

## Comparative Analysis of the State of Resistance to Cavitation Erosion of Alloy 2017A Compared to Aluminum Alloys Type 5083, Type 6082 and Type 7075

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**Abstract:** *Surface erosion, by solid particles, or by the hydrodynamics of the cavitation phenomenon, reduces the service life and energy performance of parts such as turbine rotors, pumps, and steam propellers. In order to reduce the costs of using materials currently used in such parts, such as stainless steels and high-strength alloy bronzes, current research aims to use materials such as aluminum and its alloys, considered to have poor resistance to erosive stresses, especially cavitation. For this objective, volumetric heat treatments and surface structure hardening treatments were used, so that the resistance is one that, in relation to costs, offers advantage and confidence. Our work also falls into this direction, which highlights the effect of volumetric heat treatments, artificial aging, on the resistance to vibratory cavitation of three types of alloys 5083, 6082 and 7075. The evaluation carried out by comparing the reference parameters (erosion depth, cavitation resistance) and by morphological analysis of the structure eroded by cavitation, results that the resistance of the structure to the impact with shock waves and cavitation microjets, is dependent on the parameters of the heat treatment regime, through the resulting mechanical properties and microstructure.*

**Keywords:** *Cavitation erosion, maximum erosion depth, cavitation resistance, microstructure, aluminum alloy, artificial aging heat treatment*

### 1. Introduction

The use of aluminum alloys has become of interest to designers and manufacturers of parts that work in cavitation currents, such as motorboat propellers, pump rotors in automotive cooling systems...and beyond, after research conducted on structures resulting from various heat treatments [1-7], or hardened using laser beam remelting methods [8-9], showed increased resistance to erosive cavitation stresses. Another argument for expanding the applications of aluminum alloys, to parts with important mechanical and hydrodynamic stresses, is the fact that through new technologies of volumetric heat treatment, or surface hardening, the mechanical properties (mechanical strength and elongation at break, yield strength, hardness, resilience) acquire values comparable to those of unalloyed and low-alloyed carbon steels [11-13]. The present study is part of this line of research aimed at the use of alloys in various parts subjected to cavitation and It is intended to be a critical analysis of two specific aspects encountered in aluminum alloys in general, and precipitation-hardenable aluminum alloys in particular:

- Identifying possibilities for improving the mechanical characteristics of precipitation-hardenable aluminum alloys by applying various artificial aging heat treatments;
- Identification of the possible link between the mechanical characteristics and the cavitation erosion behavior of aluminum alloys in general, and precipitation-hardenable aluminum alloys in particular.

To achieve the proposed objectives, the 5083 alloy was analyzed, in two states (cast and rolled), to which different heat treatments were applied, as well as the precipitation-hardenable aluminum alloys, from the 6xxx and 7xxx series, respectively the 6082 aluminum alloy, T651 state and the 7075 aluminum alloy, T 651 state, whose behavior was compared with that of aluminum alloy 2017A, state T451. The comparison was made on states that constituted the working materials of the research team led by Prof. Brândușa Ghiban and Prof. Ilare Bordeasă, using similar investigation methods.

## 2. Research material and methodology

The aluminum alloy samples were taken from 30mm thick sheet metal, from COLOR METALS SRL, having the chemical composition indicated in table 3.1. The chemical composition of the metallic material was determined by spectral analysis. For the experimental investigations of this work, the following specimens were used:

- Alloy 2017A in rolled condition, T451 condition, respectively solutioning at 504°C, holding for 3-4 hours, with cooling in water, followed by natural aging at room temperature (20-25) °C for a minimum of (5-6) days.
- Alloy 5083cast condition, as well as rolled condition H111 (respectively solution hardening from 454 °C to 399 °C and aging (annealing at 343 °C, followed by cooling in air)
- Alloy 6082status T651(respectively hardening of solution annealing at 525°C, holding for 4 hours, with cooling in water, followed by artificial aging at 175°C for 8 hours),
- Alloy 7075, T 651 condition(respectively hardening of solution at 525°C, holding for 4 hours, with cooling in water, followed by artificial aging at 175°C for 8 hours).

**Table 1:** Chemical composition of experimental samples

Alloy	Chemical composition, %wt										
	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Zr	Pb	Al
Experimental 2017A	0.68	0.3	0.09	0.62	0.86	0.17	0.088	0.2	0.023	0.15	rest
EN AW-2017A	0.4	0.5	0.1	0.4-1.0	0.6-1.2	0.18-0.28	0.2	0.2	-	-	rest
Experimental 5083	0.41	0.29	0.106	0.52	4.21	0.12	0.16	0.028	-	-	rest
EN AW-5083 SR EN 573-3	Max 0.40	Max 0.40	Max 0.10	0.4-1.0	4.0-4.9	0.05-0.25	Max 0.25	Max 0.15	-	-	rest
Experimental 6082	0.8	0.3	0.09	0.62	0.86	0.17	0.088	0.1	0.023	0.15	rest
EN AW-6082	0.7-1.3	≤0.5	≤0.1	0.4-1.0	0.6-1.2	≤0.25	≤0.2	≤0.2	-	-	rest
Experimental 7075	0.68	0.107	1.58	0.076	2.05	0.19	5.76	0.2	0.023	0.15	rest
En-aw-7075	0.4	0.5	1.2-2.0	0.3	2.1-2.9	0.18-0.28	5.1-6.1	0.2	-	-	rest

Specific aging heat treatments were applied to each type of alloy, as follows:

- Alloy 2017 was subjected to various artificial aging heat treatments at 120°C, 140°C and 190°C, with holding times at each temperature of 1 hour, 12 hours and 24 hours, respectively.
- For alloy 5083, homogenization treatments were applied to the as-cast specimens at: 350°C / air/ followed by artificial aging at 180°C / 1h, 12h, 24h; 450°C / air / followed by followed by artificial aging at 140°C / 1h, 12h, 24h; 450°C / air / followed by followed by artificial aging at 180°C / 1h, 12h, 24h. Homogenization treatments were applied to the samples in the rolled state at: 450°C /air/ followed by artificial aging at 140°C / 1h, 12h, 24h; 450°C /air/ followed by artificial aging at 180°C / 1h, 12h, 24h.
- For alloy 6082 in T651 condition, artificial aging heat treatments were performed at 190°C, 160°C, 140°C, each with holding times of 1 hour, 12 hours and 24 hours respectively, as well as specimens covered with TIG welding.
- The 7075A alloy in the as-cast condition underwent artificial aging heat treatments at 160°C, with holding times of 1 hour, 12 hours and, respectively, 24 hours. On the experimental specimens in the laminated state, artificial aging heat treatments were performed on experimental samples with dimensions of 10x10x50 (mm) as follows: aging at 140°C, with three holding periods, 1 hour, 12 hours and 24 hours; artificial aging at 180°C, with three holding periods, 1 hour, 12 hours and 24 hours.

The heat treatments were performed in a Nabertherm furnace at the Laboratory of Metallic Materials Science and the Physical Metallurgy Section of the Politehnica University of Science and Technology in Bucharest. Each type of heat treatment was tested six times to evaluate the mechanical properties: tensile strength, yield strength, elongation, toughness, hardness and microhardness. The grain size was determined according to ASTM E3, ASTM E407, ASTM E112 standards, using Barker electrolytic reagent with a power of x100. Structural analyses were performed with an OLYMPUS microscope. Resistance tests to hydrodynamic stresses caused by cavitation were carried out in the Cavitation Erosion Research Laboratory at Politehnica University Timișoara, using standard vibrating equipment with piezoceramic crystals [14]. Due to the low sample weight (maximum 8 g, compared to the required weight of 15.8...16.6 g for the vibrating sample test), this test was performed with a stationary sample. The experimental program was managed by a computer with software that ensured precise control of the functional parameters, including the power of the ultrasound generator (500 W), the amplitude (50 μm) and the vibration frequency (20,000 ± 3% Hz), with a liquid temperature of 22 ± 1 °C, to maintain constant hydrodynamic cavitation intensity throughout the experiment.

