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INFLUENCE ON THERMAL TREATMENTS IN THE HARDNESS AND MICRO HARDNESS OF THE ALLOY 7075

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Abstract. *Aluminum alloys are used extensively in manufacturing components for industry automotive and aerospace due to its physical and mechanical properties. These alloys are excellent materials to be use in structural components, automotive and aerospace industry due to their low weight and allow a high carrying capacity and excellent usability. They are use in many structural applications requiring high resistance, low weight, high impact toughness, low thermal expansion coefficient and good corrosion resistance. The properties of the alloys depend on the type of alloys (composition) and microstructure, in turn depend on the history Thermal / mechanical suffered by the alloy during its processing. In this context, research involving the interrelationship between the alloy, the manufacturing route and the properties are of academic interest and industrial application.*
This work aimed to evaluate the influence of manufacturing processes: Solidification, homogenization / solubilization and aging in the alloy Al7075 using characterization techniques such as optical microscopy, hardness and microhardness. This was fundamental to verify if the mechanisms dissolution of precipitates from solidification (homogenization and solubilization) and subsequently the formation of the precipitates in the hardening (precipitation) Are being effective for the hardening mechanisms by grain size control, solid solution, and precipitation present in the 7075 alloy.

Keywords: *Alloy 7075-T651, Aging, Solubilization, Microstructure, Hardness-Microhardness.*

1. INTRODUCTION

Leagues of aluminum are used extensively in manufacture components for automotive and aerospace industry due to their physical and mechanical properties (HASKEL, 2006). These leagues are excellent materials for they be used in structural components of the automotive and aerospace industry by his/her low weight and to allow a high shipment capacity and excellent usabilidade (CHAUDHURY, S.K., and D APELIN, 2006). They are used in many structural applications that request a high resistance, low weight (SHIVKUMAR e*t al*, 1990), high resistance and tenacity to the impact, low coefficient of thermal expansion and good resistance to the corrosion (MA, *et al*, 204).

The properties of the leagues depend on the chemical composition type and also of his/her microestrutura, for his/her time it depends on the thermal report / suffered mechanic for the league during his/her processing. In this context researches involving the interrelation among the league (composition), the production route and the properties are of academic interest and of industrial application.

The industry habitually associates the aluminum the other engineering metals, as the copper, the zinc and the manganese, to generate the calls alloys. In agreement with the associated elements, the alloys possess advantages on the pure aluminum, as larger resistance mechanical, larger fluidity in the completion of molds, etc. (ABAL, 2015. The alloys of aluminum treatable termicamente are of great industrial importance. Researches involving the interrelation among the alloy (composition), the production route and the properties are of academic interest and of industrial application, starting from the wanted property to foresee the possible conditions / parameters that should be used in the processing of the alloy. The thermal treatments are accomplished with the objective of modifying the microestrutural and consequent to alter the mechanical properties, chemistries or to relieve the residual tensions (ASM, 2006). Some alloy of aluminum, among which it is included to 7075, they accomplish such condition and they can be benefitted by the thermal treatments, increasing his/her resistance limit to the traction and hardness, among other properties.

The objective è to show the influence of the hardening mechanisms that you/they act in each stage of the process: rude of Solidification Solubilication and Aging.

2. PROCEDURE

For the development of the experimental part of this work experiments were driven involving the production processes more used in the production of pieces of leagues of aluminum: reflow, solidification, homogenization / Solubilication, tempering and artificial aging. To evaluate the changes microstructural and of the mechanical properties they were characterized in each stage, according to the figure1.

