# Estimation of the resistance at the cavitation erosion of the CuSn12 bronze based on mean durability

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## Keywords

Cavitation resistance, mean durability, mean depth erosion, mass loss, bronze, treating

## 1. Introduction

The ASTM G32-2010 International Standards recommend the materials behavior evaluation at cavitation erosion, by curves and parameters which define degradation degree of the exposed surfaces at cavitation, expressed by the amount of material removed by cavitation, the caverns dimension produced, respectively the speeds with which they occur, prof. K. Steller [1], using various results, obtained in the Gdansk Laboratory, proposes the mean durability parameter ($\delta_{med}$).

The results obtained by Steller, regarding of the estimation of resistance with this parameter, shows that it is a credible indicator of the increase or decrease of the materials resistance to the impact with microjets generated by cavitation bubble implosion. Starting from these considerations, the work shows the increase in resistance, brought of the CuSn 12 bronze, through thermal treatment.

## 2. Materials and methods of research

The tested material is a copper alloy (type bronze symbolized EN CuSn12-C, according to DIN EN 1982), whose chemical composition and mechanical characteristics are: 85.16 % Cu, 11.18 % Sn, 0.4856 % Zn, 0.7983 % Pb, 0.5226 % Fe, 0.6933 % Ni, 0.2 % Sn, 0.0304 % Mn, 0.0382 %S, 0.0714 %Sb, <0.003 %P, $R_m$ = 300 MPa, $R_{p0.2}$ = 150 MPa, 92 HB, A5 = 9 %.

The research was carried out on three samples of the delivered state and three samples from the state obtained by heat treatment. The tests were performed on the vibrator device with the piezoceramic crystals, of the Polytechnic University of Timisoara, respecting the laboratory's custom and the norms regarding the conditions and the testing procedure, as well as those of the characterization of the behavior during the cavitation attack [2-4].

The functional parameters of the apparatus , controlled and maintained at the values prescribed for the test regime, for the five metals, are [3]: The power of the ultrasonic electronic generator (500 W); vibration frequency (20000 ± 200 Hz); duble amplitude of the vibrations (50 µm); water temperature (22 ± 1°C) The tests was realized in double distilled water.

## 3. Results and discussion

In Table 1 there are presented images of evolution of surface degradation by cavitation erosion at 4 characterization times.

The images in the Table 1 show that:

Table 1. Images of the surface degradation.

<table>
<tr><th rowspan="2">Material type</th><th colspan="5">Attack duration, min</th></tr>
<tr><th>0</th><th>30</th><th>75</th><th>120</th><th>165</th></tr>
<tr><td>State delivered</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>The state obtained by thermal treatment (quenching + tempering)</td><td></td><td></td><td></td><td></td><td></td></tr>
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- the area of the eroded surface and the depth of the craks increases with the duration of exposure to the cavitation attack;

- the degradation of the surface of the bronze, in the delivered state, is much more pronounced that obtained by of the thermal treatment.

For all tested samples, the experimental values obtained for the cumulated mass losses, for the intermediate intervals of the cavitation attack, were mediated. Figure 1 shows the mass losses evolation, and the Figure 2 the corresponding erosion rates.

Evolution of the curves, of the two figures, clearly shows that by thermic treatment of quenching and tempering, the cavitation resistance increases significantly.

The ratio of cumulative mean depths erosion $MDE_{SL}/MDE_{STT}$ (where SL is delivered state, and STT is the state obtained by treating), at the final cavitation duration (165 minutes), shows a increase to cavitation resistance by 1.23 x.

MDE values are calculated with relationship:

$$\Delta MDE = \frac{4 \cdot M_{max}}{\rho \cdot \pi \cdot d_p^2} \qquad (1)$$

where:

- $M_{max}$ - is the mass loss through erosion, after 165 minutes of exposure to cavitation, in mg
- $d_p$ - the diameter of the sample surface, exposed to cavitation attack ($d_p$= 15,8 mm),
- $\rho$ - bronze density ($\rho$ = 8.9 g/cm$^3$).

Calculating the value of the mean durability parameter ($\delta_{med}$), recommended by K. Steller [1], with the relationships below:

$$\delta_{med} = \frac{165 \cdot (e^{3 \cdot \alpha} - 1)}{3 \cdot \alpha \cdot V_{max}} \qquad (2)$$

where:

$$\alpha = \frac{3}{165} \cdot \left( \frac{165 \cdot V_{max} - \int_0^{165} A \cdot t(\cdot 1 - e^{-B \cdot t}) dt}{165 \cdot V_{max}} \right) \qquad (3)$$

and $V_{max}$ is the volume the maximum volume, eroded in 165 minutes, as shown in fig. 1.

