Study of the Effect of Melting and Casting Temperature and Heat Treatment on the Mechanical Properties of Aluminum 7075

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Abstract:- Series xxx7 alloys are produced from aluminum alloys by adding mainly zinc, Zn, magnesium, Mg, copper, and Cu to aluminum. They have high mechanical properties that distinguish them from other aluminum alloys. In this research, the effect of adding different percentages of nickel [1 0.5, 0.1,] %Wt., and different heat treatments, namely the 6T artificial aging treatment, and the reflux treatment, usually aging and RRA, on the tensile properties, Vickers hardness, and microstructure of aluminum alloy 7075 was studied. Habit of aging. It has been shown that the reflux and RRA treatment gives better results than the 6T artificial aging treatment, and the adding of nickel in general has led to a softer crystalline structure of the studied alloy and higher values of Vickers hardness and tensile properties of the alloy.

***Keywords:-** 7075 Aluminum, Strength , Hardness , Microstructure.*

I. INTRODUCTION

Aluminum metal is distributed in the rocks of the Earth at a rate greater than that of all other metals. It represents about 8% of the Earth’s crust. Aluminum is a silvery-white metal with a very light weight. Its specific gravity is 2.7 cm/gr 3, which is equivalent to one third of the specific weight of steel. It is a conductor. It is good for heat and electricity, as its conductivity is two-thirds of that of copper. However, it is a low hardness metal that does not exceed 40 HB and 2, and its tensile strength does not exceed 90 mm/N. Therefore, most of the applications and fields in which we use aluminum are in alloy form, adding that the alloy elements are The main alloys that are added to aluminum are: magnesium Mg, copper Cu, manganese Mn, zinc Zn, silicon Si and, and we obtain by adding these elements For aluminum on basic aluminum alloys, which Numbered by the Aluminum Association [1] as follows

- xxx1 Pure aluminum (99.0% or more pure(
- xxx2 aluminum alloy - copper
- xxx3 aluminum-manganese alloy
- xxx4 aluminum alloy - silicon
- xxx5 aluminum-magnesium alloy
- xxx6 aluminum-magnesium-silicon alloy
- xxx7 aluminum-zinc alloy
- xxx8 Aluminum alloys – other elements

Each of these series is characterized by a characteristic that distinguishes it from the rest of the series, such as the excellent electrical conductivity enjoyed by the first series alloys 1,xxx, which is why they are used in electrical applications. The resistance is very high, such as the xxx2 and xxx.7 series alloys, which are widely used in the manufacture of aircraft parts and components. The xxx3 series has the ability to form and conduct heat, and is used in the manufacture of soft drink cans and heat exchangers. xxx5 successions alloys have excellent corrosion resistance, so they are used in shipbuilding; As for the xxx6 series alloys, they have excellent ability to be extruded, so various products [2] with different sections are made from them by extrusion.

Aluminum is usually subject to heat treatment for artificial aging treatments to improve its mechanical properties and change the crystalline structure. Aging begins with solution heat treatment at high temperatures to ensure the dissolution of all elements in the basic aluminum phase, and then sudden cooling to room temperature (quenching), to reach The saturated solid solution, where precipitated elements are formed later during the heat treatment by aging. Aging in aluminum alloys begins with the formation of GP (Preston – Guinier) areas, which are solutions rich in dissolved atoms spread in cohesive knots, which cause distortion in the crystalline structure. These The nodes resist the movement of dislocations, which leads to an increase in the strength of the metal. For example, the strength of the xxx7 series alloys increases due to the deposition of the 2MgZn stage in clusters, which forms a second phase [3] within the basic aluminum solution α. The properties of aluminum alloys can also be improved by... By adding some other alloying elements, for example, boron B improves the electrical conductivity of aluminum alloys used in electrical applications, but it increases the difficulty of working the

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alloy due to its formation of borides, while cadmium (Cd), lead (Pb), and tin (Sn) improve workability, and chromium (Cr) improves corrosion resistance. It increases sensitivity to watering when present in high levels, and nickel (Ni) is used with lead to enhance properties at high temperatures and reduce the coefficient of expansion.