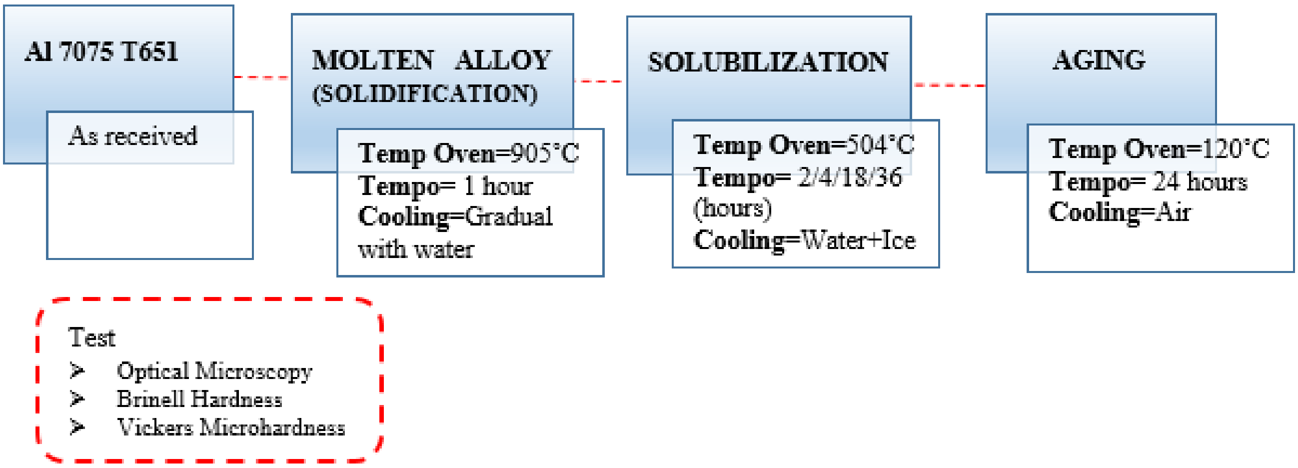

Figure 1. Flowchart of the experimental procedure

3. MATERIAL AND METHODS

The departure material used was the alloy Al 7075 T651 in the form of laminated foil the hot in the condition: solubilitation and aged artificially, produced by ALCOA – France. The nominal chemical composition, according to the supplying company is given in the Table 1

Table 1 Chemical composition of commercial aluminum alloy 7075 T651 weight (%weight)

ALLOY CHEMICAL ANALYSIS AL 7075									
% By weight	Si	Fe	Cu	Mn	Cr	Zn	Ti	Others	Al
Maximum	-	-	1.20	-	0.18	5.10	-	-	-
Minimum	0.40	0.50	2.00	0.30	0.28	6.10	0.20	0.15	Remaining
Coefficient of thermal expansion(20-100°C)=23,6 □m/m.K									

Table 1 Chemical composition commercially pure aluminium

Element	**Si**	**Zn**	**Mg**	**Cu**	**Fe%**
Concentration	0,101%	0,018%	<0,005%	0,013%	0,174%

The commercial alloy Al 7075 T651 was recast to 905ºC. Seeking to obtain different sizes of grains in the samples in the rude state of solidification experiments was accomplished with directional solidification, that is, with taxes of extraction of heat varying in each position of the solidified proof body of the league of aluminum. The solubilização treatment that seeks to homogenize the samples after the solidification, it was accomplished in a temperature of 504ºC (% larger than the usual of norm) for four (04) intervals of time of it floods different: 2, 4, 8 e 36 hours. Seeking to avoid the precipitation still during the cooling after the solubilitation other, samples underwent quenching (quenching in water). For so much, a solution was used the base of water, alcohol and salt with temperature below the -5°C. The aging was accomplished with temperature and time recommended by the literature for treatments type T6 in the alloy Al 7075: 120°C for 24 hours for all the displays (ASM, 1991).

Seeking to accompany the changes microestruturais and in the mechanical properties of hardness of the alloy Al 7075 samples in different processing stages, the samples were characterized by the techniques of optical and electronic microscopia of sweeping, hardness in the scale Brinell (HB) and rehearsals of hardness in the scale microdureza Vickers (HV).

