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THE EFFECT OF MG, CU ADDITION ON MICROSTRUCTURE AND MECHANICAL PROPERTIES OF ROLLING AL-LI ALLOYS

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ABSTRACT

Aluminum-lithium alloys used in the aerospace industry as structural components and strengthened by age-hardening. This study aims to improve properties of Al-Li alloys such as strength, behavior hot rolling and addition element, i.e. Mg and Cu to this alloy. Several tests were carried out to evaluate the performance of alloy, such as hardness, tensile, and microstructure by OP, SEM and XRD. Result showed that addition 3.2% Cu to base alloy improve strength from (62MPa) to (78MPa) when aging at 175°C.and improve hardness from (97.3 Hv) to (119.79Hv) At the same temperature. But the improvement is great when addition 0.6% Mg to base alloy improve tensile strength from (62MPa) to (124MPa) at the same time improved hardness from (119.79Hv) to (152.96Hv) at the same temperature.

Key words: (Al-Li) alloys, mechanical properties.

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1. INTRODUCTION

Al-Li alloys have increased attention for their stiffness and weight to be used in aerospace and military applications for the reason that they good superior properties, for example, a high specific strength and low density from those of traditional Al alloys [1, 2]. The performance for aerospace materials effects on the specific strength and density, engineering properties needed for the transport airplane such as fracture toughness, elastic modulus, shear strength, tensile strength, fatigue, and compressive yield strength is necessary for determent in the Al-Li alloys.[3]

Aluminum is a lightweight metal 2.7 g/cm3 and Adding a small number of elements to an alloy promotes weight reduction such as Mg 1.738 g/cm3, Li 0.534 g/cm3, Si 2.33 g/cm3, and Be 1.848 g/cm3are the only basic metallic metals with a lower density from Al that can be alloyed for Al. Addition Mg to Al effects in alloys by low corrosion and poor toughness, Li is the lightweight metal and the smallest dense solid element of these metals, and only Mg and Li own middle solubility's in the Al matrix [6,7]

The good properties of the A-Li alloys are attributed to the additional Li which affected on density and the elastic modulus. When addition 1wt%Li reduces the density of the Al alloy by about 3% and increase the elastic modulus by about 6%.[2,4,5]. Addition Li to Al improvement the solubility of Al create very fine precipitates at high temperature [8].

Al-Li alloys have better toughness, strength, and low density [9,10].The fracture toughness of Al-Li alloys at solidification temperature is higher than that of traditional Al alloy [11,12,13]. This is a paper study the effect of addition of Mg and Cu on the hardness test, the tensile test and the microscopic structure of the Al-Li alloys.

2. EXPERIMENTAL METHODS

2.1. Materials and Procedures

The chemical composition of the Al-Li alloys used in this investigation was analyzed by SPECTOMAXX(Germany) and the composition was shown in Table(1). The samples were prepared by the gas furnace at a temperature of 800 ° C and then the furnace was placed in a heating furnace which was manually made to work together at 525 ° C for 6 hours. After that, we worked hot rolling at 260 ° C to reduce the thickness of samples from 8mm to 5mm. In addition to the treatment of the treatment at 560°C for an hour and then put out with cold water at (8°C), finally artificial aging work at 175°C for 16 hours as shown Figure(1).

Table 1 Chemical composition of alloys (wt.)

Code alloy	Al	Li	Cu	Mg
A	98	2	-	-
B	94.8	2	3.2	
C	94.2	2	3.2	0.6

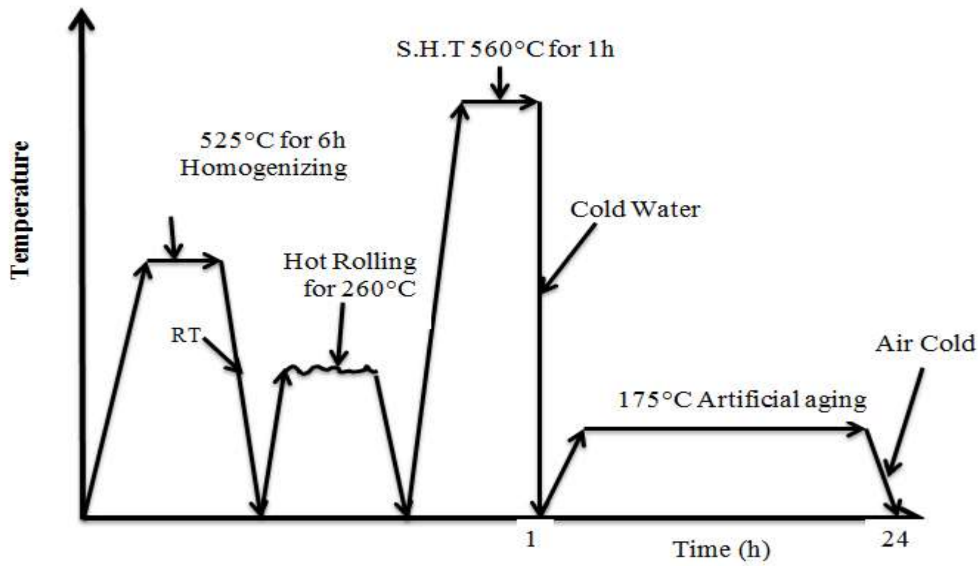

Figure 1 Work plan for research

2.2. Microstructure Testing

The metallographic samples were cut from the same position of each casting, hot rolling, and artificial aging, they were polished and etched with a solution of (15%HF,10%HCl,25%HNO_3,50%Water)and then tested by optical microscope, X-ray and examined by electron microscope, it was used for phase identification .