Silver Ag contributes to hardening by precipitation and resistance to corrosion by stress cracking, tin (Sn) improves friction resistance and is therefore used in the manufacture of bearings, and titanium (Ti) is used to soften the grains [4] of cast aluminum castings. The xxx7 series alloys are considered one of the most important aluminum alloys. They contain zinc as the main element, in addition to magnesium and copper (Zn-Al Cu-Mg), as the addition of these elements leads to good properties of these alloys. Many researchers have studied the properties of the xxx7 series alloys due to their distinctive properties that are suitable for a large number of applications, especially applications in the aerospace and aerospace industries. The high-strength xxx7 series alloys have excellent properties, especially after applying heat treatments to them, such as high tensile strength, light weight, and workability. Excellent formability and acceptable corrosion resistance, and one of the most important of these heat treatments is the "Return Aging (RRA) treatment", which results in better mechanical properties and corrosion resistance than the traditional 6T artificial aging treatment. This has been shown [5] by researcher Viana The researcher A.F. Oliveira and his colleagues [6] and his colleagues studied the effect of 6T, 7T and RRA heat treatments on the structure of the 7050, 7150 and 7075 alloys, their hardness, tensile strength and resistance to corrosion by stress cracking (SCC), and they obtained the best results when applying the RRA treatment. The researcher Esmailian M and his colleagues studied The effect of the return time [30-40-50 min] in the RRA treatment on the tensile properties and hardness of alloy 7055. The RRA treatment resulted in better tensile properties than the 6T treatment. Increasing the return time led to an increase in both the grain size and the precipitation density, which affects the properties. [7] Mechanical. As for the researcher Ranganatha R. and his colleagues, they applied different heat treatments to alloy 7049, namely: 6T and 73T, and finally the RRA treatment [8]. Another group of researchers studied the effect of aging conditions on the properties of the school alloy. Researcher Song Chen and his colleagues studied the effect of three-stage aging on the properties of alloy 7085. Three-stage aging improved the tensile strength by 5% over double aging, with [9]. Improving SCC corrosion resistance. Researcher Cao Cheng and his colleagues studied the effect of pre-aging on the hardness of the alloy Zn -2%Mg -5.2%Al containing 0.45% copper, as pre-aging led to a greater density of the 32Mg-T, Al(49) phase and softness. Its grains were transformed from a coarse slice-like form to a finer form, and the needle-like S-phase decay of MgCu2Al led to an increase in hardness values [11,10].

Another group of researchers worked to improve the properties of seventh-series aluminum alloys by adding percentages of some alloying elements, 112 Fouad Dhahiyah et al. Researcher Guo Zhanying and his colleagues studied the effect of zirconium content, Zr, in percentages [0.1, 0.05, 0, 0.15],% and homogenization processing parameters. Thermal impact on the grain size of the 7150 aluminum alloy. The two-stage homogenization resulted in a finer grain size of the 7150 alloy [12] and a higher density of Zr3Al precipitates. As for the researcher Huang K.P and his colleagues studied the effect of adding scandium at a rate of 0.4% and 0.45% on the hardness of the alloy Mg -3%Zn - 6%Al with the application of artificial aging treatment for different periods of time and temperatures. They obtained the highest result when aging at a temperature of 120°C for a period of time. 16 hours and a percentage of scandium [14] of 0.45%. As for the researcher Shiva. Ch. Krishna, he added nickel to aluminum alloy 7075 at weight percentages of nickel of 0.35 -2.3 wt%, and he studied the effect of this addition on the tensile, hardness, and impact properties of the alloy without studying the effect of heat treatments. This alloy contains different percentages of nickel [15]. In this research, nickel was added in different percentages [1 0.5, 0.1, wt%] to the 7075 aluminum alloy, and the effect of 6T and RRA heat treatments on the microstructure, Vickers hardness, and properties was studied. Tensile strength of aluminum alloy 7075 containing the mentioned percentages of nickel

II. MATERIALS AND METHODS

Alloy 7075, the subject of the research, was received in the form of a billet with a thickness of 12 cm. Table 1 shows the chemical composition of the aluminum-zinc-magnesium-copper alloy 7075, and it shows the standard composition of alloy 7075 according to the description of the Aluminum Association [1], and the experimental composition of this alloy after its analysis. Using a Spectrolab spectroscopy device. The alloys to be tested in this research were prepared by weighing pieces of aluminum alloy 7075 and then calculating the corresponding amount of nickel powder (purity 99.9%) so that these added amounts of nickel achieve the required weight percentages in the samples studied, which are %wt) 1 0.5, 0.1 (Ni), [taking into account the increase in the calculated quantity by a small amount, about 10%, due to the loss occurring in the amount of added nickel as a result of combustion, oxidation and lack of dissolution. The nickel powder was coated with pure aluminum foil to reduce oxidation and combustion during the smelting process, which will lead to a decrease in its percentage These weighed pieces of aluminum alloy 7075 with nickel powder coated with aluminum foil were placed in a graphite crucible, and the melting process was carried out. The effect of heat treatments and the addition of nickel 113 on the mechanical properties of high-resistance aluminum alloys in an electric furnace with a maximum temperature of 1200°C.] 16[The melting took place at a temperature of 850ºC. In order to ensure the melting and spread of the nickel in the melt, it was kept at this temperature for an hour. 5. The melt was stirred well approximately every half hour using an Aviti drawbar to ensure uniform distribution of the nickel in the melt.