### 3. Experimental results and their interpretation

#### 3.1. Comparative analysis of the parameters maximum penetration depth and cavitation resistance

The analysis of the differences in resistance to erosion generated by vibratory cavitation is performed based on histograms containing the values of the reference parameters recommended by ASTM G32-2016 standards [15] and used in laboratory practice [10-13]: the average value of the maximum erosion depth after 165 minutes of cavitation,  $MDE_{max}$ , and the cavitation resistance  $R_{cav}$ .

Since the analysis uses states resulting from the application of artificial aging thermal treatments with various regimes, the meaning of the notations on the abscissas shows the temperature of the thermal treatment and the holding time. Since for all thermal treatment regimes the cooling was done in air, this mention was not made in the notation.

The 5083 aluminum alloy is part of the 5xxx series, having Mg as the main alloying element, and is considered a non-hardenable alloy by heat treatment. In his work, Istrate D. [10] performed a combination of heat treatments, namely 350°C/100 min + 180°C/ (1h, 12h, 24h), 450°C/100 min +140°C/ (1h, 12h, 24h) and 450°C/100 min +180°C/ (1h, 12h, 24h). The analysis of the data in fig.1 shows that the best cavitation resistance is for the as-cast samples subjected to the combined treatment 350°C/100min + 180°C / (1h, 12h, 24h), with a cavitation resistance of 9.9 min/μm, more than 3 times the resistance of the control sample, and the lowest cavitation resistance is for the non-thermally treated samples. The combination of thermal treatments 450°C/100 min +140°C/

(1h, 12h, 24h) and 450°C/100 min +180°C/ (1h, 12h, 24h) does not produce a considerable improvement in cavitation resistance. The calculated average penetration depths of cavitation erosion (fig.2) are about 40 μm for the control sample and for the samples treated at 350°C/100 min + 180°C / (1h, 12h, 24h), while the average penetration depths of the combination of thermal treatments 450°C/100 min +140°C/ (1h, 12h, 24h) and 450°C/100 min +180°C/ (1h, 12h, 24h) are about 30-52 μm.

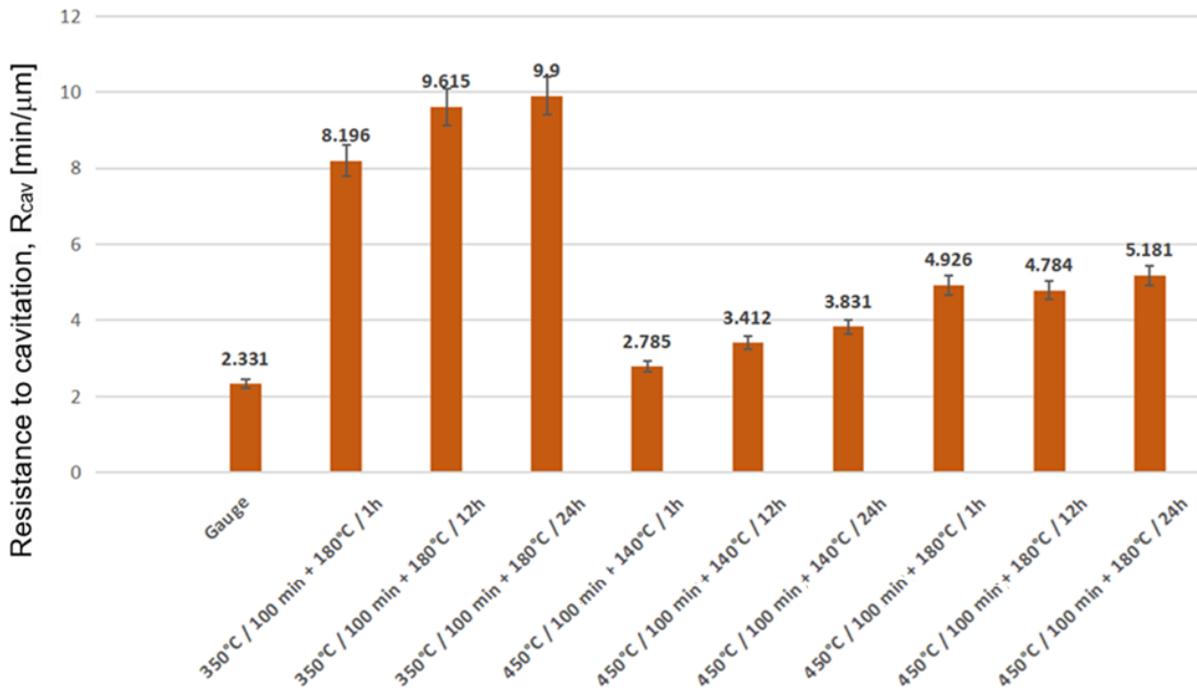


Fig. 1. Histogram comparing cavitation resistances of alloy 5083, cast and different structural states (after [10])

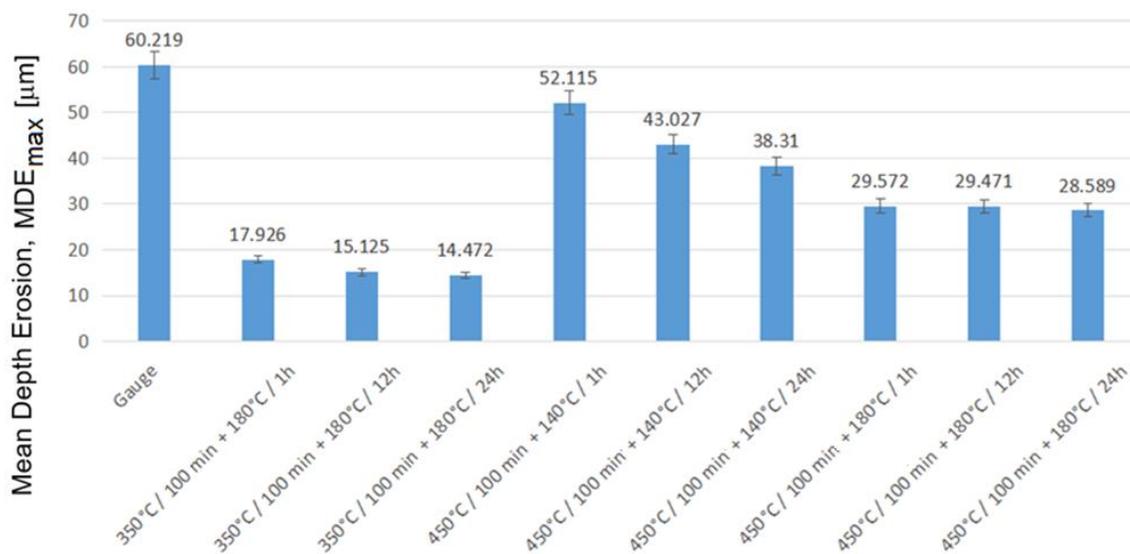


Fig. 2. Histogram of comparison of erosion depths of alloy 5083, cast and different structural states (after [10])

