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Microstructural and Mechanical Analysis of 7075 Aluminum Alloy After Shot Peening Treatment

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Abstract

This study aims to perform the mechanical and microstructural analysis of the 7075 aluminum alloy after thermal and mechanical treatments. This alloy is highly valuable in the aerospace and automotive industries due to its excellent strength-to-weight ratio. The research seeks to enhance the mechanical properties of the alloy through specific heat treatment processes. Initially, the samples underwent a solution heat treatment at 500 °C for 4 hours, followed by artificial aging at 120 °C for periods of 1, 3, and 6 hours (T6 heat treatment). This process is intended to improve the mechanical properties of the material. In addition, mechanical treatments such as hardness testing and shot peening

— which involves blasting the surface with small metallic spheres — were also conducted. The results showed a significant increase in material hardness, from 68.5 HRB (solution-treated) to 81 HRB (after 6 hours of aging). Furthermore, tensile tests revealed a notable enhancement in the mechanical behavior of the alloy, including increased toughness for the solution-treated specimens and improved resilience for those subjected to both thermal and mechanical treatments. In summary, the study concludes that the T6 heat treatment significantly enhances the mechanical properties of the AA7075 aluminum alloy, making it highly suitable for high-performance applications. The combination of thermal and mechanical treatments optimizes the strength and durability of this alloy, making it ideal for use in sectors such as aerospace.

Keywords
AA7075, Heat Treatment, Shot Peening, Mechanical Properties, and Hardness.

1. Introduction
Aluminum is the most abundant metal in the Earth's crust. Bauxite, the primary aluminum ore, accounts for approximately 8% of the Earth's crust (ABAL, 2014). Alumina (Al_2O_3) was known in the 18th century; however, the first unsuccessful attempt to isolate the metal was made by Sir Humphry Davy in 1807, when efforts to isolate alkaline metals led to partial reductions. It was only in 1825 that H.C. Ørsted successfully isolated aluminum (P.G. Sheasby and R. Pinner).

Due to its excellent combination of properties—lightweight, high electrical and thermal conductivity, and recyclability—aluminum has become the most widely used non-ferrous metal in the world, with broad applicability in various sectors, including industry, civil construction, aerospace, and household goods (Ceteq, 2013). Aluminum has remained the predominant material in aircraft, comprising approximately 80% of their structural weight, owing to the development of alloys with enhanced mechanical strength (ABAL, 2007).

Despite its favorable properties, pure aluminum requires continuous improvement in aspects such as mechanical strength and heat treatment efficiency to meet the demands of high-performance sectors such as aerospace. This study aims to investigate and optimize these properties, contributing to the development of more efficient and durable materials.

In order to enhance the physical and mechanical properties of aluminum, alloying elements are widely used. The aluminum alloy used in this study—AA7075—belongs to the 7XXX series, which includes zinc, magnesium, and copper as its main alloying elements. These alloys are heat-treatable and exhibit excellent mechanical properties and high performance, making them widely used in the aerospace industry. Regarding the role of the alloying elements, zinc increases the potential for solid solution strengthening and enhances the effects of heat treatment; magnesium improves strength without compromising ductility (ABAL, 2011); and copper contributes to increased strength and improves the heat treatment response of the alloy (I.J. Polmear, 2004).

Additionally, the AA7075 alloy undergoes heat treatment processes to enhance its mechanical properties. The samples used in this study underwent T6 heat treatment, which consists of solution heat treatment followed by artificial aging. The behavior of materials in different physical states is determined by the way atoms are bonded. Most metals crystallize in cubic systems; in the case of aluminum, the atoms are arranged in a face-centered cubic (FCC) unit cell (ABAL, 2011).

1.1 Objectives
The research on the *Microstructural and Mechanical Characterization of the AA7075 Aluminum Alloy* aims to analyze the influence of thermal and mechanical treatments on the mechanical and microstructural properties of the AA7075 aluminum alloy. To this end, the study involves performing solution heat treatment and artificial aging, as well as conducting shot peening using different types of shot media and carrying out microstructural characterization of the samples. Additionally, the research includes mechanical characterization before and after thermal and mechanical treatments to assess the effects on the material's hardness and tensile strength. The ultimate goal of the research is to determine how these treatments enhance the properties of the AA7075 aluminum alloy, making it suitable for high-performance applications such as those in the aerospace sector.

2. Literature Review

Aluminum is the most abundant metal in the Earth's crust, with bauxite, its primary ore, accounting for about 8% of it. Although alumina (Al_2O_3) was known in the 18th century, it was only in 1825 that Hans Christian Oersted successfully isolated the metal, after earlier failed attempts by Sir Humphry Davy. Due to its outstanding combination of properties such as low density, high electrical and thermal conductivity, and excellent recyclability, aluminum has become the most widely used non-ferrous metal in the world, with applications across multiple sectors including industry, civil construction, aerospace, and household goods. Its high strength-to-weight ratio has made it a predominant material in the aerospace industry, accounting for approximately 80% of an aircraft's weight, especially after the development of high-strength aluminum alloys.