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Table 1 Weight Percentages of Elements in Alloy .7075

Element	Standard Installation	Experimental Installation
Silicone	**0.4**	**0.085**
Titanium	0.02	0.5
Chromium	0.27-0.17	0.18
Iron	0.6	0.17
Copper	1.3-2	1.8
Magnesium	2.2-2.8	2.35
Manganese	0.3	0.01
Zinc	5.2-6.2	5.8
Aluminum	Bal.	Bal.

Then molten was poured into the steel mold, shown in Figure 1, which was prepared in advance to obtain cylindrical castings, which had a diameter of 25 mm and a height of 150 mm. The metal mold was heated before the casting process to a degree of 300 °C to avoid pre-freezing of the molten and to reduce defects in the casting. The resulting castings. Finally, the castings were taken out from inside the mold after cooling. The chemical composition of the castings was confirmed by spectroscopic analysis using a Spectrolab device. Table 2 shows the chemical composition of the castings studied in the research.

Table 2 Chemical Composition of 7075 Alloy with Proportions of Nickel (% wt)

Element	A	B	C	D
Nickel	-	0.12	0.35	1.07
Silicone	0.086	0.085	0.083	0.081
Titanium	0.06	0.049	0.045	0.043
Chromium	0.19	0.179	0.178	0.177
Iron	0.17	0.159	0.155	0.154
Copper	1.8	1.678	1.675	1.668
Magnesium	2.35	2.334	2.333	2.345
Manganese	0.01	0.01	0.01	0.01
Zinc	5.8	5.678	5.654	5.697
Aluminum	Bal.	Bal.	Bal.	Bal.

All castings were subjected to solution heat treatment at a temperature of 480 ºC for 8 hours, then quenching in cold water. Then two different heat treatments were applied to the castings D, C, B, and A. The first case was heat treatment (6T), and the second case It is the re-aging treatment after recovery (RRA). The 6T treatment was applied by artificially aging the castings at a temperature of 120 ºC for a period of 24 hours, then quenching in cold water. As for the treatment (RRA), it was carried out by first artificial aging at a temperature of 120 ºC for an hour. 24 Then re-aging at 180 ºC for 30 minutes, then artificial re-aging at 120 ºC for 24 hours.

Fig 1 The Steel Mold used for Casting

III. RESULTS AND DISCUSSION

➢ *Tensile Strength*

The tensile test was performed according to ASTM 557B using the OLSEN TINIUS KS25H testing device, and the dimensions of the tested tensile sample are shown in Figure 2. Figures 3 and 4 show the yield stress and tensile strength values, respectively, for the base 7075 alloy and the 7075 alloy containing 0.5, 0.1, wt%[1%] of nickel when subjected to two different types of heat treatment, namely 6T and RRA. We notice from Figures 3 and 4 that the tensile properties (yield stress) of alloy 7075 for various heat treatment conditions (after casting, 6T, and RRA) increased in value with an increase in the nickel percentage until it reached 0.5%, and with an increase in the nickel percentage above this value, the values of the tensile properties began to decrease. Down. It can also be noted that the RRA heat treatment gave better results than the 6T heat treatment, as we find that the maximum value of the tensile strength was for the alloy containing 0.5% nickel, Mpa = 415 UTS, and the yield stress, Mpa = 379 YS, when applying the 6T heat treatment, in While these values increased when applying the RRA heat treatment at the same percentage of nickel, they reached 437 Mpa for the tensile strength (UTS) and 403 Mpa for the yield stress (YS).

➢ *Hardness Test*

Study The hardness test was carried out in accordance with Specification 92E-ASTM using a Vickers hardness measuring device type: 230GNEHM HARTEPRÜFER, the load application time was 20 sec, and the applied load was Kgf. 4. Five hardness readings were taken from each sample from different areas to determine the average value of hardness. . Figure 5 shows the Vickers hardness values for the base 7075 alloy and the 7075 alloy containing 0.5, 0.1, [1 wt%]% of nickel, when subjected to 6T or RRA heat treatment. We also notice from Figure 5 that the hardness of alloy 7075 for various heat treatments. The effect of heat treatments and the addition of nickel 115 on the mechanical properties of high-resistance aluminum alloys (after casting, 6T, RRA) its value increased with an increase in the percentage of nickel until it reached 0.5% and with an increase in The percentage of nickel above this value begins to decrease the hardness of the alloy. It can also be noted that the RRA heat treatment gave better results than the 6T heat treatment, as we find that the maximum value of the hardness of the alloy containing 0.5% nickel is HV 227 when the 6T heat treatment was applied, while the hardness of the alloy increased when the heat treatment was applied. RRA at the same nickel percentage and was .232 HV .