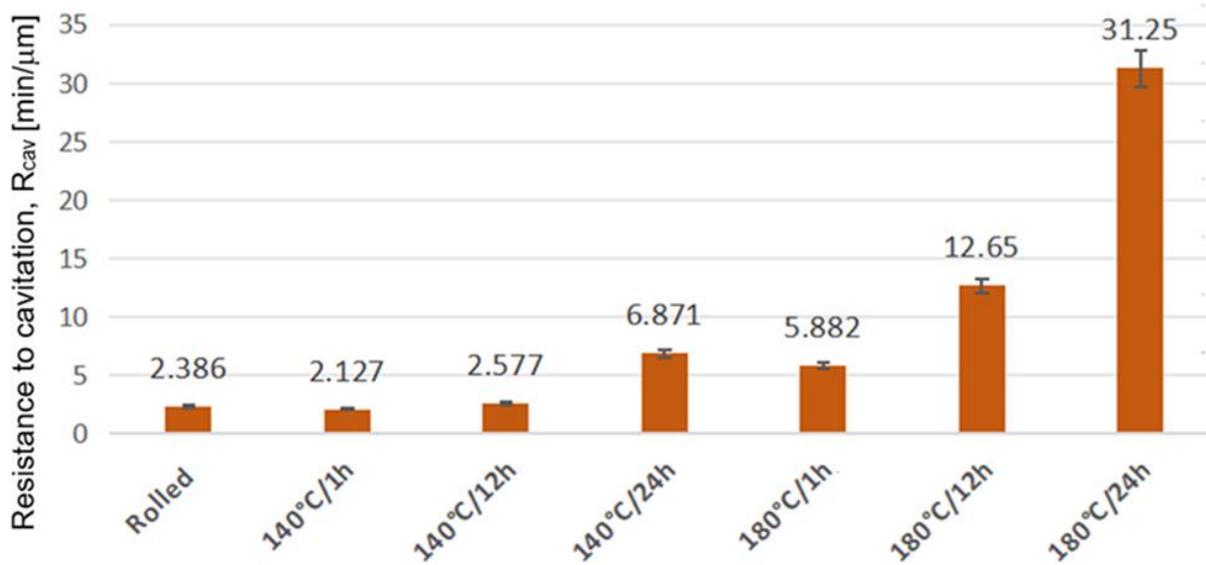


Fig. 3. Histogram comparing the cavitation resistances of alloy 5083, rolled and different structural states (after [10])

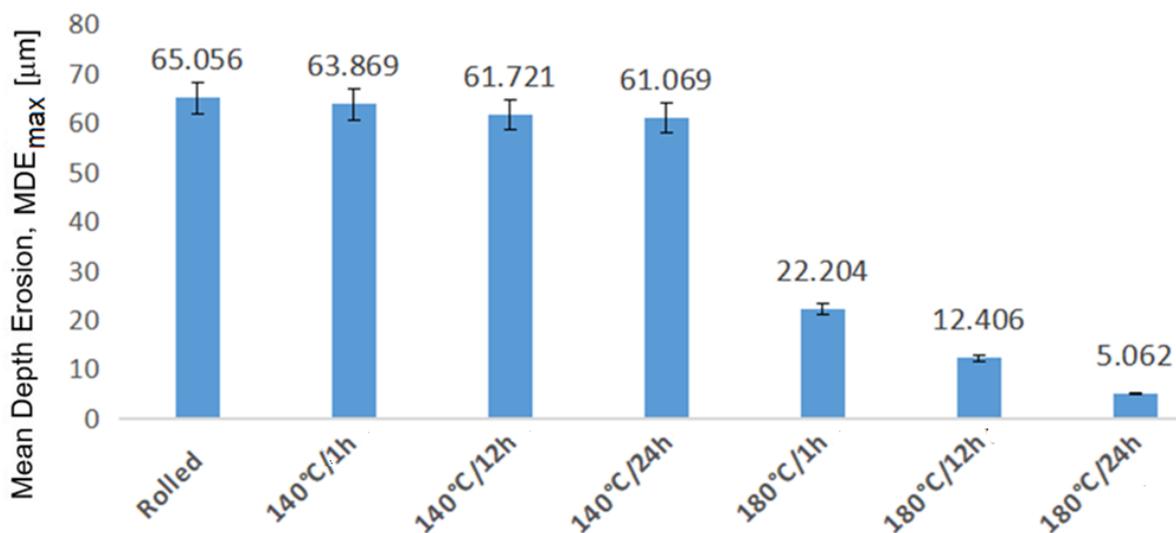


Fig. 4. Histogram of comparison of erosion depths of alloy 5083, rolled and different structural states (after [10])

In the case of samples of alloy 5083 in the rolled state, it is noted that the application of different heat treatments has a significant effect on the cavitation resistance, the highest cavitation resistance being in the samples subjected to the 180°C/24h heat treatment, over 12 times higher than the non-heat-treated sample (fig. 3). Also, the application of heat treatments at 180°C/1h, 12h can lead to a considerable improvement in the cavitation resistance, respectively 6-12 min/ $\mu\text{m}$ , compared to 2.4 min/ $\mu\text{m}$  (fig. 3). Regarding the calculated penetration depths of cavitation erosion, they are about 5-22  $\mu\text{m}$  for samples treated at 180°C /1h, 12h, 24h, compared to that of the non-thermally treated sample, respectively 65  $\mu\text{m}$  (fig. 4).

**Aluminum alloy type 6082**, state T651 is part of the 6xxx series, having as main alloying elements Mg and Si, the hardening phases being  $\text{Mg}_2\text{Si}$  and  $\alpha\text{-AlFeSi}$ . In his work, Demian [12] performed aging heat treatments at 140°C, 160°C and 190°C, at each temperature with holding times of 1h, 12h and 24h. Through the histograms in fig. 5 and fig. 6. The differences in resistance to the hydrodynamic stresses of vibratory cavitation are shown, which the 11 researched states had, in which the symbolization (notation) is simplified: by temperature and holding time, respectively by TIG for the remelting regime.

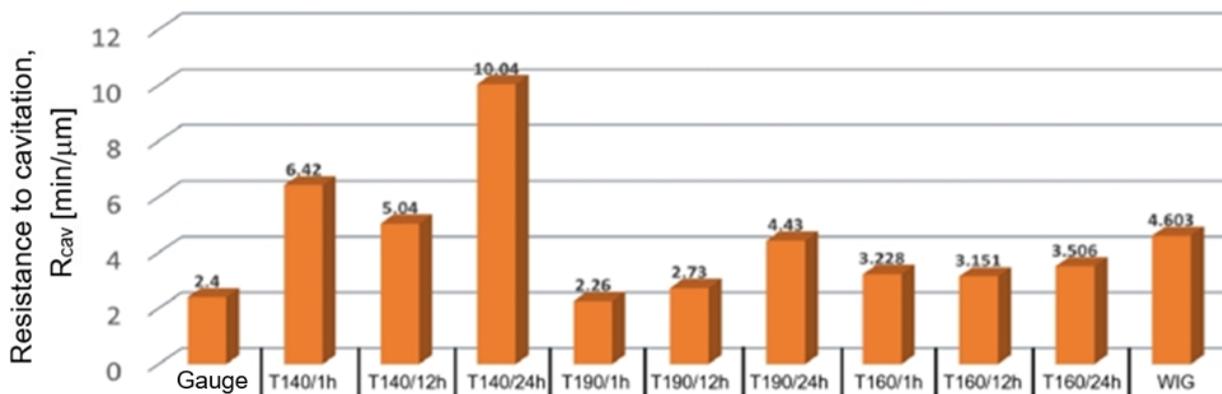


Fig. 5. Histogram comparing cavitation resistances of alloy 6082, rolled and different structural states [12]