To improve its mechanical and physical properties, alloying elements are commonly added to aluminum. The alloy investigated in this study, AA7075, belongs to the 7XXX series and includes zinc, magnesium, and copper as primary alloying elements. These alloys are heat-treatable and known for their excellent mechanical properties and high performance, making them suitable for demanding applications such as in the aerospace industry. Zinc increases solid solution strengthening and enhances heat treatment responses; magnesium improves strength without compromising ductility; and copper further boosts mechanical strength and enhances response to thermal processing. The AA7075 alloy used in this study was subjected to T6 heat treatment, which involves solution heat treatment followed by artificial aging to achieve superior mechanical performance.

The physical behavior of metallic materials is defined by atomic arrangements, and aluminum adopts a face-centered cubic (FCC) structure, which contributes to its ductility. The historical development of aluminum dates back to the 19th century, when isolation methods were first discovered. In 1886, the Hall-Héroult process was independently developed by Charles Martin Hall and Paul Héroult, enabling large-scale aluminum production via electrolysis of bauxite, thus drastically reducing costs and increasing availability. This advancement triggered its wide adoption in several industries. In the 1920s, German researchers identified that Al-Zn-Mg ternary alloys provided high tensile strength, but also exhibited stress corrosion cracking. To make such alloys viable, further studies were conducted, and by 1938, the addition of copper and manganese helped improve corrosion resistance. In Japan, a similar high-strength alloy—referred to as ESD (Extra Super Duralumin), was introduced in combat aircraft. Eventually, enhancements in alloying led to the development of AA7075 in 1943, with optimized compositions of Cu, Zn, and Mg.

Aluminum's versatility stems from its mechanical strength and corrosion resistance, especially when alloyed with other elements. The metal in its molten state can dissolve alloying elements into a solid solution; upon cooling, these may precipitate, significantly affecting the final material properties. Aluminum alloys are generally categorized into heat-treatable and non-heat-treatable types. Non-heat-treatable alloys, such as the 1XXX series, derive their strength from mechanical work, while heat-treatable alloys, like those in the 7XXX series, gain strength through thermal processes including solution treatment, quenching, and aging. The 7XXX series is particularly known for high strength, with tensile strengths reaching up to 600 MPa, making them ideal for structural applications where mechanical performance is critical.

The AA7075 aluminum alloy stands out for its exceptional strength-to-weight ratio, making it essential in aerospace, automotive, and military sectors. Typically composed of aluminum with approximately 5.6% zinc, 2.5% magnesium, and copper, this alloy forms $MgZn_2$ precipitates during heat treatment, which are responsible for its hardening. Heat treatments are crucial in optimizing the mechanical properties and manufacturability of aluminum alloys. The most common for AA7075 is the T6 temper, involving solution treatment, rapid quenching, and artificial aging. Solution treatment dissolves alloying elements into a homogeneous solid solution, which upon rapid cooling forms a supersaturated solid solution. Artificial aging then induces precipitation of strengthening phases at temperatures between 95 °C and 205 °C. This process enhances yield strength more significantly than tensile strength, often at the expense of ductility and toughness. The T6 condition offers superior mechanical performance compared to the T4 temper, despite its reduced ductility.

3. Methods

The material used in this study consisted of aluminum alloy 7075 samples in the as-received condition, with no prior heat treatment. These samples underwent a T6 heat treatment, which included a solution heat treatment followed by artificial aging, with the purpose of improving mechanical performance. After the heat treatment process, the samples were submitted to hardness testing, grinding, and residual stress analysis. All procedures were carried out at the Nuclear and Energy Research Institute (IPEN) of the University of São Paulo (USP), as showns in Figure 1.

Figure 1. Aluminium samples.

The solution heat treatment was performed at 500 °C for 4 hours. After this process, the samples were subjected to artificial aging by being placed again in the furnace. A total of 16 samples were aged at 120 °C and removed in intervals of 0, 1, 3, and 6 hours, with four samples per interval.

Once the heat treatments were complete, the samples were ready for mechanical testing. Although Vickers hardness testing was initially planned, due to the unavailability of equipment, the Rockwell B hardness test was adopted instead. In this test, each specimen was positioned so the indenter of the durometer could be brought into contact with the sample surface. A preliminary load was applied, followed by a major load of 100 kg using the equipment's lever. The hardness readings were taken from the analog dial once the load was removed.