➢ *Microstructure*

Study of the microstructure To obtain microscopic images according to the 3E-ASTM standard, an optical microscope was used with a magnification of 200X and a Met Optika B-353. The surfaces of the samples were sharpened using a semi-automatic sharpening device with water sharpening paper of grades 600, 800, and 1000. 1200, then polished using 0.25 µm synthetic diamond paste, then the surfaces of the samples were scratched by dipping them for a time ranging between (10-20) seconds in the Keller exposure solution, which has the following composition [17]: 1 cm 3 HF, 1.5 cm 3 HCl, 2.5 cm 3 HNO3, 95 cm 3 H2O Figure 6 shows microscopic images of samples of alloy 7075 base that do not contain nickel. Figures 7-9 show microscopic images of samples of alloy 7075 containing percentages of 1%, 0.5%, and 0.1% of nickel, respectively, from For various heat treatments after casting (without heat treatment), 6T treatment, and RRA treatment. It can be noted that the microstructure of the samples before being subjected to 6T or RRA heat treatments, that is, of the samples after casting, contained an internal network of dendrites around the primary grains, and many Of smooth, equal grains containing grains perpendicular to each other, and the density of the cross-network began to gradually decrease after applying the 6T treatment, and the density of the cross-network became less when the RRA treatment was applied. It can also be noted that the heat treatments led to a decrease in the grain size and a softening of the crystalline structure of the alloy. 7075 and that the decrease in particle size as a result of the RRA heat treatment was more than when applying the 6T treatment, and that this change in particle size in addition to the changes in the precipitated phases (this change in phases was studied in another study of ours) has led to an improvement in the properties Mechanical (maximum tensile strength UTS, yield stress YS, and hardness HV) for alloy 7075. It can also be noted that adding nickel to alloy 7075 generally led to a decrease in the grain size, and that the smallest grain size we obtained when the percentage of nickel in the alloy was 0.5%, and this This explains that the highest values of tensile and hardness properties were for alloys containing 0.5% nickel subjected to RRA treatment.

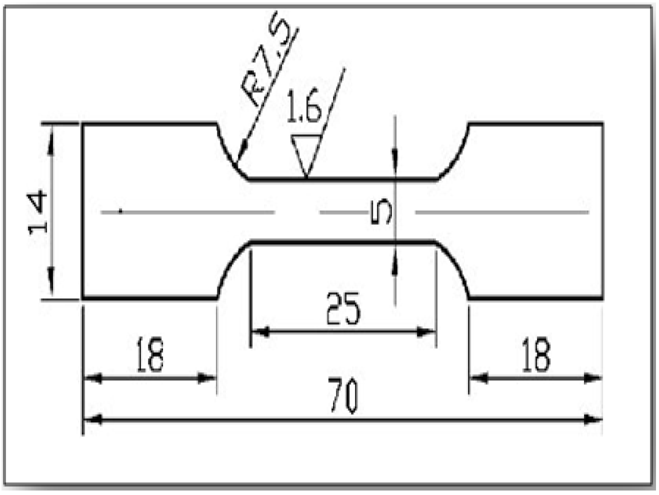

Fig 2 Dimensions of the Tensile Specimen in MM

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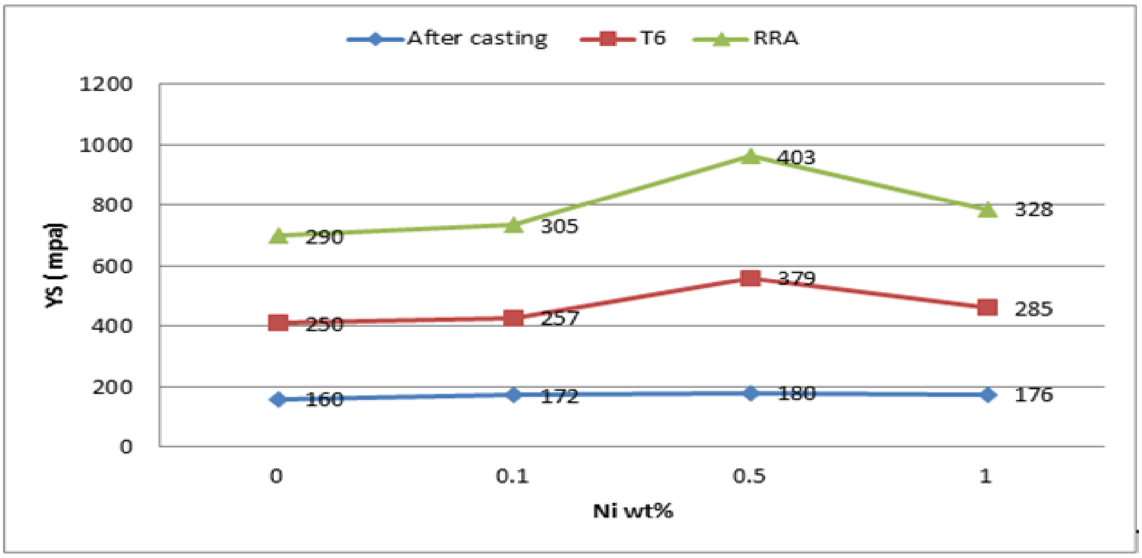