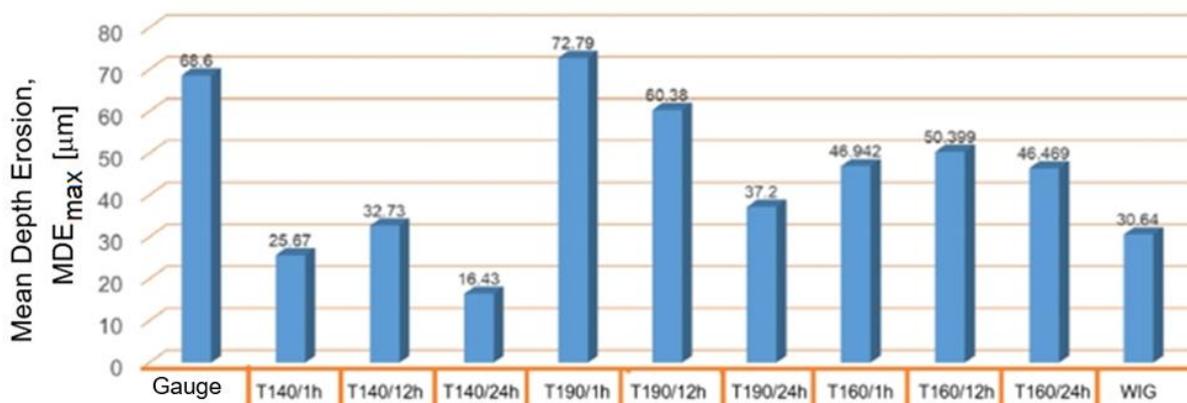


Fig. 6. Histogram comparing erosion depths of alloy 6082, rolled and different structural states [12]

The analysis of the data in fig. 5 shows that the highest cavitation resistance is conferred by aging treatment at 140°C/24 h, respectively the cavitation resistance can increase almost 5 times. Increases in cavitation resistance are also obtained after applying other aging treatments, either at 160°C or at 190°C, but not to the same extent as after 140°C.

The analysis of the data regarding the dependence of the average erosion depth on the structure's resistance to cavitation erosion, presented in fig. 6, shows that the higher the cavitation resistance, the smaller the area of erosion produced in the attacked surface, respectively the smaller the cavern dimensions. The data are correlated, so that the smallest depths are at 140°C/24 hours, and the largest depths are at 190°C/1h.

**Aluminum alloy type 7075**, is part of the 7xxx series, having as main alloying elements Zn, Mg and Cu, the hardening phases being  $Mg_5Al_8$ ,  $MgZn_2$ ,  $Mg_2Si$ , and  $(Fe,Cr)_3SiAl_2$ . In his work, Odagiu [13] compares two states of the alloy, respectively cast and rolled T651, applying different aging heat treatments to each state. Thus, in the cast state, 160°C/ (1h, 12h, 24h), and in the T651 laminated state, aging heat treatments were applied, respectively 120°C/ (1h, 12h, 24h) and 140°C/ (1h, 12h, 24h). The analysis of the data in fig. 7 shows that the highest cavitation resistance is in the aged state only in the cast state, the aging treatment at 160°C/ (1h, 12h, 24h) bringing insignificant improvements, and the lowest cavitation resistance is in the rolled states, in which the aging treatments even diminish this resistance. The data in fig. 8 are in correlation with those in fig. 7, that is, the lowest average depth of cavitation erosion is that corresponding to the cast and aged state at 160°C/ (1h, 12h, 24h). It is worth noting that the strength state of the 7075 alloy is very low. Also, the average depths of cavitation error are about 40 $\mu$ m for the as-cast states, and in the range of 6-16  $\mu$ m for the rolled and aged states.

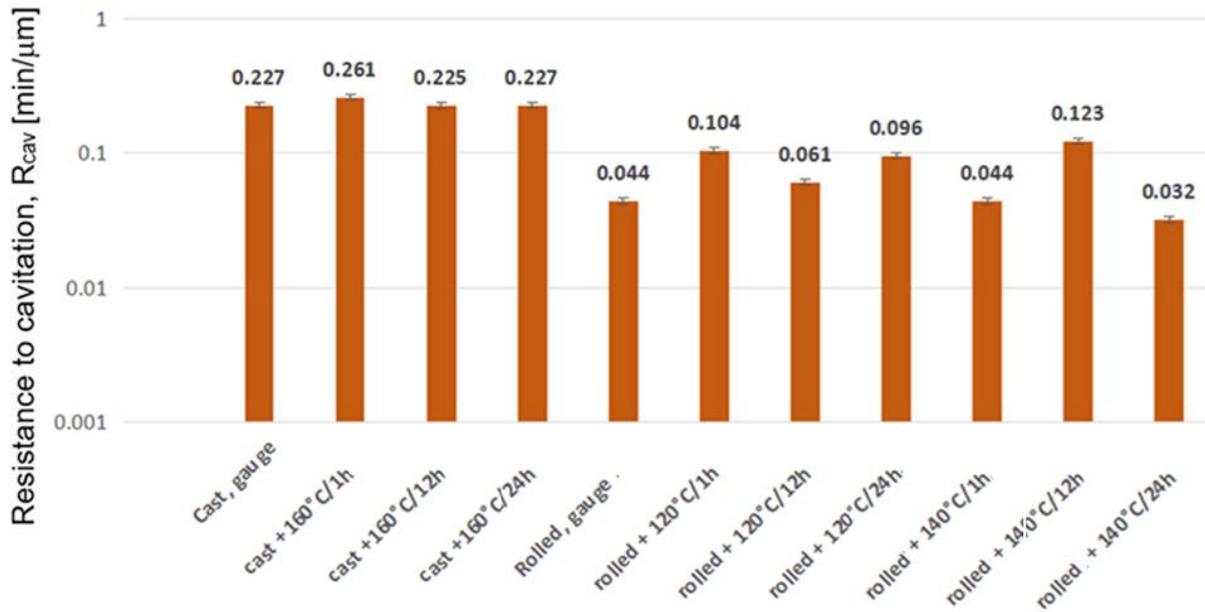


Fig. 7. Histogram comparing the cavitation resistances of alloy 7075, cast/rooled and different structural states (after [13])