After the first round of hardness testing, one sample from each group was ground using 600 and 1200 grit sandpapers in preparation for residual stress analysis. Residual stresses were measured via X-ray diffraction (XRD), focusing on the face-centered cubic (FCC) 311 crystallographic plane. An X-ray beam was directed through a collimator (2 mm or 4 mm in diameter) and diffracted at various angles, allowing for the measurement of interplanar spacing and calculation of residual tensile or compressive stresses. The diffractometer operated with a voltage of 40 kV and a current of 20 mA, using a chromium tube and the Kα line. The crystallographic plane used was FCC (311), with a scanning range between 129.23° and 149.63° and psi tilting angles of 0.0°, 18.4°, 26.6°, 33.2°, 39.2°, and 45°.

Once this first residual stress analysis was complete, the samples were subjected to shot peening. This surface treatment involves cold working the surface by bombarding it with spherical media such as steel, ceramic, or glass beads. Shot peening induces beneficial compressive stresses on the surface, improves fatigue resistance, and compacts the microstructure. After this step, another residual stress measurement via XRD was conducted on the peened samples.

One sample from each group was subjected to shot peening in order to evaluate the influence of different shot sizes on the mechanical surface properties. The chemical composition of the shot media used in the process was determined and is presented as follows: Chromium (Cr) from 18%, Nickel (Ni) from 8.5%, Silicon (Si) from 2%, Manganese (Mn) from 1.1%, Carbon (C) from 0.1 %, and Iron (Fe) from 70,3%. This composition characterizes the material as high-hardness stainless steel shot. The high content of alloying elements, especially chromium and nickel, imparts excellent mechanical strength and corrosion resistance to the media, making it suitable for repeated impact applications.

The shot diameter plays a crucial role in the outcome of the shot peening process. Larger shot particles tend to induce deeper plastic deformation on the surface, creating compressive stresses at greater depths, but with fewer impacts per area. On the other hand, smaller shot particles provide more intense but shallower compressive stress layers due to a higher number of impacts over a given area, which is especially effective for treating finer surface features. The shot types used in this work are shown in Table 1.

Table 1. Shot Sizing

Shot	Diameter (m)	Volume (m^3)	Mass (Kg)	Kinetic Energy (J)
AC20	0.195×10^{-3}	30.83×10^{-3}	1.78×10^{-3}	2.04×10^{-3}
AC60	0.978×10^{-3}	4.85×10^{-3}	2.23×10^{-3}	2.54×10^{-3}
AC100	1.20×10^{-3}	9.05×10^{-3}	4.16×10^{-3}	4.75×10^{-3}

For samples not subjected to etching, a second Rockwell hardness test was conducted to determine the effect of shot peening on surface hardness. In a later stage, sixteen flat specimens were extracted using wire electrical discharge machining (WEDM). This high-precision process involves the use of a thin, electrically charged wire to erode material immersed in a dielectric fluid, typically allowing for complex geometries and minimal thermal distortion.

In a second phase, 16 test specimens in sheet form were obtained by wire electrical discharge machining (EDM), as showns in Figure 2. Wire EDM is a process in which an electrode, usually made of brass, copper, or graphite, in the shape of a wire with the diameter of a needle, is fully ionized (electrically charged) and passes through the workpiece in a submerged tank with fluid for non-ionized wire EDM. These electrical discharges generate intense heat, sufficient to melt and vaporize the material of the workpiece, allowing for high-precision cuts and complex shapes.

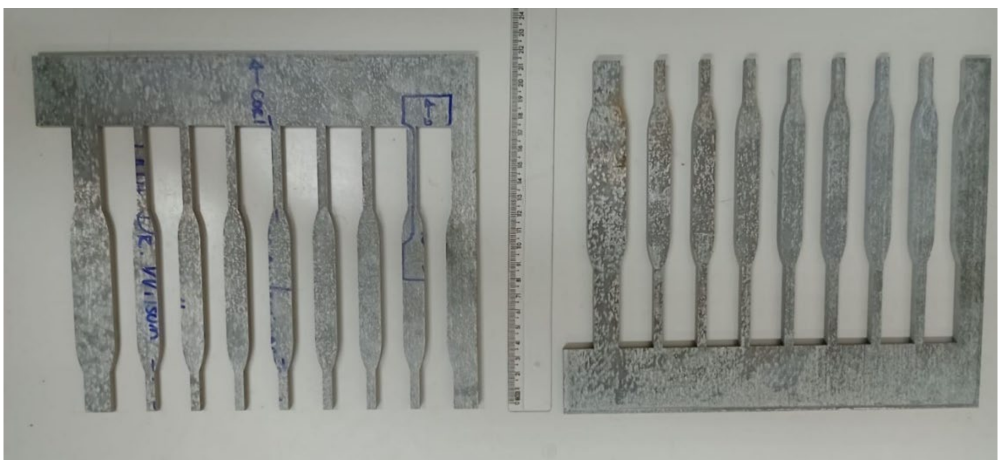

Figure 2. New aluminum samples

To verify the chemical composition of the alloy, X-ray fluorescence (XRF) analysis was performed using an EDX-720 spectrometer. The system emits electromagnetic radiation that excites the atoms in the sample, and the characteristic X-rays emitted by each element allow for qualitative and quantitative chemical analysis.