4. RESULTS AND DISCUSSION

4.1 Optical microscopy

The commercial aluminum alloy Al 7075 T651 as received, with cut in the longitudinal sense to the lamination direction is also noticed grains with defined and prolonged outlines in the sense of the lamination (lamination texture), as it is shown in the figure 2.

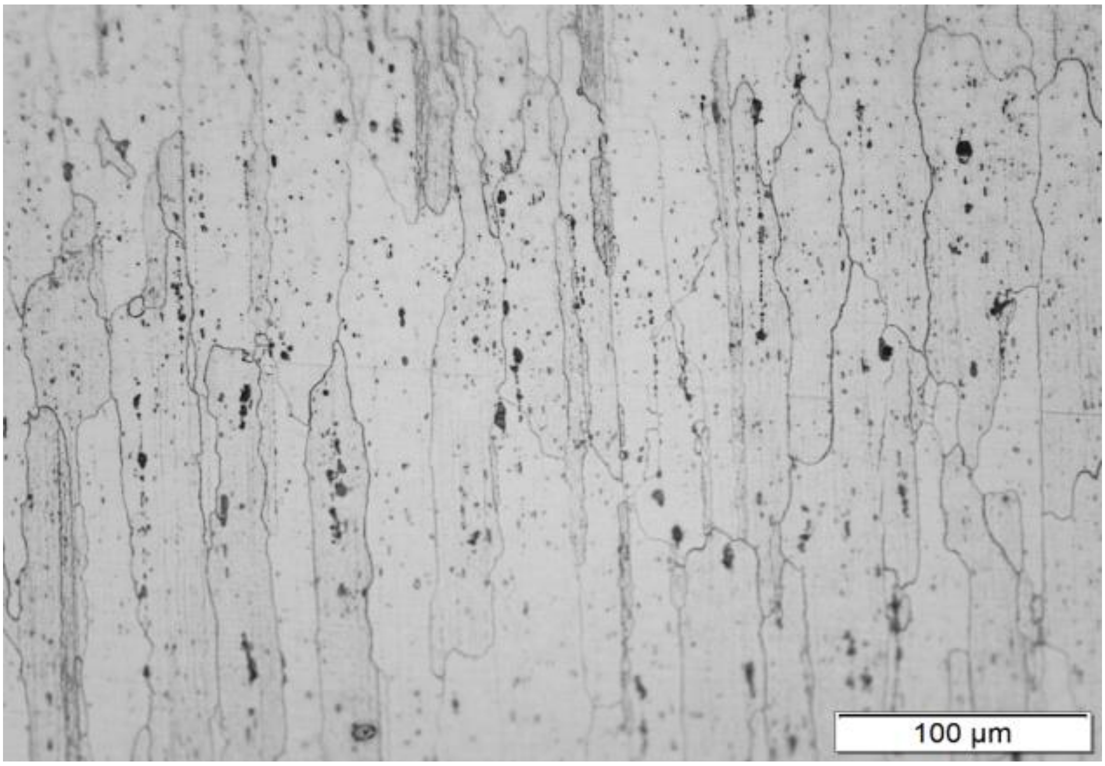

Figure 2 Alloy microstructure Al 7075 T651 as received. Attack with Keller reagent for 10s

A figure 3, the alloys in the crude solidification state in the grain boundaries are observed typical micro porosities of molten structure. It is also possible to observe the “coring”, that is, the center of the grains, composed of a rich primary phase in aluminum (leaves clear), and the measure that approaches the outlines happens a shading indicating solute enrichment (gray part).