Fig 3 Change in Yield Stress of Aluminum alloy 7075 by Changing the Nickel Percentage and Heat Treatment Method

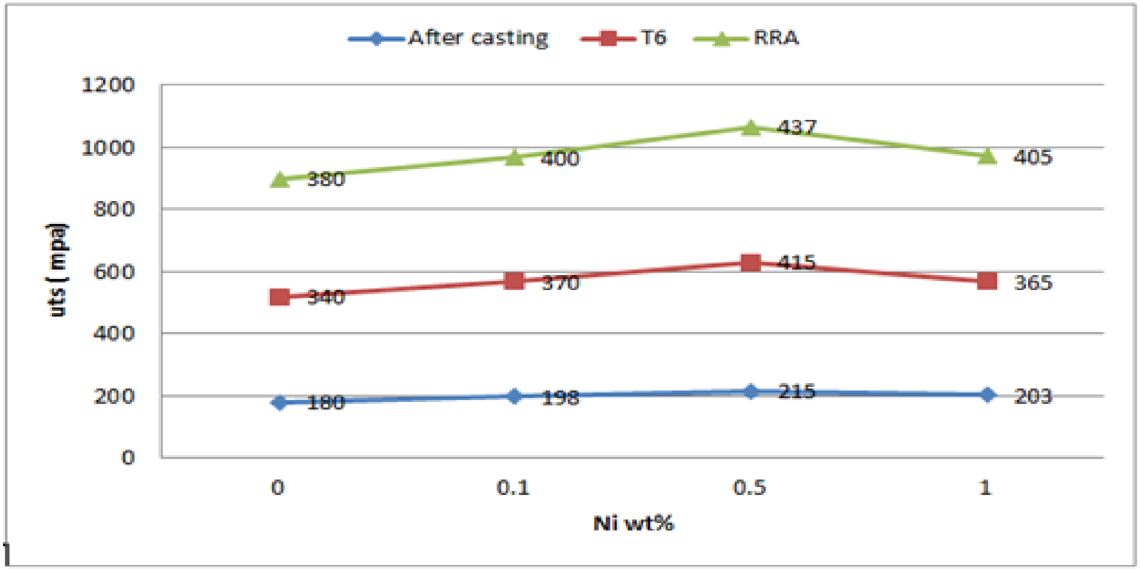

Fig 4 Change in Tensile Strength of Aluminum Alloy 7075 by Changing the Percentage of Nickel and the Heat Treatment Method