The WEDM samples were then subjected to the same T6 heat treatment previously described, including solutionizing at 500 °C for 4 hours followed by aging at 120 °C for varying durations. These samples were machined into tensile test specimens in accordance with ABNT NBR ISO 6892-1 (May 2013), using the standard formula $L_0 = k\sqrt{S_0}$, where L_0 is the initial gauge length, k is the proportionality constant, and S_0 is the initial cross-sectional area. The tensile tests were performed under uniaxial loading until rupture, and the stress-strain curves obtained were used to extract mechanical properties such as yield strength, ultimate tensile strength, elastic modulus, and ductility.

Based on the earlier XRD results from peened samples, depth versus stress profiles were analyzed to determine which type of shot provided the most favorable residual stress distribution. The selected shot type was then used in a second shot peening stage applied to the heat-treated and aged samples. These were again submitted to tensile testing to evaluate the mechanical behavior after double peening.

Finally, to investigate the grain structure and deformation, one sample from each shot peening condition was selected for metallographic analysis. A small section of each sample was cut, mounted in thermosetting resin under a pressure of 125–150 kgf/mm² at 150 °C, and polished using a series of abrasive papers. After polishing, the samples were observed under optical microscopy to compare theoretical expectations with the actual microstructural deformation caused by the treatment.

3. Results and Discussion

The results obtained from the application of thermal and mechanical treatments on the AA7075 aluminum alloy demonstrated significant improvements in the material's mechanical properties. The initial Rockwell B hardness tests indicated a gradual increase in surface hardness as a function of artificial aging time. Samples without artificial aging showed an average hardness of 65.3 HRB, whereas those aged for 6 hours reached values close to 83.4 HRB, shows in Table 2. These results confirm the effectiveness of aging in promoting the precipitation of hardening phases ($MgZn_2$), which impede dislocation motion and enhance work hardening, as described by Callister (2014) and Davis (2001). The Hardness vs. Aging curve is presented in Figure 3.

Table 2. Hardness Test

Sample	Without Artificial Aging Recall (HRB)	Artificial Aging Recall – 1h (HRB)	Artificial Aging Recall – 3h (HRB)	Artificial Aging Recall – 6h (HRB)
1	65.3	73.5	76.9	83.4
2	72.1	73.1	78.6	77.9

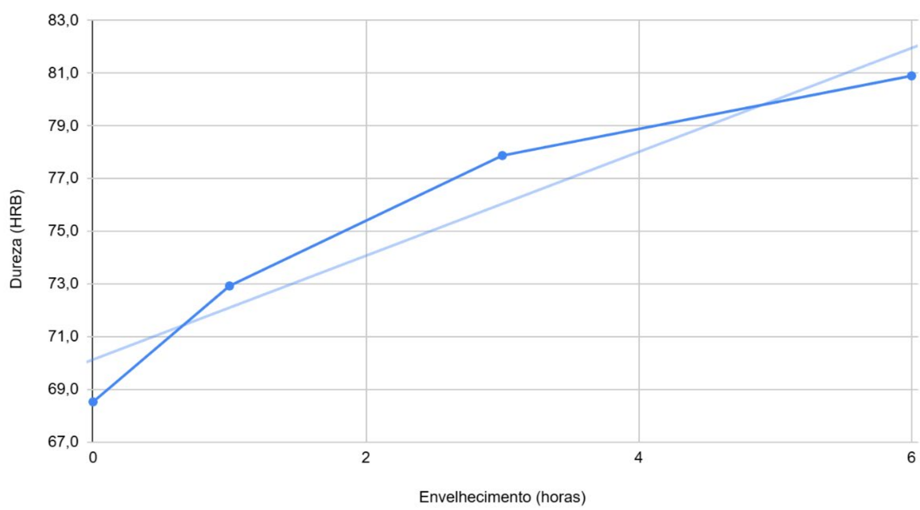

Figure 3. Hardness vs Aging Curve

The residual stress analysis performed via X-ray diffraction on ground samples revealed negligible stress levels in untreated specimens, reflecting a homogeneous and balanced microstructure post-heat treatment. However, all shot-peened samples exhibited compressive residual stresses, as expected, due to localized plastic deformation on the surface. Among the analyzed media, the AC20 shot produced the highest initial compressive stress due to its greater number of impacts per unit area. In contrast, the AC60 shot, with an intermediate diameter and more regular geometry, produced the most consistent results, with lower variability and greater stress uniformity across all aging durations, thus proving ideal for practical applications.