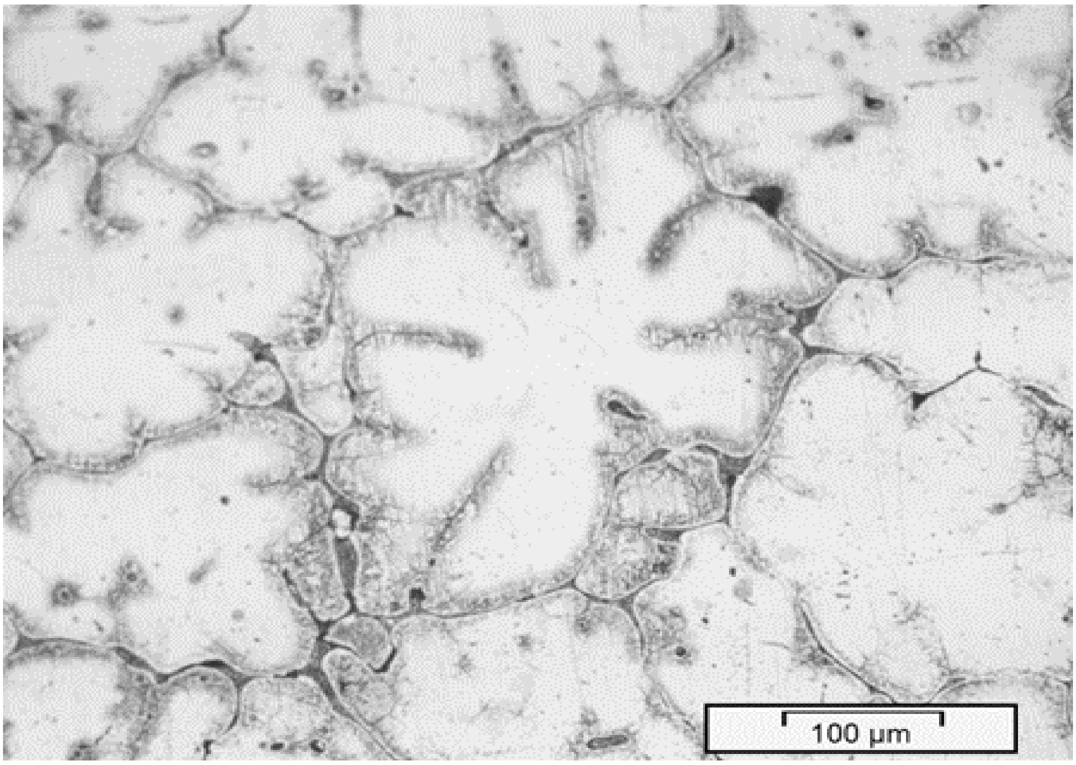

Figure 3 Alloy microstructure Al 7075 as solidification. Attack with Keller reagent for 3s

Figure 4, alloy microstructure Al 7075 solubilized / quenched in water. Note an aluminum matrix with less defined grain outlines than in the solidification condition.