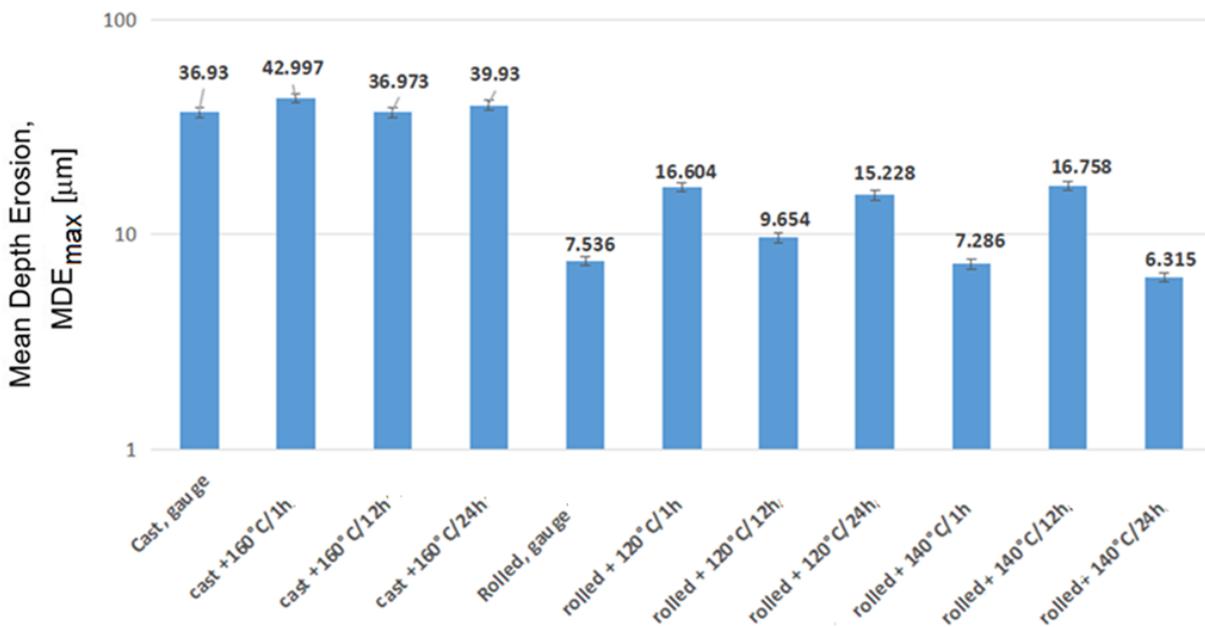


Fig. 8. Histogram of comparison of erosion depths of alloy 7075, cast/rolled and different structural states (after [13])

Regarding the cavitation test parameters of the 7075 alloy samples in the rolled state, it is noted that they show a much higher cavitation resistance than in the rolled state, the values increasing by over 100 times (fig. 9). At the same time, it can be observed that a thermal aging treatment at 140°C/24h leads to an improvement in cavitation resistance, respectively 31.25 min/ $\mu\text{m}$ , compared to 23.72 min/ $\mu\text{m}$  for the untreated sample (fig. 9), the other thermal aging treatments reduce the cavitation resistance. Regarding the calculated cavitation erosion penetration depths, these are reduced, respectively 6.3  $\mu\text{m}$  for 140°C/24h, compared to 7.53  $\mu\text{m}$  for the untreated sample (fig. 10), while for the other thermal aging treatments these are in the value range 7.2-16.6  $\mu\text{m}$ .

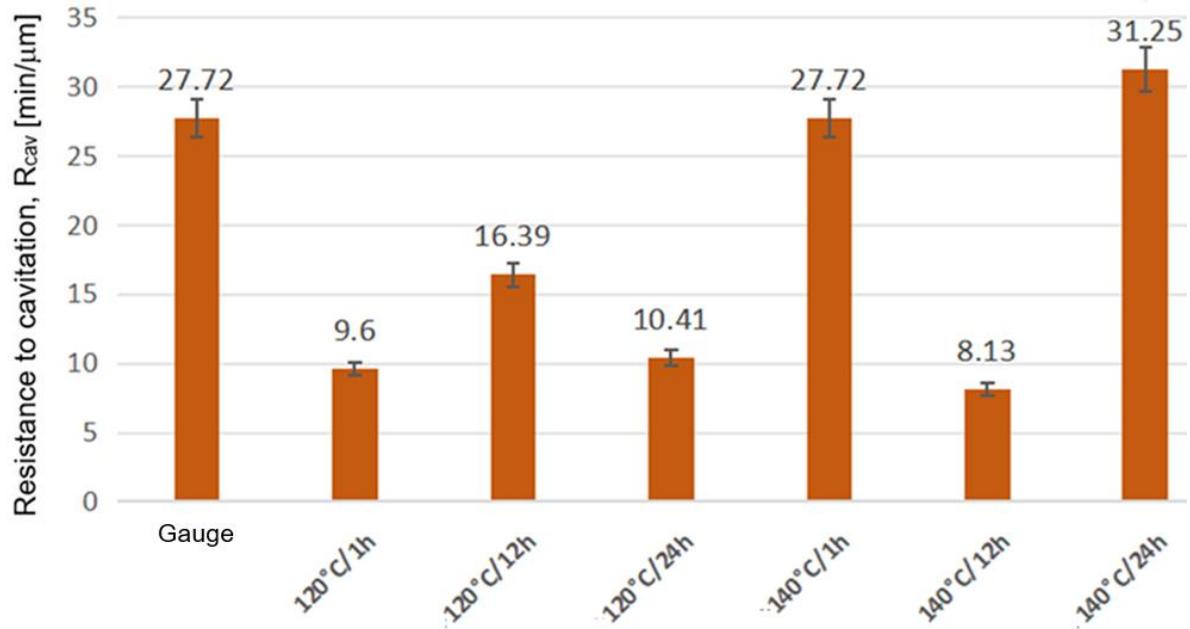


Fig. 9. Histogram comparing the cavitation resistances of alloy 7075, rolled and different structural states (after [13])

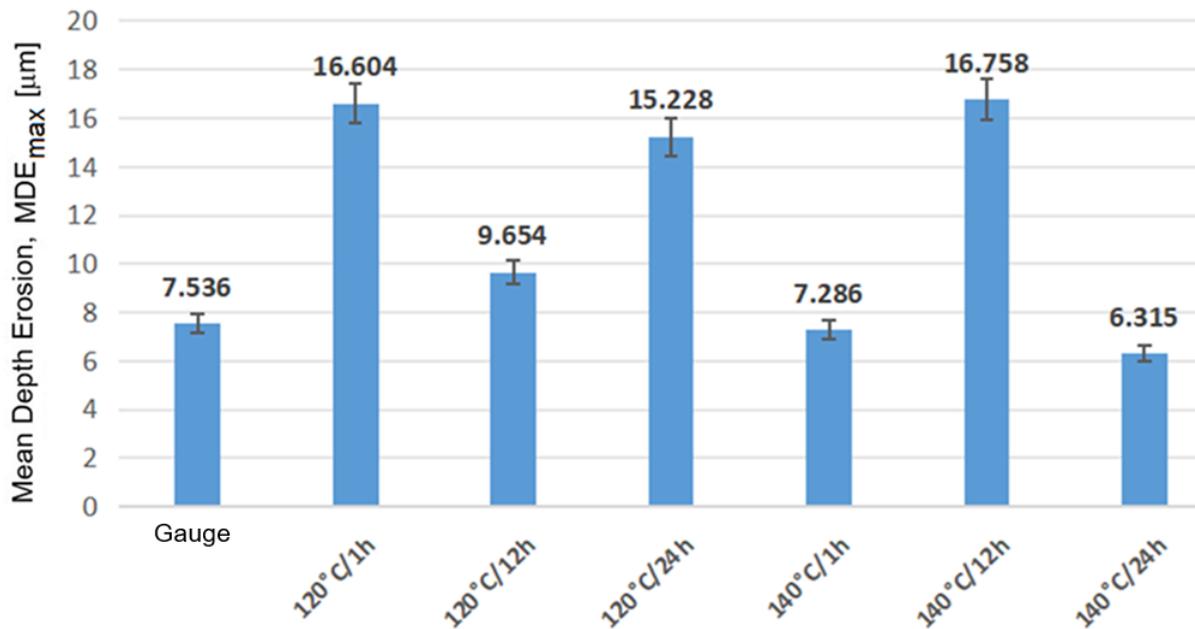


Fig. 10. Histogram of comparison of erosion depths of alloy 7075, rolled and different structural states (after [13])

The comparative analysis of the cavitation erosion resistance of alloy 2017A compared to that of alloys 5083, 6082 and 7075 allowed the creation of the histograms in fig. 11 and fig. 12 from which the following remarks can be made:

- The 2017 aluminum alloy, T451 condition and heat-treated for aging at 120°C/1h has the highest cavitation resistance among the alloys taken for comparison, respectively 16.03 min/ $\mu\text{m}$ , compared to the 7075 alloy with the lowest cavitation resistance, respectively 0.261min/ $\mu$ .
- Alloy 2017A has an average penetration depth of about 22 $\mu\text{m}$ , having an intermediate value compared to that of alloy 5083 with the lowest average depth value of about 14 $\mu\text{m}$ .

