phenomena. The problem is a difficult one because it involves complicated flow phenomena combined with the reaction of the particular material of which the solid surface is made, (Dular, 2004).

Cavitation can also occur in a static or nearly static liquid. When an oscillating pressure field is applied over the free surface of a liquid contained in a reservoir, cavitation bubbles may appear within the liquid bulk if the oscillation amplitude is large enough. This type of cavitation is known as acoustic cavitation, (Franc, 2004).

Recently there were many attempts to predict the magnitude of the cavitation erosion. For example Pereira found a relation between the volume of transient cavities and its rate of production to the material deformation energy, (Pereira, 1998).

Another suggestion is that the damage of the solid surface is a consequence of a sequence of events – from cavitation could collapse to the spherical implosion of a single bubble that causes the damage, (Patella, 2004).

Other authors revealed correlation between structure and properties of different metallic materials in conection with cavitation erosion resistance (Bordeasu, 2008, Ghiban, 2009).

The aim present paper is to identify specific cavitation erosion structural features of two copper based alloys.

2. MATERIALS AND METHODS

Two very well known copper alloys were tested with cavitation method. Chemical composition of experimental copper based alloys is given in table 1. Cavitation destruction and surface microscopically study were performed in magnetostrictive vibrating apparatus at Cavitation Laboratory (Polytechnic University of Timisoara). Stereomicroscopy and SEM analysis were performed after 165 minutes of cavitation erosion at University Politehnica Bucharest at Center of Expertise of Special Materials (UPB-CEMS). Different investigations were performed: stereomicroscopy (at Olympus SZX57), microscopy (type Reichert microscope) and scaning electron microscopy (type Phylips SEM).

Alloy	Chemical composition, %					
	Zn	Al	Ni	Mn	Fe	Cu
Brass	38,62	-	-	-	-	61,38
Bronze	-	11,13	6,32	1,32	6,07	75,17

Tab. 1. Chemical composition of experimental copper alloys

3. RESULTS AND DISSCUSION

Results concerning structural investigation after cavitation erosion test are given in figure 1-5.

As one may see from figure 1 (a) brass consists in cast structure, with nonhomogeneous disposal of α solid solution and β solid solution and bronze (figure 1 b) has a cast structure formed from α solid solution, γ_2 solid solution and rounded eutectic of $(\alpha+\gamma_2)$.

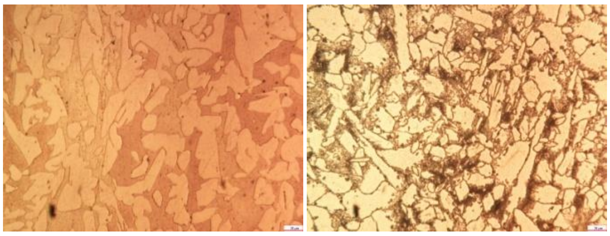
After examination of cavitation surfaces in transversal section in both copper experimental alloys one may remark that cavitation advances by eroding in the same proportion of both structural cast states (figure 2).

The depth of cavitation erosion is given in figure 3. The length of cavitation is different: in brass is about 157,5 μm, and in bronze is 49,23 μm.

The extension of cavitation in measured in figure 4, so 45,87% of surface in brass is affected by cavitation, respectively 32,5% in bronze.

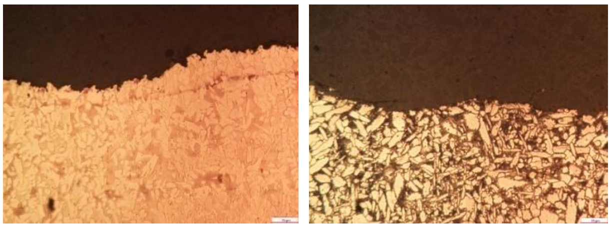
The SEM analysis, which is given in figure 5, reveals that surfaces (in both copper alloys) contrain uniform degradation with fine and intergranulation very fine cracks. The dimensions of cavitation are very small, about 1-5 μm.

Cavitation can take different forms as it develops from inception. Initially, it is strongly dependent on the basic non-cavitating flow structure. However, as it develops, the vapor structures tend to disturb and modify the basic flow.



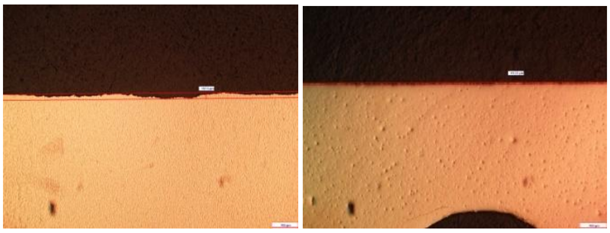
a b

Fig. 1. Microstructural images of experimental copper alloys: a- brass, b- bronze ($FeCl_3$, etillic alchool, HCl attack, x500)



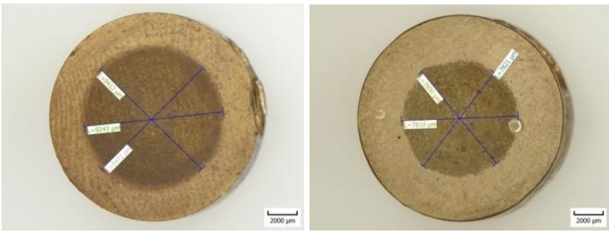
a b

Fig. 2. Microstructural images of experimental copper alloys of after 165 minutes of cavitation test: a- brass, b- bronze ($FeCl_3$ etillic alchool, HCl attack, x200)



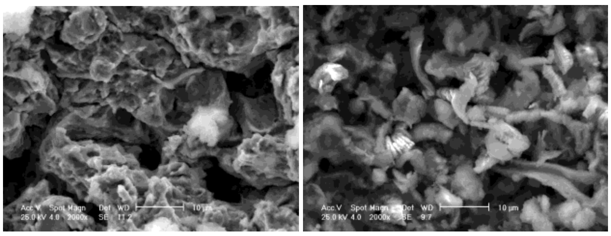
a b

Fig. 3. Microstructural images of experimental copper alloys of after 165 minutes of cavitation test in non attacked state: a- brass, b- bronze (x100)



a b

Fig. 4. Stereomacrostructural aspect of brass (a) and bronze (b) after measuring cavitation affected zone, x8



a b

Fig. 5. SEM images of (a) and bronze (b) after 165 minutes of cavitation test (x2000)

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

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. CONCLUSIONS AND FUTURE RESEARCHES

After testing at cavitation erosion for two copper alloys, brass and bronze, the following conclusions may be put in evidence:

- Brass consists in cast structure, with nonhomogeneous disposal of α solid solution and β solid solution and bronze has a cast structure formed from α solid solution, γ_2 solid solution and rounded eutectic of $(\alpha+\gamma_2)$.
- The SEM analysis reveals that surfaces (in both copper alloys) contrain uniform degradation with fine and intergranulation very fine cracks, with dimensions of cavitation about 1-5 µm.
- The quantitative aspects of cavitation are different in brass in comparison with bronze: so maximum depth of cavitation in brass is 157.5µm in comparison with only 49.23µm in bronze. Also, the extension of cavitation in brass is 47.87 % in comparison with only 32.5% in bronze.

Future research plans, based on our results help for either the development of new materials with increased erosion cavity resistance, or in knowing the mechanism of cavitation evolution during erosion.

ACKNOWLEDGEMENTS

The work has been funded by the Sectoral Operational Programme Human Resources Development 2007-2013 of the Romanian Ministry of Labour, Family and Social Protection through the Financial Agreement POSDRU/88/1.5/S/60203.

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