In the laboratory, two types of shot were analyzed under an optical microscope to assess their morphology and dimensional consistency. The AC20 shot type was observed at magnifications of 20x and 40x. These observations helped to correlate the shape and size uniformity of the particles with their performance during the peening process.
Next, chemical etching was performed. A small plastic cylinder was attached to the sample surface using clay to delimit the etching region. Hydrochloric acid was carefully added to the cylinder to fully cover the sample surface, and the reaction was allowed to proceed for 20 seconds. The sample was then rinsed, dried, and the depth of material

removal was measured using a micrometer. A third and final residual stress analysis was carried out to assess the stress states after both shot peening and acid etching, providing insights into how deep the compressive residual stresses extended.

Based in the Figure 4, it is evident that the spherical AC20 shot exhibits an irregular shape; however, the particles that match the theoretical geometry show an average actual diameter very close to the supplier's specifications, ensuring process reliability. Additionally, the dimensional accuracy observed is crucial for guaranteeing process reproducibility, since shot media with varying sizes tend to generate different compressive stress layers on the treated surfaces.

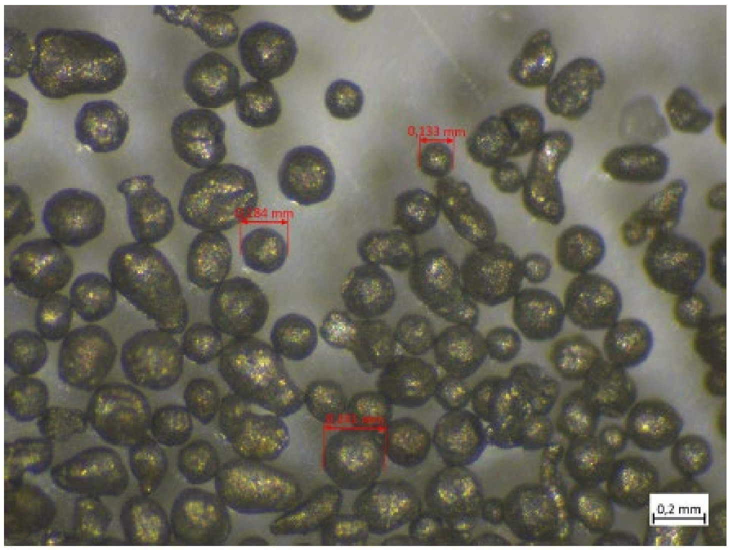

Figure 4. Microstructure of AC 20 shot

Microscopic analysis of the AC20 shot media revealed that, although some particles exhibited irregular shapes, those with a regular spherical geometry presented an average diameter of 0.195 mm, identical to the value specified by the supplier. This dimensional consistency is essential to ensure the repeatability of the shot peening process, as shot size directly influences the depth and uniformity of the compressive stress layer formed on the material surface (Kirk & Pollock, 1990). In contrast, the larger-diameter AC50 shot showed a more uniform and regular shape, shows in the Figure 5, an average diameter of 1.096 mm, which tends to promote a more homogeneous distribution of residual compressive stresses, as also confirmed in the literature on mechanical surface treatments.

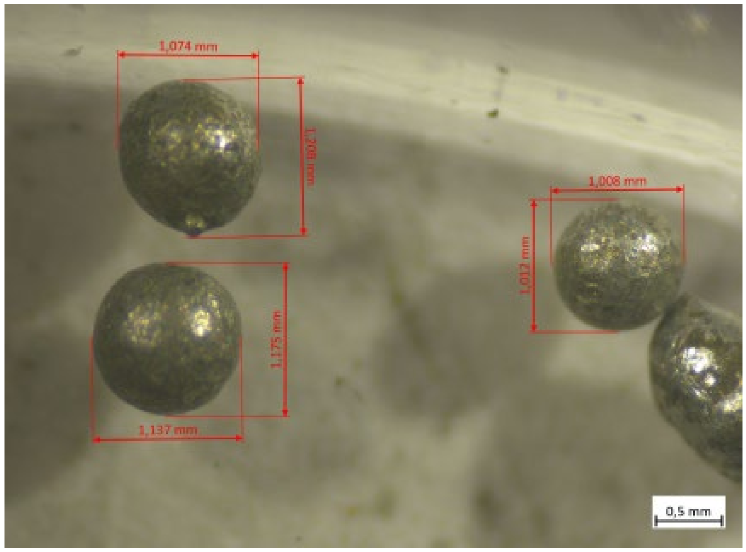

Figure 5. Microstructure of AC 50 shot

For the residual stress analysis, only the samples that underwent grinding were considered. The X-ray diffraction analysis revealed that all the samples exhibited negligible residual stresses, indicating that the grinding process did not induce significant internal stresses in the material. The X-ray diffraction technique is effective for evaluating residual stress states in materials, especially in cases of high precision requirements. The results shows in the Table 3 and Figure 6.