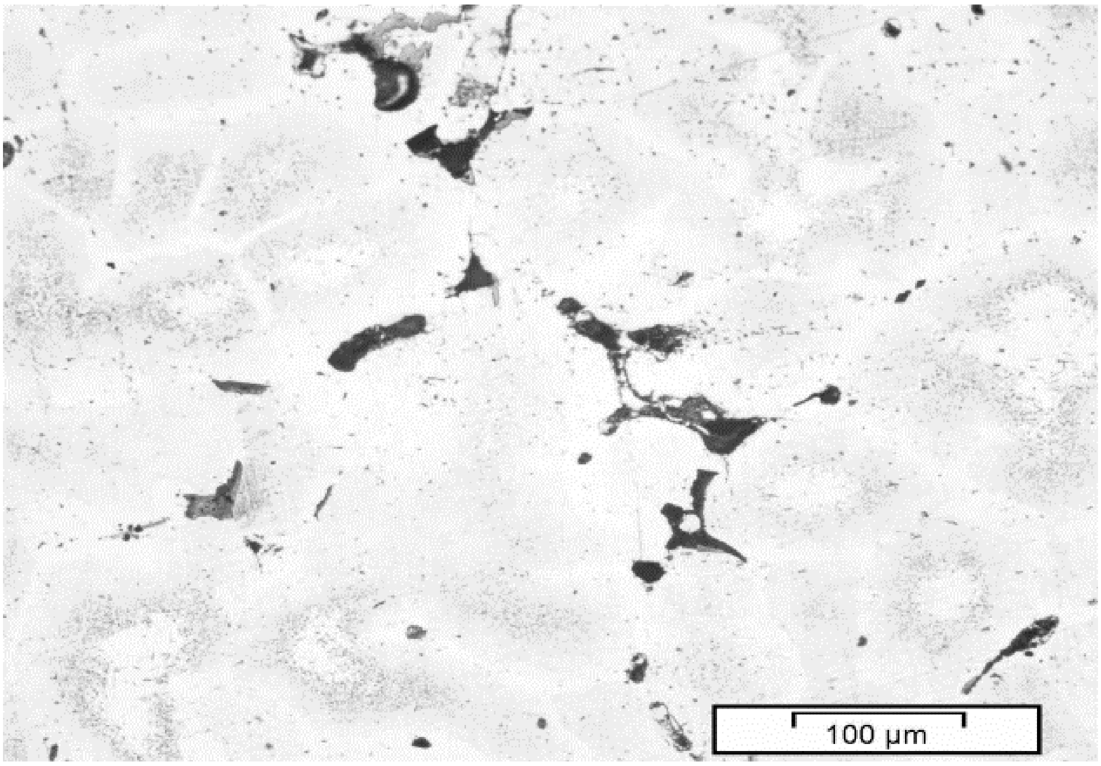

Figure4 Alloy microstructure Al 7075 (with dendritic arm spacing 247 ± 27µm) as solubilized (504˚C) for 18 hour and quenched in water. Attack with Keller reagent for 3s

Figure 5, alloy microstructure Al 7075 after aging. Note that the microstructure is very similar to solubilized, since the precipitates are nanometric.