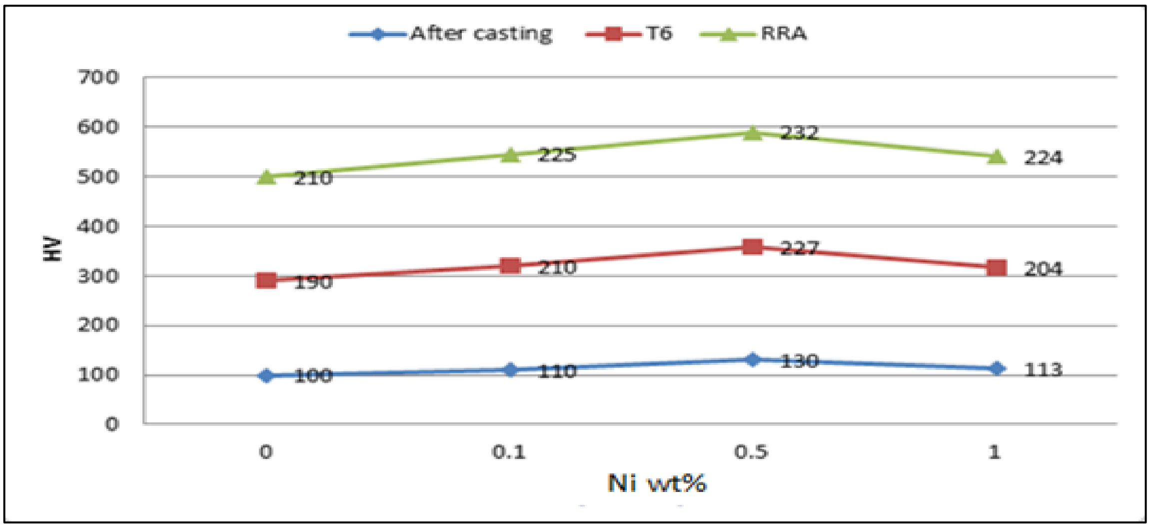

Fig 5 Change in Vickers Hardness of Aluminum Alloy 7075 by Changing the Nickel Percentage and Heat Treatment Method

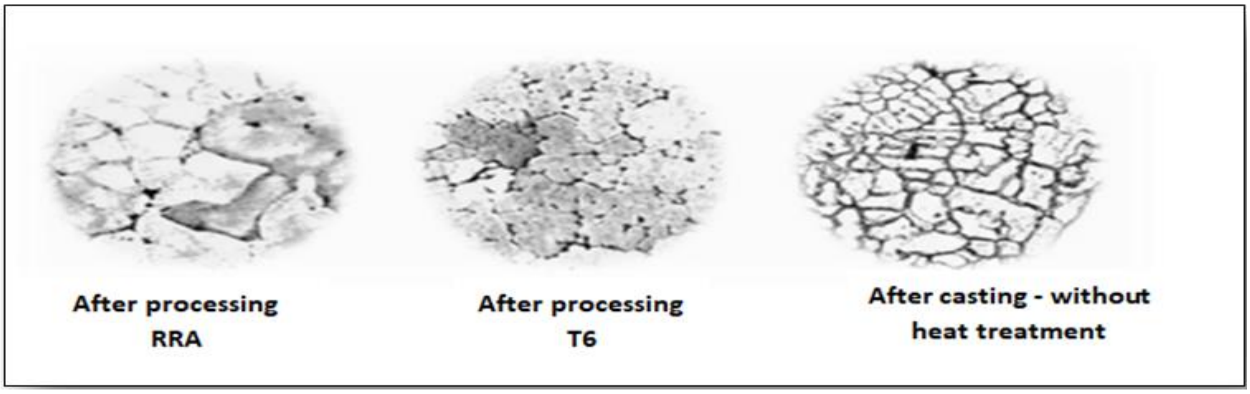

Fig 6 Micrographs at X200 Magnification of Alloy 7075 without the Addition of Nickel after Applying Various Heat Treatment

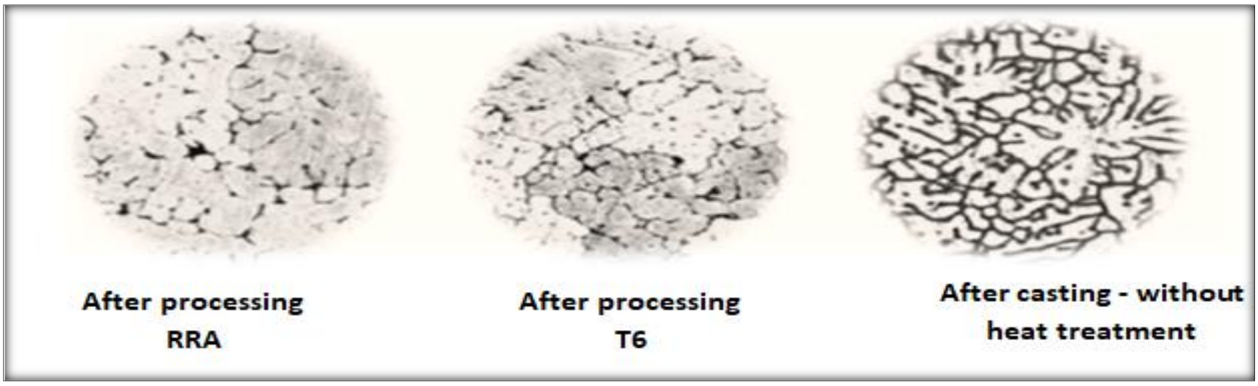

Fig 7 Micrographs at X200 Magnification of Alloy 7075 with 0.1% Nickel Added after Applying Various Heat Treatments