Table 3. Residual Stress analysis

Sample	0AC (MPa)	20AC (MPa)	60AC (MPa)	100AC (MPa)
0h	52.7 ± 7,2	- 135.9 ± 3.1	- 47.2 ± 3.8	- 45.8 ± 5.4
1h	- 64.9 ± 9.7	- 103.8 ± 4.2	- 51.1 ± 6.9	- 48,8 ± 6.4
3h	- 84.7 ± 11.2	- 107.4 ± 7.7	- 51.9 ± 3.9	- 50.2 ± 7.8
6h	- 141.2 ± 5.8	- 110.1 ± 9.7	- 63.7 ± 1.5	- 129.5 ± 12.9

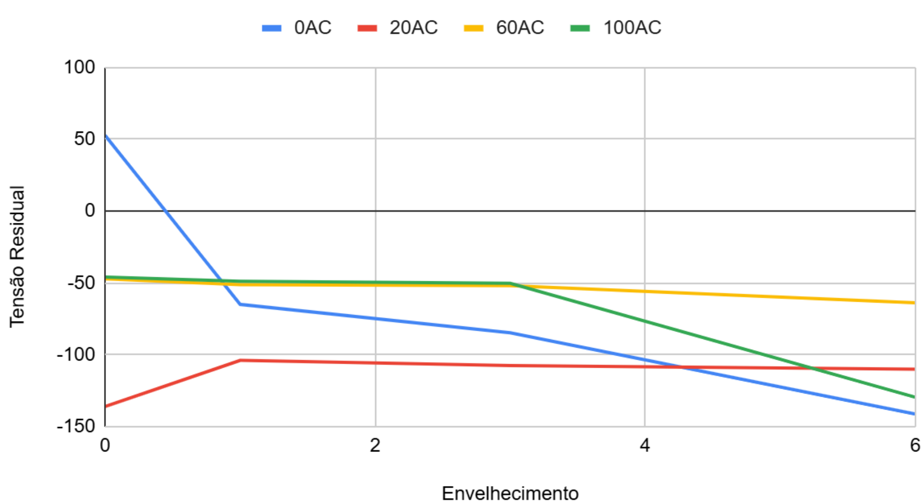

Figure 6. Residual Stress vs Aging Curve

After the blasting process, new hardness tests were performed, which showed an average increase of 9.5 HRB, confirming the synergistic effect between the thermal and mechanical treatments in increasing the surface hardness of the AA7075 alloy. The plastic deformation induced on the surface promotes the accumulation of dislocations and grain refinement, which contributes to the strengthening mechanisms described by the classical theory of materials science. The results obtained are shown in the Table 4.

Table 4. Hardness Test

Sample	Without Artificial Aging Recall (HRB)	Artificial Aging Recall – 1h (HRB)	Artificial Aging Recall – 3h (HRB)	Artificial Aging Recall – 6h (HRB)
1	77.6	86.6	83.9	90.3

The hardness test results showed an average increase of 9.5 HRB after the shot peening treatment, with the sample subjected to 1 hour of solutionizing showing the greatest hardness increase. This behavior is consistent with the findings of Xie et al. (2022), who reported that shot peening induces changes in the material's microstructure, resulting in increased surface hardness due to the plastic deformation caused by the process. The impacts from shot peening cause grain refinement and dislocation accumulation, hindering the movement of new dislocations and consequently increasing surface hardness (Swietlicki et al., 2021).

The surface hardness analysis, ranging from 77.6 HRB (non-aged sample) to 90.3 HRB (sample aged for 6 hours), follows the expected trend, indicating that shot peening combined with artificial aging produced a result in line with literature findings, as discussed by Davis (2001) and Callister Jr. (2021). This suggests an agreement between the applied thermal and mechanical treatments.

X-ray fluorescence analysis confirmed the chemical composition of the alloy, with aluminum (80.14%), magnesium (12.39%), and zinc (5.64%), as the main constituents, shows in the Table 5, along with minor amounts of copper, chromium, and manganese. This composition aligns with the standard formulation of 7XXX series aluminum alloys, known for their excellent precipitation hardening behavior due to the formation of strengthening $MgZn_2$ precipitates.

Table 5. Chemical Composition of Aluminum alloy.

Element	Concentration (%)
Al	80.14
Mg	12.39
Zn	5.64
Cu	1.43
Cr	0.37
Mn	0.03

Tensile test results showed that the untreated samples exhibited high ultimate tensile strength approximately 43801.5 N as shown in Table 6, but limited ductility. On the other hand, solution-treated samples displayed lower maximum strength but greater elongation, indicating increased toughness. Samples subjected to both artificial aging and shot peening with AC60 media presented improved tensile strength combined with enhanced energy absorption capacity. The stress-strain curves of these samples demonstrated more stable behavior and larger deformation areas, highlighting the effectiveness of the combined treatment in optimizing the alloy's mechanical response for demanding structural applications.

Table 6. Results obtained in the tensile test.