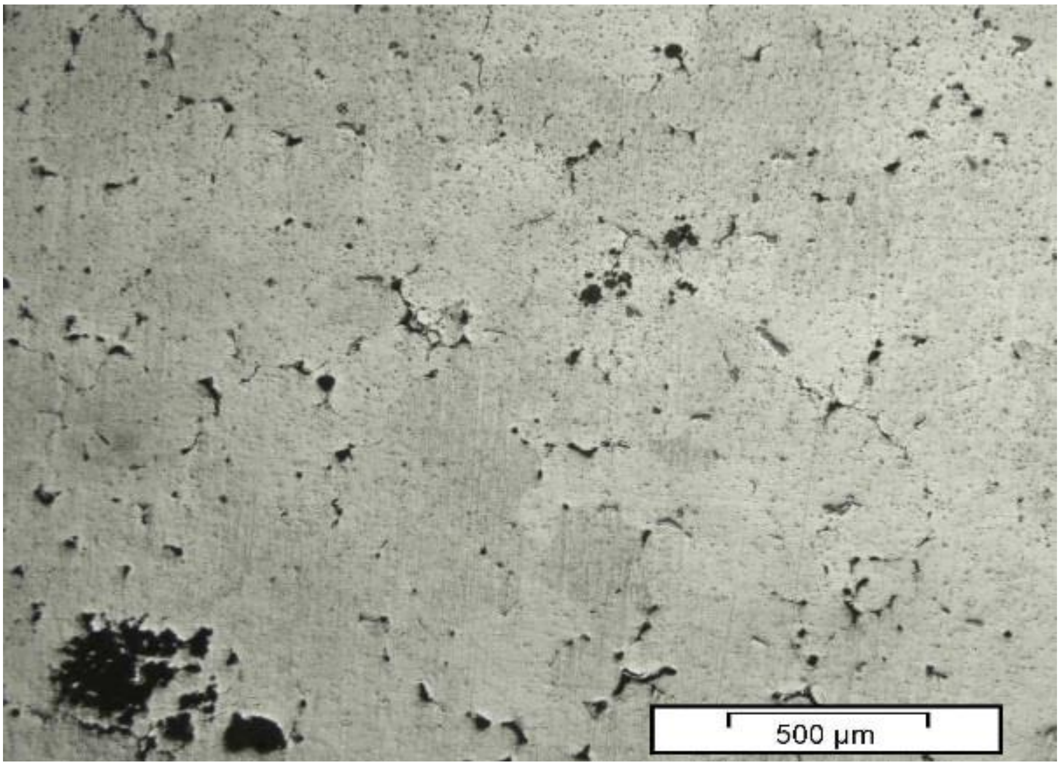

Figure5 Alloy microstructure Al 7075 (with dendritic arm spacing 247 ± 27µm) as solubilized (504˚C) for 36 hour, quenched in water and aging (120˚C) for 24 hour. Attack with Keller reagent for 3s

4.2 Brinell Hardness

Analyzing the results of the rehearsal of hardness Brinell along the sample where and medium value was of 160 HB. It is noticed that the standard deviation of the measures if he/she finds between 3% and 5%, demonstrating that sample presents a homogeneous behavior as the hardness.

For the solid state of solidification, a decrease of the value of the hardness is observed with an average of 102 HB and a deviation of 2% Also has a variation of the hardness in function of the spacing interdendrítico, with a light increase of the hardness with the reduction of the spacing interdendrítico. Isso pode ser devido ao fato de que, para espaçamentos menores, os contornos são mais uniformes e definidos. Already for the larger spacings the outlines are more heterogeneous and less defined, and, therefore, they offer a smaller resistance the deformation than it generates the indentation. For the case of the state solubilized, the medium hardness was of 80 HB and a deviation of 5%, comparing the results can be noticed that there is a light tendency of reduction of the hardness with the increase of the spacing interdendritic, that is, by reducing the cooling rate. And to check with the aging state the average hardness was 155 HB and a deviation of 7%, this increase can be attributed to the nanometric precipitates, coherent with the matrix that are formed during the aging, because these precipitates bar the movement of the discordances thus increasing the mechanical strength of the alloy. Figure 6 presents a summary of the

Average value results of the Brinell hardness test throughout the sample, for different processes, table 3:

Table 3 – Brinell hardness

Process	Brinell Hardness (HB)		Observation
	Mean	Deviation (%)	
Al (Pure commercially)	20	±1	-
Al 7075 T651 as received	160	±4	It presents a homogeneous behavior regarding Hardness
Al 7075 (Solidification)	102	±2	Hardness variation as a function of the dendritic arm spacing, with a slight increase of the hardness with the dendritic arm spacing reduction .
Al 7075 (Solubilization)	80	±5	Slight tendency of the hardness reduction with of the dendritic arm spacing increase, that is, with the reduction of the rate of cooling.
Al 7075 (Aging)	155	±7	The hardness increase can be attributed to nanometric precipitates, consistent with the matrix that are formed during aging.

Figure 6 shows a summary of the hardness variation as a function of the alloy condition.