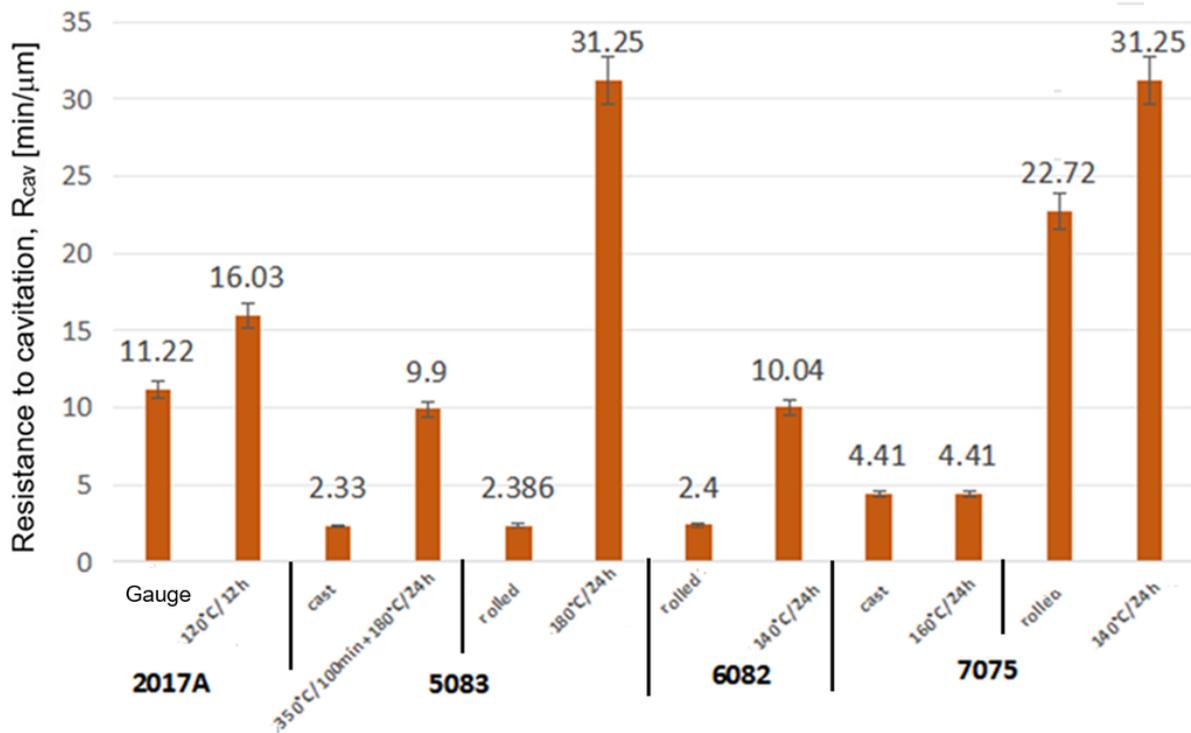


Fig. 11. Histogram comparing the cavitation resistances of alloy 2017A, compared to alloys 5083, 6082 and 7075, control and heat-treated samples

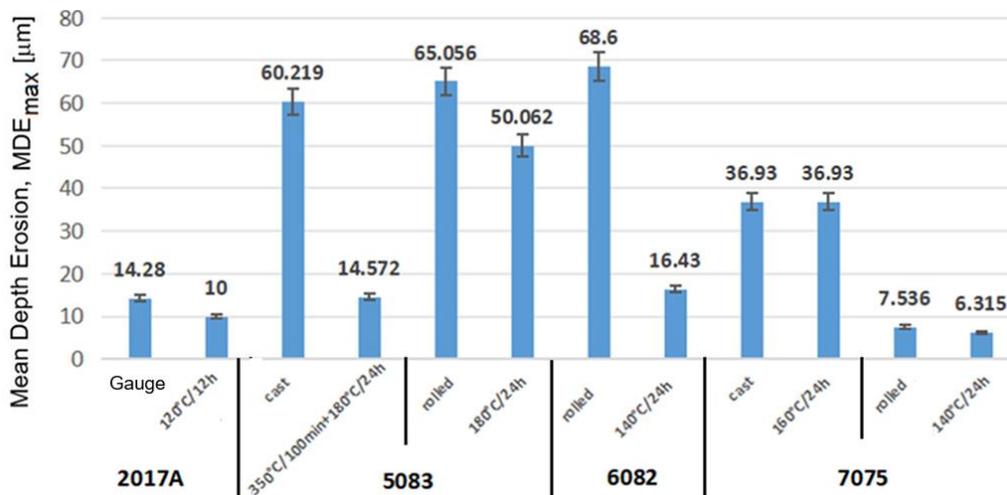


Fig. 12. Histogram comparing erosion depths of alloy 2017A, compared to alloys 5083, 6082 and 7075, control and heat treated samples

Thus, a hierarchy of cavitation resistance can be made within the different series of aluminum alloys, namely:

$$R_{cav}(7075) > R_{cav}(5083) > R_{cav}(2017A) > R_{cav}(6082) \tag{1}$$

and also a hierarchy of calculated penetration depths of cavitation erosion, within the different series of aluminum alloys, as follows:

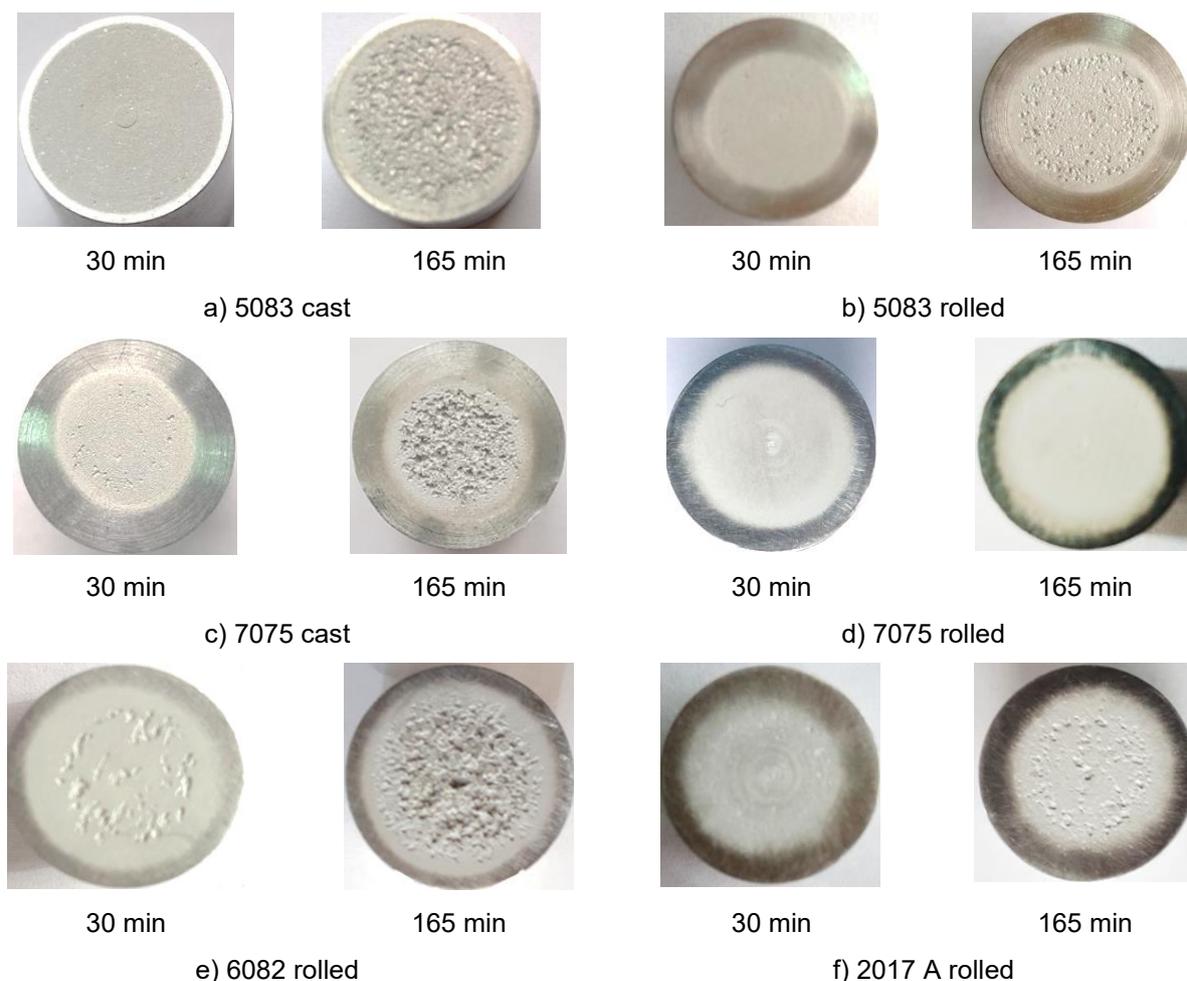
$$\delta(5083) > \delta(6082) > \delta(2017A) > \delta(7075) \tag{2}$$