Treatment	Max Strength (N)	Total Deformation (mm)	Rupture Strength (N)	Modulus of Elasticity (GPa)	Yield Stress (N)
Untreated	43801.5	14.2	42859.9	81	37870.8
Solubilized 500°C 4h	36653.9	29.5	35617.7	124	28426.1

Lastly, the chemical etching depth analysis revealed that the AC60 shot was the most effective in inducing uniform compressive stress across the surface, without producing excessive surface irregularities or distortions. These findings reinforce its suitability for precision industrial processes where surface integrity and performance are critical. The results obtained in this test are shown in Tables 7, 8 and 9.

Table 7. Results obtained in shot AC 100.

Residual Stress	Depth analysis			
Time	0	50	100	150
0h	-51.2	-152.6	-216.8	-170.3
1h	-48.4	-174.6	-131,9	-164,1
3h	-30.4	-130.3	-182.5	-174.2
6h	-96.2	-154.7	-143.5	-145.1

Table 8. Results obtained in shot AC 60.

Residual Stress	Depth analysis			
Time	0	50	100	150
0h	- 41.1	-164.8	-281.8	-197.8
1h	-54.1	-178.4	-227.7	-116.6
3h	-65.9	-181.4	-210.8	-199.4
6h	-45.2	-208.8	-237.9	-205.5

Table 9. Results obtained in shot AC 20.

Residual Stress	Depth analysis			
Time	0	50	100	150
0h	-121.9	-64.7	- 655.6	-157.3
1h	-119.9	-289.3	-202.2	-191.5
3h	-121.9	-102.6	-141.3	-52.7
6h	-118.2	-88.1	-216.7	-174.9

The AC 20 shot peening media also presents high residual compressive stresses, but with a peak of -655.65 MPa at 141 µm, deviating from the standard curve, shows in the Figure 7, which could jeopardize the standardization of the results and potentially lead to overlapping jetting impacts, causing irregularities in the work-hardening.

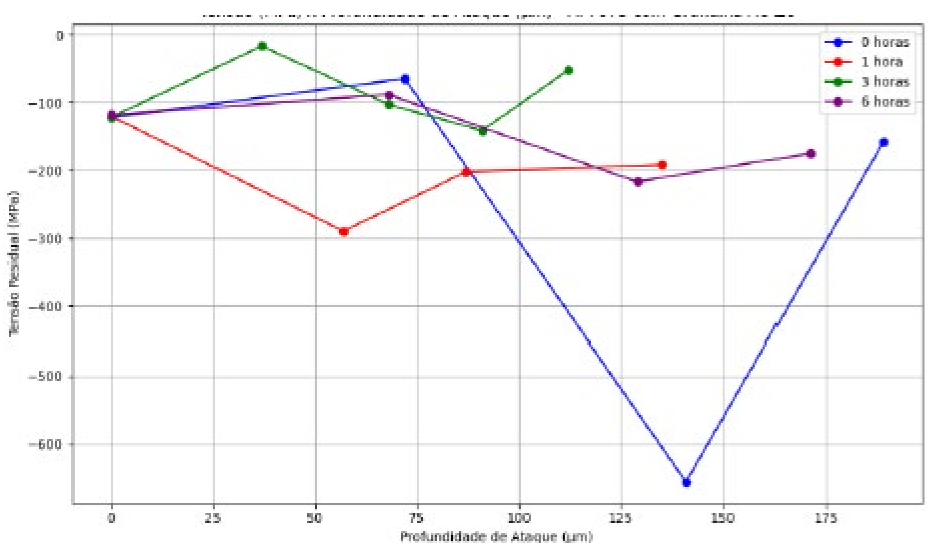

Figure 7. Depth Analysis vs Residual Strees of the AC20 Shot.

In contrast, the AC 60 shot peening media (intermediate media) demonstrated more stable results across all aging conditions, shows in Figure 8, indicating that the plastic deformation caused by shot peening produced a controlled effect.