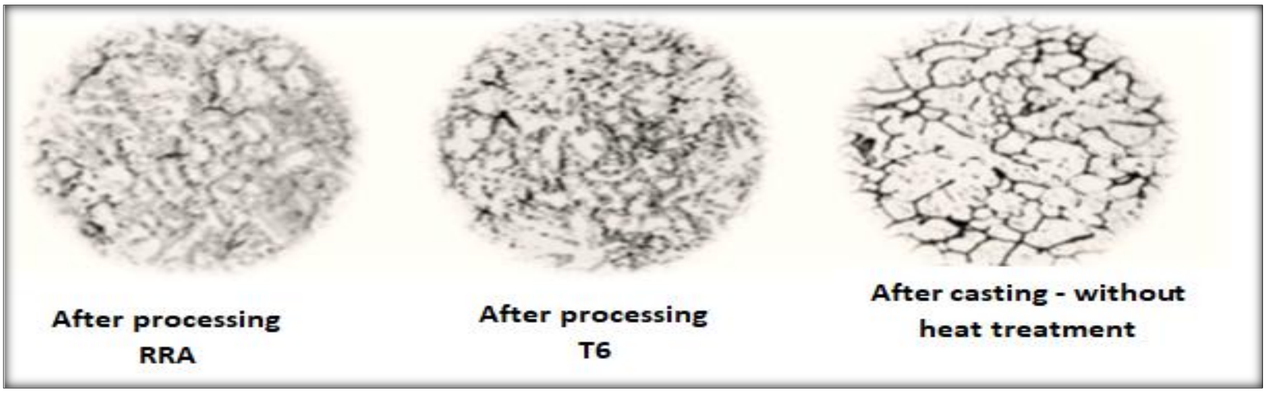

Fig 8 X200 Microscopic Images of Alloy 7075 with 0.5% Nickel Added after Applying Various Heat Treatments

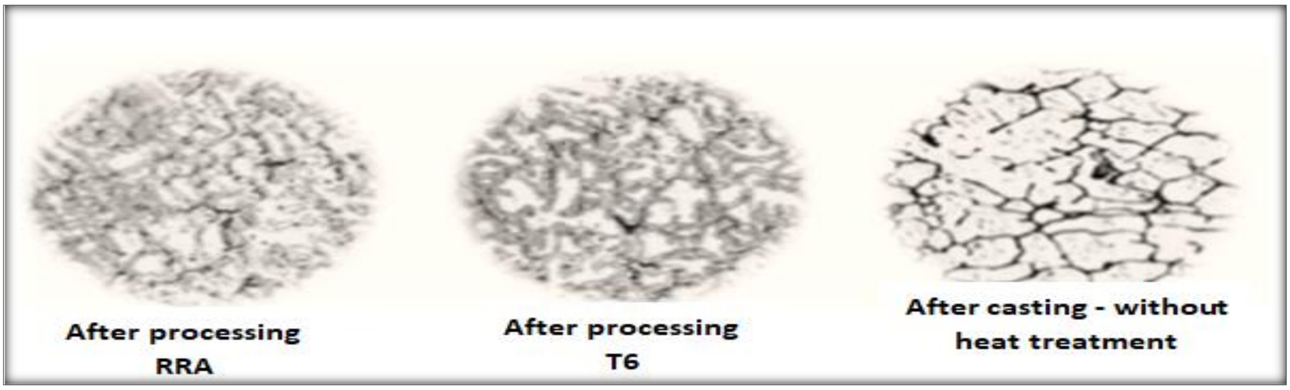

Fig 9 Micrographs at X200 Magnification of Alloy 7075 with 0.1% Nickel Added after Applying Various Heat Treatment.

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IV. CONCLUSIONS

- The 6T heat treatment improved the mechanical properties of aluminum alloy 7075 without any addition of nickel, as it increased the values of tensile strength, strength, and Vickers hardness by 88.9%, yield stress, 56.25%, and 90%, respectively.
- The values of these properties of aluminum alloy 7075 without any addition of nickel increased further when applying the RRA heat treatment, as the yield stress and hardness values of both tensile strength and Vickers strength increased by 111%, 81.25%, and 110%, respectively.
- The heat treatments led to a decrease in the grain size and a softening of the crystalline structure of alloy 7075. The decrease in the grain size as a result of the RRA heat treatment was greater than when applying the 6 T treatment.
- The mechanical properties of Alloy 7075 improved when nickel was added in general, and the highest values for these properties were when applying the RRA treatment when adding 0.5% nickel, while these values decreased with an increase in the percentage of nickel above the mentioned value, as the yield stress and hardness values of both tensile strength and Vickers increased by an amount 103.25%, 123.9% and 78.5% respectively when adding 0.5% nickel to the alloy than without adding nickel, and when applying the same RRA heat treatment.
- Adding nickel to alloy 7075 generally reduced the particle size of the alloy. We obtained the smallest particle size when the percentage of nickel in the alloy was 0.5%.