### 3.2 Comparative analysis of the morphology of surfaces tested for cavitation erosion

The cavitation phenomenon encountered in the investigated aluminum alloys is specific to all samples, regardless of the state of the material (control or heat treated). Thus, in the first 15...30 minutes of vibratory cavitation, it respects its specific erosive mechanism through which, in the attacked surface, more elasto-plastic deformations and crack networks are produced and the peaks of roughness and abrasive dust are eliminated [16, 17]. The expulsions of material, with the creation of pitting, are significantly reduced in the mass values recorded by weighing. For this reason, the appearance of the surface looks like a polished/matt one. In the following time intervals, depending on the state of the material, massive expulsions of material occur, leaving large, interconnected cavitations [18-19].

A careful analysis of the propagation of the fracture front through cavitation erosion in the studied aluminum alloys shows that the surfaces subjected to erosion comprise two specific zones, namely an area that is affected by cavitation, with a larger diameter and a concentric zone, inside which suffers a strong erosion phenomenon [20, 21]. This fact is found in all the studied aluminum alloys, the proportion of these zones being influenced by the state of the material, respectively by the aging heat treatment.

To understand the morphological analysis and the evolution of the destruction of the attacked surface, in fig. 13, macro (photographic) images of the eroded surface are presented, taken with the Canon Power Shot A 480 camera, only for the semi-finished states (states without heat treatment) of the 4 types of alloys after 30 minutes and 165 minutes of cavitation.



**Fig. 13.** Images of surface structure degradation by erosion of cavitation vibratory

In the case of alloy 5083, the structural destruction occurring during the cavitation test is generated by the dislocation of Mg5Al8 particles which does not cause significant hardening, leaving the

surface eroded, with numerous secondary cracks. The application of the combination of heat treatments can reduce the maximum cavitation penetration depths, up to about 14  $\mu\text{m}$  to 350°C/100 min + 180°C/24h, in as-cast condition. In the case of rolled samples, regardless of the type of treatments applied erosion manifests itself profoundly by increasing the number and geometric dimensions of pits and caverns.

In the case of alloy 6082, the cavity surfaces are similar to any hardening treatment, with faceted cavities, with propagation of the fracture front in steps, by cleavage, specific to precipitation hardened materials. If in the control sample the total surface affected by the cavitation attack is 85%, it can reach 80% in the heat treated samples, and the surface most affected by the cavitation attack in the control sample is 74% reaching 66% in the aged samples.

In alloy 7075, the cavities are quite large, angular, which are generated by hardening compounds based on (Mg, Mn, Cu). The cavities are coalescent, interconnected, leaving the surface extremely rough after degradation by cavitation erosion. In the as-cast specimens, the control specimen has the largest eroded surfaces, respectively about 68% and 54%, while in the treated specimens these surfaces are 69% and 57%. In the rolled specimens, the proportion of surfaces affected by erosion is different: in the control specimens it is about 80%, reaching 91% in the heat-treated specimens, while the surface most affected by erosion in the control specimen is about 70%, reaching 82% in the heat-treated specimens.

As a general conclusion, the 2017A alloy with or without improvement treatments has a cavitation resistance intermediate to the analyzed aluminum alloys, respectively 7075, 6082 and 5083 and, therefore, a calculated penetration depth intermediate to the alloys considered. It can also be appreciated that the cavitation resistance values of these aluminum alloys are very low compared to those of other classes of metallic materials (stainless steels, INCONEL superalloys, etc. [22-24]), being part of the category of metallic materials not resistant to cavitation erosion.

As a general conclusion, the 2017A alloy with or without improvement treatments has a cavitation resistance intermediate to the analyzed aluminum alloys, respectively 7075, 6082 and 5083 and, therefore, a calculated penetration depth intermediate to the alloys considered. It can also be appreciated that the cavitation resistance values of these aluminum alloys are very low compared to those of other classes of metallic materials (stainless steels, INCONEL superalloys, etc. [22-24]), being part of the category of metallic materials not resistant to cavitation erosion.

#### 4. Conclusions

This paper makes a critical analysis of the comparison of the cavitation resistance of the 2017A aluminum alloy with other aluminum alloys, namely 5083, 6082 or 7075. The analysis allows the formulation of the following conclusions:

1. Alloy 2017A with or without improvement treatments has a cavitation resistance intermediate to the analyzed aluminum alloys, namely 7075, 6082 and 5083 and, therefore, a calculated penetration depth intermediate to the alloys considered. It can also be appreciated that the cavitation resistance values of these aluminum alloys are very low compared to those of other classes of metallic materials (stainless steels, INCONEL superalloys), being part of the category of metallic materials not resistant to cavitation erosion.
2. A possible hierarchy of cavitation resistance within different series of aluminum alloys could be:  $R_{\text{cav}}(7075) > R_{\text{cav}}(5083) > R_{\text{cav}}(2017A) > R_{\text{cav}}(6082)$ .
3. A possible hierarchy of calculated penetration depths of cavitation erosion, within different series of aluminum alloys, can be:  $\delta(5083) > \delta(6082) > \delta(2017A) > \delta(7075)$ .

#### References

- [1] Bordeasu, Ilare, Cristian Ghera, Cornelia Laura Salcianu, Alexandru-Nicolae Luca, and Robert Stefan Parmanche. "On the Influence of Mechanical Properties of Aluminum Alloys on Their Resistance to Cavitation Erosion". Paper presented at the 13th International Conference on Applied Sciences (ICAS2025), Hunedoara, Romania, May 29-31, 2025. *Journal of Physics: Conference Series* 3153 (2025): 012001.
- [2] Istrate, Dionisie, Beatrice-Gabriela Sbarcea, Alin Mihai Demian, Andreea Daniela Buzatu, Laura Salcianu, Ilare Bordeasu, Lavinia Madalina Micu, Cristian Ghera, Bogdan Florea, and Brandusa Ghiban.