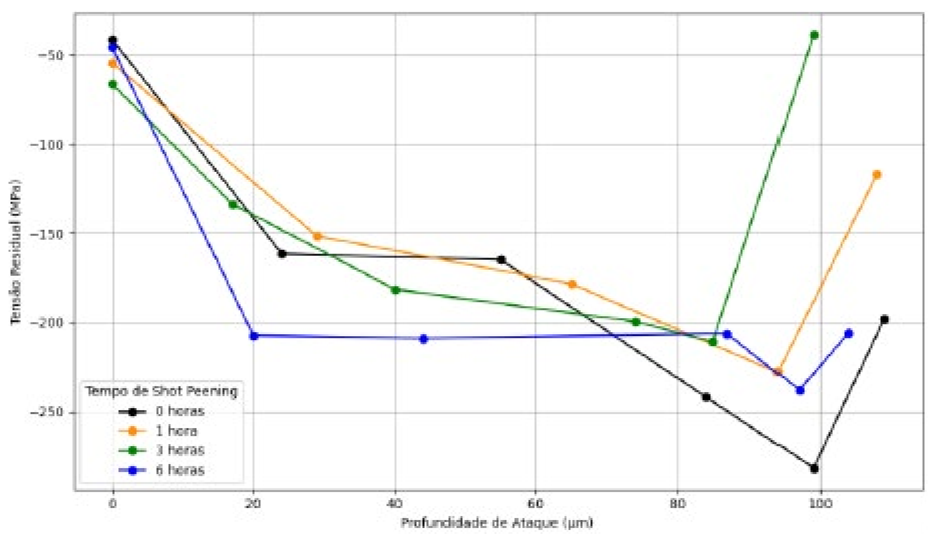

Figure 8. Depth Analysis vs Residual Strees of the AC60 Shot.

The results for the AC 100 shot peening media show higher residual compression at deeper attack depths compared to the other shot peening media, as, according to existing literature, larger shot media tend to generate greater plastic deformation in the deeper layers. Furthermore, the results presented in Figure 9 present exhibit high variability, which may compromise the reliability of subsequent tests.

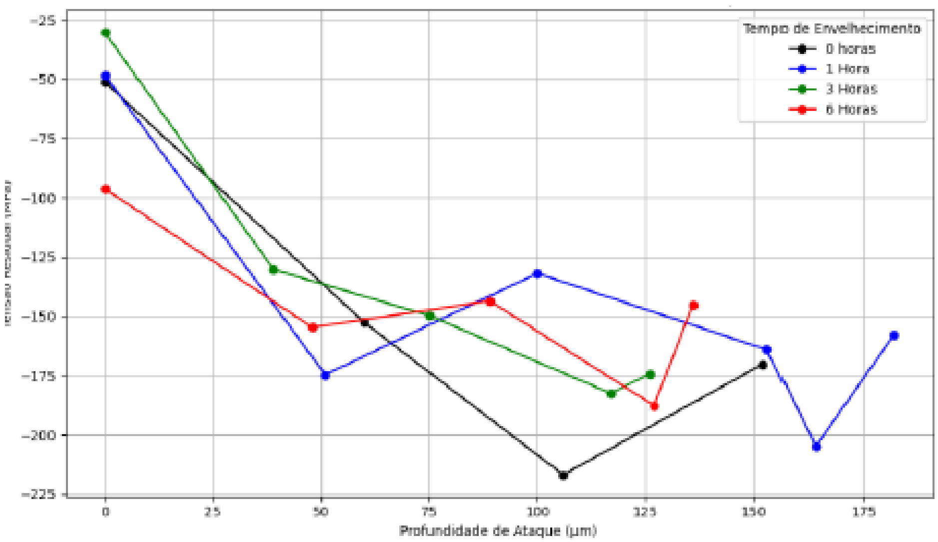

Figure 9. Depth Analysis vs Residual Strees of the AC100 Shot.

4. Conclusion

This study demonstrated that the combination of T6 heat treatment (solution treatment at 500 °C for 4 hours and artificial aging at 120 °C for up to 6 hours) and mechanical shot peening is highly effective in enhancing the mechanical performance of the AA7075 aluminum alloy. The results confirmed that aging time directly influences the increase in surface hardness, and that shot peening further amplifies this effect, particularly when using properly selected media such as AC60. The mechanical behavior observed through tensile and hardness tests revealed significant improvements in toughness and tensile strength, aligning with the performance requirements of lightweight, high-strength components used in the aerospace and automotive sectors. In addition, X-ray diffraction confirmed the introduction of compressive residual stresses by the shot peening process, which is favorable for fatigue resistance. Therefore, it can be concluded that T6 heat treatment, when combined with shot peening using intermediate-sized spherical media, provides an optimal balance of strength, hardness, and structural stability in AA7075 alloy, enabling its safe and efficient use in components subjected to severe service conditions.

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Biographies

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Wilson Carlos da Silva Junior holds a Bachelor's degree in Mechanical Engineering (1983) from the University of Mogi das Cruzes, a Master's degree in Engineering from USP (2000), and a Ph.D. in Biomedical Engineering from the same university (2010). He completed postdoctoral research at IPEN (2017). He has worked as an engineer and consultant in failure analysis, with expertise in both destructive and non-destructive testing, and has experience in material strength, mechanical vibrations, and biomaterials. He has been a faculty member at UMC, UNIBAN, and held various academic leadership positions. Currently, he is a professor at IFSP, a coordinator in the Master's program, and an advisor for scientific initiation projects, focusing on prosthetic failures, additive manufacturing, and material simulations. Additionally, he is an associate researcher in projects with institutions such as POLI-USP and Instituto Mauá de Tecnologia, funded by FAPESP.