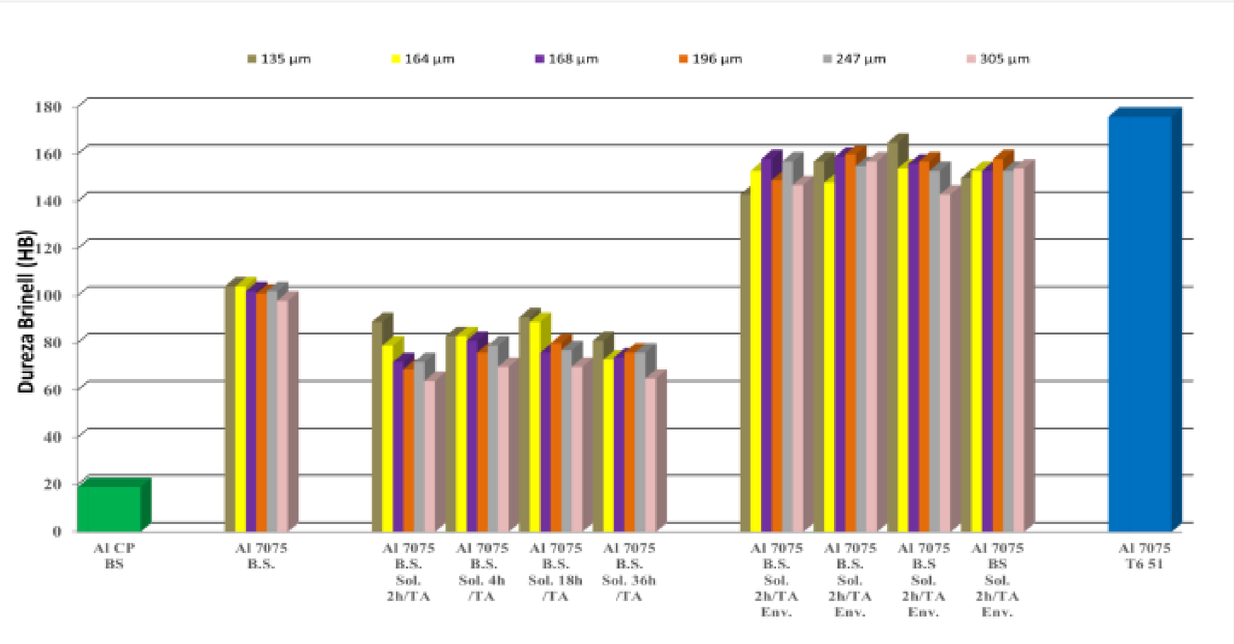

Figure6 Influence on HB hardness with (1) the addition of solute: Commercially pure aluminum (Al CP) versus commercial alloy Al 7075 and with (2) the processing conditions: Aging (Env) and crude solidification (BS) for different solidification rates Interdendritic spacing).

4.3 Vickers Microhardness

Analyzing the results of the Vickers micro hardness test along the sample, and mean value was 175 HV. Note that the standard deviation of the measurements is between 1% and 5%, demonstrating that the sample shows a homogeneous behavior regarding micro hardness. For the solid state of solidification, a decrease in the value of the micro hardness with an average of 140 HV, as far as the dispersion of the micro hardness measures is noticed that it is more significant than in the previous case of the hardness. Since for the molten alloy the microstructure is much more heterogeneous, composed of a primary phase with low concentration of solute and the region of contours with high concentration of solute (mentioned above). For the case of the solubilized state the average micro hardness was 83 HV and a deviation of 6%, during the solubilization, that is, with high temperature (504 ° C) and adequate time the dissolution of grain boundaries, especially of the aesthetic phases, was dissipated. Over time, the Zn, Mg and Cu alloying elements were dissolved in the aluminum matrix to form a solid solution. The tempering process in water, with high cooling rate, aimed to keep these elements in solid solution. This was confirmed because after aging the average hardness was 155 HV and a deviation of 7%. This increase can be attributed to nonmetric precipitates, consistent with the matrix that is formed during aging, because these precipitates bar the movement of the dislocations thus increasing the mechanical strength of the alloy. Figure 7 shows a summary of the micro hardness variation according to the state of the alloy.

Average value results of the Vickers Micro hardness test throughout the sample, for different processes, table 2:

Process	Vickers Microhardness (HV)		Observation
	Mean	Deviation (%)	
Al (Pure commercially)	20	±1	-
Al 7075 T651 as received	175	±3	It presents a homogeneous behavior regarding Microhardness.
Al 7075 (Solidification)	140	±7	The alloy microstructure is more heterogeneous, composed of a primary phase with low concentration of solute and the contours region with high concentration of solute.
Al 7075 (Solubilization)	83	±6	Dissolution of the grain boundaries at a suitable time, especially the eutectic phases.
Al 7075 (Aging)	155	±7	The hardness increase can be attributed to nanometric precipitates, consistent with the matrix that are formed during aging.