- “Correlation between Mechanical Properties—Structural Characteristics and Cavitation Resistance of Cast Aluminum Alloy type 5083”. *Crystals* 12, no. 11 (2022): 1538.
- [3] Istrate, Dionisie, Ilare Bordeasu, Brandusa Ghiban, Bogdan Istrate, Beatrice-Gabriela Sbarcea, Cristian Ghera, Alexandru-Nicolae Luca, Petrisor Ovidiu Odagiu, Bogdan Florea, and Dinu Gubencu. “Correlation between Mechanical Properties-Structural Characteristics and Cavitation Resistance of Rolled Aluminum Alloy Type 5083”. *Metals* 13, no. 6 (2023): 1967.
- [4] Bordeasu, Ilare, Brandusa Ghiban, Lavinia Madalina Micu, Alexandru-Nicolae Luca, Alin-Mihai Demian, and Dionisie Istrate. “The Influence of Heat Aging Treatments on the Cavitation Erosion Behavior of a Type 6082 Aluminum Alloy”. *Materials* 16, no. 17 (2023): 5875.
- [5] Bordeasu, I., C. Ghera, D. Istrate, Laura Salcianu, Brandusa Ghiban, Dumitru-Viorel Bazavan, Lavinia-Madalina Micu, Daniel-Catalin Stroita, A. Suta, I. Tomoiaga, and Alexandru-Nicolae Luca. “Resistance and behavior to cavitation erosion of semi-finished aluminum alloy 5083”. *Hidraulica Magazine*, no. 4 (2021): 17–24.
- [6] Bordeasu, Ilare, Brandusa Ghiban, Lavinia Madalina Micu, Alexandru-Nicolae Luca, Alin-Mihai Demian, and Dionisie Istrate. “The influence of heat aging treatments on the cavitation erosion behavior of a type 6082 aluminum alloy”. *Materials* 16, no. 17 (2023): 5875.
- [7] Luca, Alexandru-Nicolae, Ilare Bordeasu, Brandusa Ghiban, Cristian Ghera, Dionisie Istrate, and Daniel-Catalin Stroita. “Modification of the cavitation resistance by hardening heat treatment at 450 °C followed by artificial aging at 180°C of aluminum alloy 5083 compared to the state of cast semi-finished product”. *Hidraulica Magazine*, no. 1 (2022): 39-45.
- [8] Ghera, Cristian, Ilare Bordeasu, Alexandru-Nicolae Luca, Cornelia-Laura Salcianu, Brandusa Ghiban, Ovidiu Odagiu, Alin-Nicuser Sirbu, and Rodica Badarau. “Increasing the resistance to cavitation erosion of 6082 aluminum alloys through thermal aging treatments at 140 °C and holding time of 12 hours”. *Solid State Phenomena* 349 (2023): 62–70.
- [9] Mitelea, Ion, Ilare Bordeasu, Florin Frant, and Ion-Drăgăș Utu. “Effect of heat treatment on corrosion and ultrasonic cavitation erosion resistance of AlSi10MnMg alloy”. *Materials testing* 62, no. 9 (2020): 921-926.
- [10] Istrate, Dionisie. *Heat Treatments Influence on the Performance of an Alloy From Al-Mg System for Marine Applications / Influența tratamentelor termice asupra comportării unui aliaj din sistemul Al-Mg pentru aplicații maritime*. Doctoral thesis. Politehnica University of Bucharest, Romania, 2023.
- [11] Luca, Alexandru-Nicolae. *Research on the resistance to cavitation erosion of some aluminum-based alloys with artificial aging heat treatment / Cercetarea rezistenței la eroziunea prin cavitație a unor aliaje cu bază de aluminiu cu tratament termic de îmbătrânire artificială*. Doctoral thesis. Politehnica University of Timișoara, Romania, 2024.
- [12] Demian, Alin Mihai. *Research on the cavitation erosion behavior of aluminum alloy type 6082 in correlation with different structural states / Cercetări privind comportamentul la eroziune prin cavitație al aliajului de aluminiu tip 6082 în corelație cu diferite stări structurale*. Doctoral thesis. National University of Science and Technology Politehnica Bucharest, 2026.
- [13] Odagiu, Petrișor Ovidiu. *Studies and Experimental Research on Mechanical Behavior and Cavitation Erosion Behavior of an Aluminum Alloy Type 7075 / Studii și cercetări experimentale privind comportarea mecanică și comportarea la eroziunea cavitațională a unui aliaj de aluminiu din seria 7075*. Doctoral thesis. Politehnica University of Bucharest, 2023.
- [14] Bordeasu, Ilare. *Monograph of the Cavitation Erosion Research Laboratory of Politehnica University Timișoara (1960–2020) / Monografia Laboratorului de Cercetare a Eroziunii Cavitaționale al Universității Politehnica Timișoara (1960–2020)*. Politehnica Publishing House, Timișoara, 2020 (in Romanian).
- [15] \*\*\*. *Standard Method of Vibratory Cavitation Erosion Test*. ASTM G-32: West Conshohocken, PE, USA, 2016.
- [16] Ahmed, Shemy Mohamed, Kazuo Hokkirigawa, Risaburo Oba, and Yasuaki Matsudaira. “Developing stages of ultrasonically produced cavitation erosion and corresponding surface roughness”. *JSME Int. J. Ser. 2 Fluids Eng. Heat Transfer Power Fuel. Thermophys. Prop.* 33, no. 1 (1990): 11–16.
- [17] Chiu, K-Y, F-T Cheng, and H-C. Man. “Evolution of surface roughness of some metallic materials in cavitation erosion.” *Ultrasonics* 43 (2005): 713–716.
- [18] Zasada, Dariusz, Judyta Anna Sienkiewicz, and Robert Jasionowski. “Grain size influences the corrosion and cavitation of Ni<sub>3</sub>Al intermetallic alloys”. *Metallurgija* 54 (2015): 47–50.
- [19] Franc, Jean-Pierre, Francois Avellan, Brahim Belahadji, Jean-Yves Billard, Laurence Briançon-Marjollet, Didier Fréchou, Daniel H. Fruman, Ayat Karimi, Jean-Luis Kueny, and Jean-Marie Michel. *Cavitation: Physical Mechanisms and Industrial Aspects / La Cavitation. Mecanismes Physiques et Aspects Industriels*. Presses Universitaires de Grenoble, Grenoble, France, 1995.
- [20] Hobbs, John M. “Experience with a 20-KC cavitation erosion test.” In *Erosion by Cavitation or Impingement*. ASTM STP 408, Atlantic City, USA, 1960.
- [21] Hobbs, John M. “Vibratory Cavitation Erosion Testing: Proceedings of a Meeting on 13 June 1963,” NEL Report No. 149, National Engineering Laboratory, East Kilbride, Glasgow, 1964.
-

- [22] Manzana, Madalina Elena. *Studies and experimental research on structural changes produced by cavitation–erosion in different metallic materials / Studii și cercetări experimentale privind modificările structurale produse de cavitație-eroziune în diferite materiale metalice*. Doctoral thesis. Politehnica University of Bucharest, 2012 (in Romanian).
- [23] Guragata, Constantin Madalin. *Studies and Experimental Researches on the Deformability and Behavior of Cavitation Erosion of INCONEL-718 / Studii și cercetări experimentale privind deformabilitatea și comportarea la eroziunea cavitațională a superaliajului tip INCONEL 718*. Doctoral thesis. Politehnica University of Bucharest, 2021.
- [24] Krella, Alicja Krystyna. “Degradation and Protection of Materials from Cavitation Erosion. A Review.” *Materials* 16, no. 5 (2023): 2058.