REFERENCES

[1]. Ten, George E. Tot and Mackenzie, D. Scott (2003) Handbook of Aluminum, Volume 7 Physical Metallurgy And Processes, Marcel Dekker, Inc.

[2]. Tapanyudomphol (2007), Aluminum and Its Alloy, 120 فؤاد ضحية وآخرون Suranaree University of Technology.

[3]. Hull, Derek and Bacon, D. J. (2011) Introduction to Dislocations, 5 Ed., Elsevier.

[4]. Kaufman, J. Gilbert and Rooy, Elwin L. (2004) Aluminum Alloy Castings Properties, Processes, and Applications, Asm International.

[5]. Viana, F., Pinto, A. M. P., Santos, H. M.C. and Lopes, A. B. (1999) "Retrogression And Re-Ageing Of 7075 Aluminium Alloy Microstructural Characterization", Journal of Materials Processing Technology, No. 92±93: 54±59. Oliveira,

[6]. A.F. Jr., De Barros, M.C., Cardoso, K.R. and Travessa, D.N. (2004) "Materials Science And Engineering A," The Effect Of Rra on the Strength And Scc Resistance on Aa7050 and Aa7150 Aluminium Alloys, No. 379, PP: 321–326,.

[7]. Esmailian, M., Shakouri, M., Mottahedi, A. and Shabestari, S. G. (2015) "Effect Of T6 and Re-Aging Heat Treatment on Mechanical Properties of 7055 Aluminum Alloy, "International Journal of Chemical, Molecular, Nuclear, Materials and Metallurgical Engineering,PP: 1291-1294 .

[8]. Ranganatha, R., Kumar, V. Anil, Nandi, Vaishaki S., Bhat, R. R. and Muralidhara, B. K. (2013) "MultiStage Heat Treatment Of Aluminum Alloy Aa7049", Trans. Nonferrous Met. Soc. China, No. 23, PP: 1570- 1575.

[9]. Song-Yi, Chen, Kang-Hua, Chen, Peng-Xuan, Dong, Sheng-Ping, Ye, Lan-Ping, Huang and Dai-Jun, Yang (2016) "Effect of A Novel Three-Step Aging On Strength, Stress Corrosion Cracking and Microstructure Of Aa7085", J. Cent. South Univ., No. 23, PP: 1858−1862.

[10]. Di Zhang, Cheng Cao, Qibiaoma, Xuwang, Zhuang, Linzhong, and Zhang, Jishan (2016) "Effects of Cu Addition On The Precipitation Hardening Response and Intergranular Corrosion of Al-5.2mg-2.0zn (Wt.%) Alloy," Materials Characterization, No. 122, PP: 177–182.

[11]. Di Zhang, Cheng Cao, Zhuang, Linzhong and Zhang, Jishan (2017) "Improved Age-Hardening Response and Altered Precipitation Behavior Of Al5.2mg-0.45cu-2.0zn (Wt%) Alloy With Pre-Aging Treatment," Journal Of Alloys and Compounds, No. 691, PP: 40-43.

[12]. Guo, Zhanying, Zhao, Gang and Chen, X.Grant (2015) "Effects of Two-Step Homogenization on Precipitation Behavior of Al3zr Dispersoids and Recrystallization Resistance in 7150 Aluminum Alloy," Materials Characterization, No. 102, PP: 122–130. Huang,

[13]. Xing, Pan, Qinglin, Li, Bo, Liu, Zhiming, Huang, Zhiqi and Yin, Zhimin (2015) "Microstructure, Mechanical Properties and Stress Corrosion Cracking of Al-Zn-Mg-Zr Alloy Sheet With Trace Amount of Sc.", Journal of Alloys and Compounds, 650: 805-820. Mandal,

[14]. P.K., Anant, Ramkishor, Kumar, Ravindra and Muthaiah, V.M. Rajavel (2017) "Effect Of Scandium on Ageing Kinetics in Cast Al-Zn-Mg Alloys," Materials Science & Engineering A, No. 696, PP: 257–266.

[15]. Ten, George E. Tot and Scott, D. Mackenzie (2003) Handbook of Aluminum, Volume 7 Physical Metallurgy And Processes, Marcel Dekker, Inc.

[16]. Habashi (2008) Alloys: Preparation, Properties, Applications, 5 Ed., John Wiley & Sons.]17[Gale, William F. and Totemeier, Terry C. (2004) Smithells Metals Reference Book, 8 Ed., ButterworthHeinemann.