Obtain:

- for delivered state $\delta_{med}$ = 8.984
- for state obtained by quenching and tempering treatment $\delta_{med}$ = 7.306

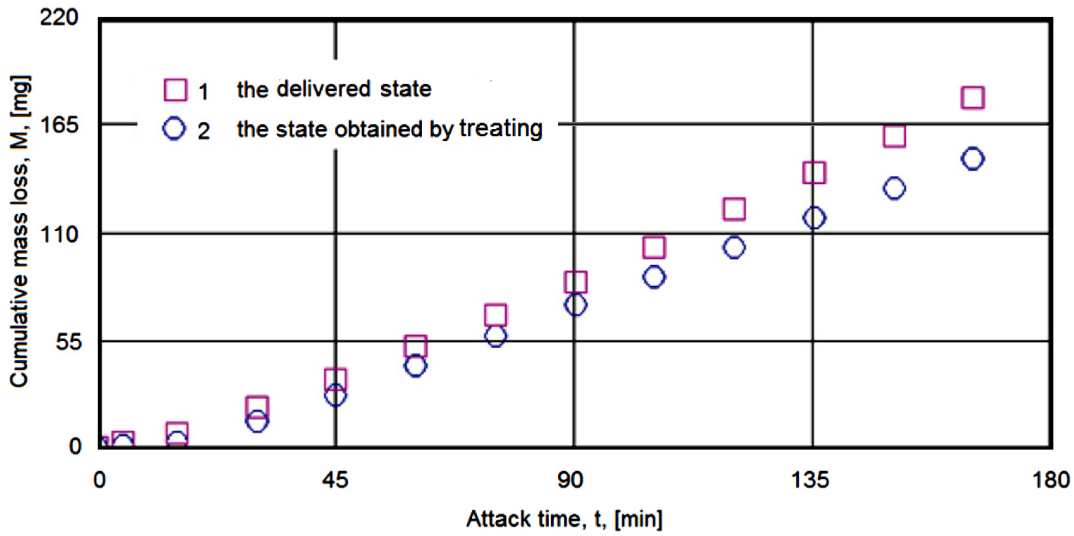


Figure. 1. Variation of mass losses with the duration of the cavitation attack.

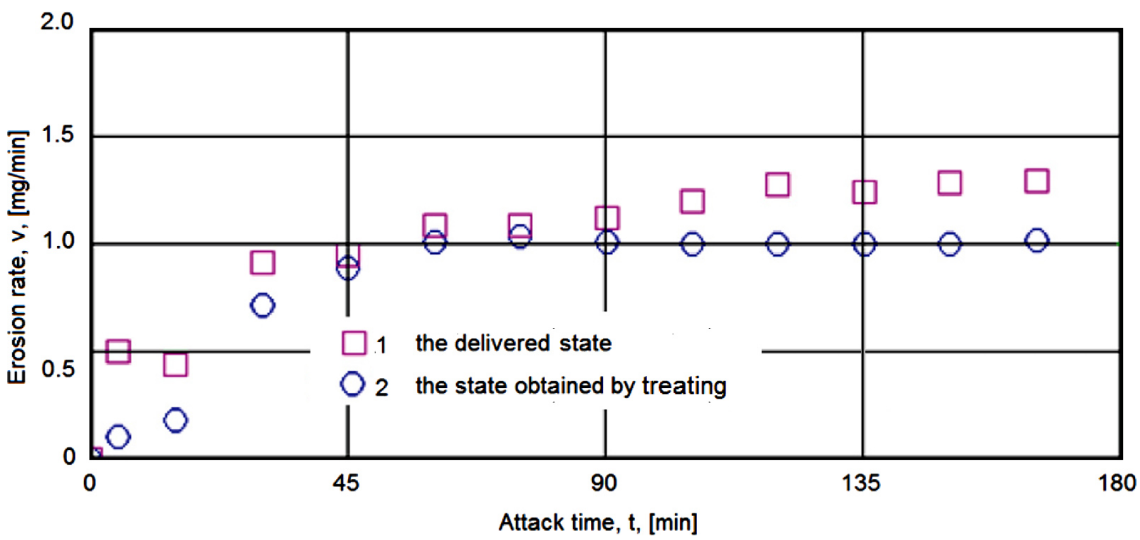


Figure 2. Variation of erosion rate with the duration of the cavitation attack

So, the percentage increase in cavitation resistance, resulting from by quenching and tempering treatment, is about 23%.

## 4. Conclusions

Following research carried, we can say that the mean durability parameter ($\delta_{med}$), defined by K. Steller, provides clues, about the material resistance to the cavitation erosion, similar with those resulting from the comparison of specific curves, recommended by ASTM G32 standards.

Volumetric heat treatmen (quenching and tempering treatment) is a solution for the pieces requested to cavitation, such as ship's propellers or body and plugs valves, made of CuSn bronze.

## References


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