Figure 6 shows a summary of the hardness variation as a function of the alloy condition.

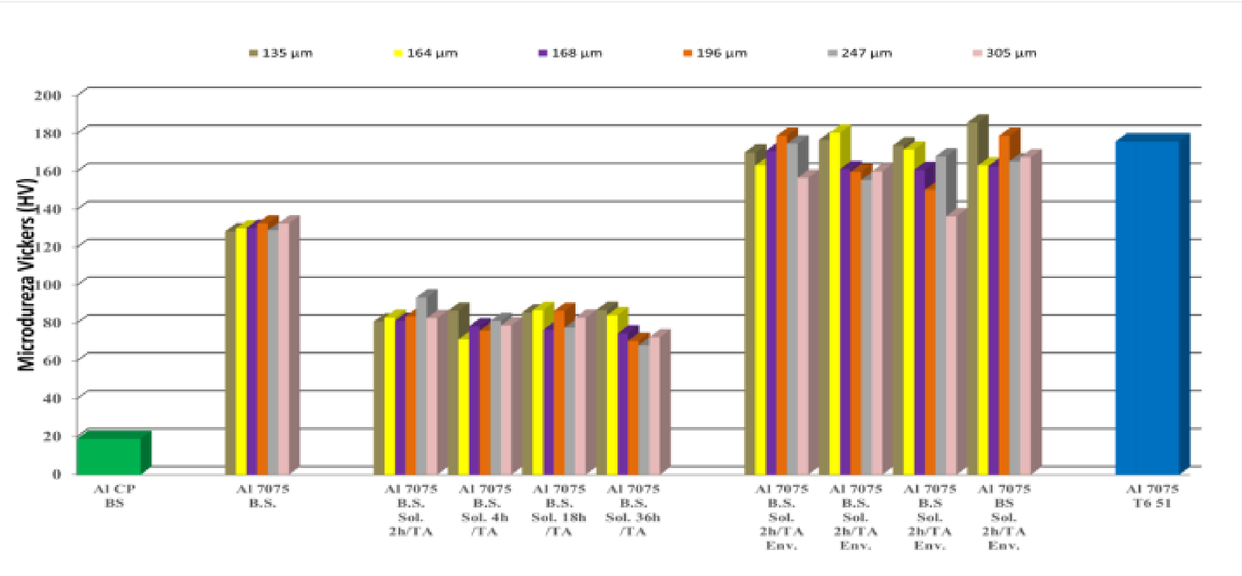

Figure7 Influence on HV microhardness with (1) the addition of solute: Commercially pure aluminum (Al CP) versus commercial alloy Al 7075 and with (2) the processing conditions: Aging (Env) and crude solidification (BS) for different solidification rates Interdendritic spacing)

5. CONCLUSIONS

Analysis of Optical Microscopy, Brinell Hardness and Vickers Microhardness were performed in Al 7075 alloy samples to determine the hardening mechanisms influence that act in each step of the process: Solidification, Solubilization and Aging.

5.1 Raw solidification:

As for the solidification step, the hardness has a slight tendency to fall with the increase of the interdendritic spacing. The same does not happen with microhardness. The grain boundaries, arising from the solute rejection during solidification, acted as a barrier, making it difficult to deformation in the indentations.

5.2 Homogenization/Solubilization:

In the homogenization / solubilization stage there was a reduction of hardness and micro hardness after solubilization independent of the soaking time. The grain outlines, originating from of the solute rejection during the solidification, and that they acted as barrier hindering the deformation in the indentations, they were dissolved during the solubilication.

5.3 Aged:

For the aging step, the size of the interdendritic spacing and the solubilization time had no significant influence on the hardness and microhardness values of the alloy after aging. Regarding the hardness and microhardness results, the condition has substantial influence of solidification, solubilized / tempered in water and aged and as received (T6 51), confirming that they can serve as control during the processing steps.

6. ACKNOWLEDGMENTS

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