2.3. Hardness Test

The microhardness was used to evaluate the product, with load 1000g with socking time 10 sec. Microhardness values were obtained by using the equation:[14]

$$Hv = 1.854 \frac{P}{d^2} \qquad [1]$$

Hv: Hardness Vickers (kg/mm²).

P: applied load (Kg).

d: the average diameter of the indentation (mm).

2.4. Tensile Test

Standard samples were cut plate prepared after artificial aging with dimensions shown in Figure (2) Computer control universal testing machine model (WDW-200) determine values of yield strength (YS, 0.2% offset), ultimate tensile strength (UTS) and elongation .the tensile speed rate(0.1 mm/min) at room temperature .

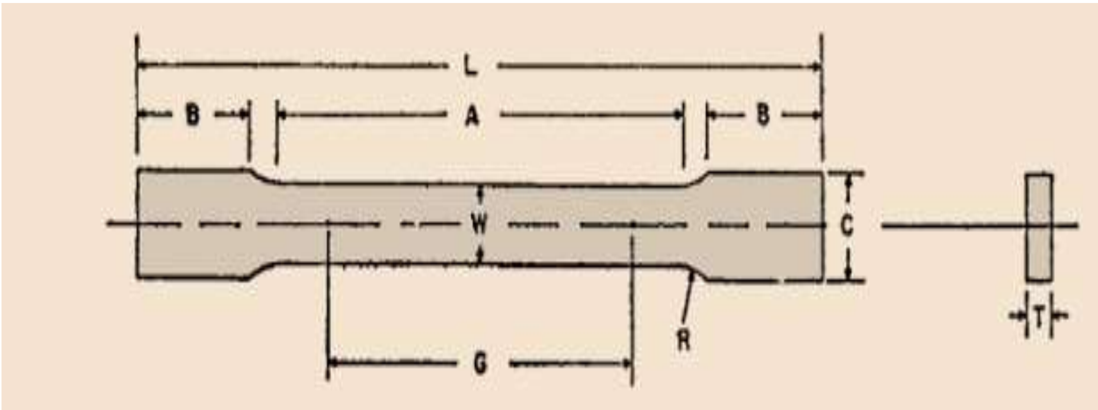

Figure 2 ASTM Sub-Size Sample for Tensile Test. Gage length (G) :(0.25±0.1) mm; Width (W) :(60.1± 0.05) mm; Thickness (T): 6mm; Radius of fillet, min (R): 6mm; Length overall length, min. (L): 110mm, Length , min. (A): 35 mm; Length of grip section, min. (B): 30mm; Width of grip Section, approximate(C): 20mm.[15]

3. RESULTS AND DISCUSSION

3.1. Micostructure

All three alloys in hot rolling and aged condition were examined using optical microscope. It is observed that the A alloy contains the phase (Al_3Li) which is completely identical with the aluminum matrix which is the source of resistance. Either B alloy was found to be phase (Al_2CuLi).The C alloy was found to be Phase deposition (Al_2MgLi) it has a hardening base role in this alloy shown as Figure (3, A, B, C).

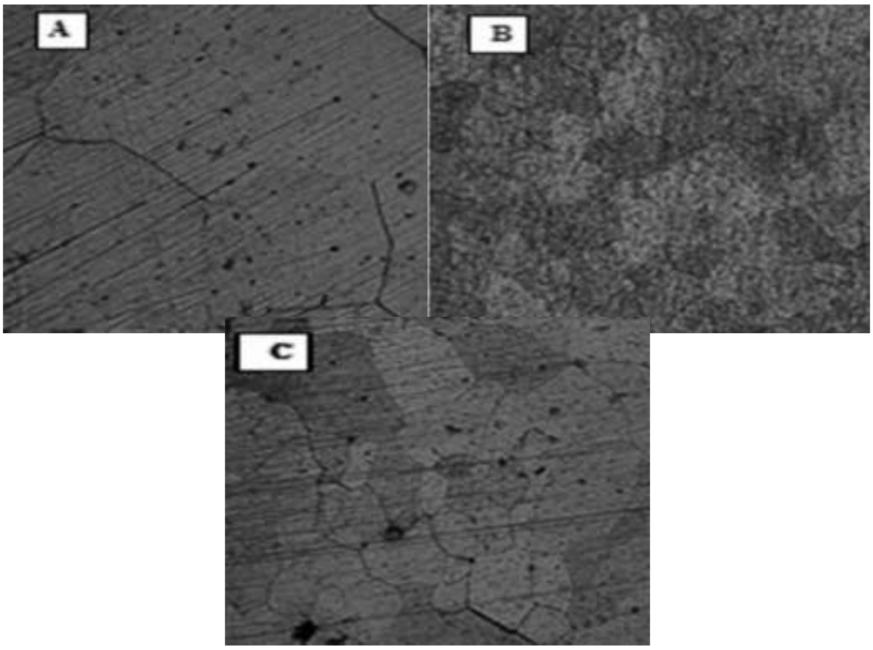

Figure 3 Microstructure of Alloys at 100X magnification; (A) After Aging 16hr. ;(B) After Aging 20hr.; (C) After Aging 8hr

Figures (4) shows refer to Scanning Electron Microscope image of phases of alloys. The microstructure included diffusion of element in which increased by localized elevation in temperature, and then enhancement the mechanical property such as hardness , tensile , wear, and corrosion resistance of the alloys by creating a new phases.

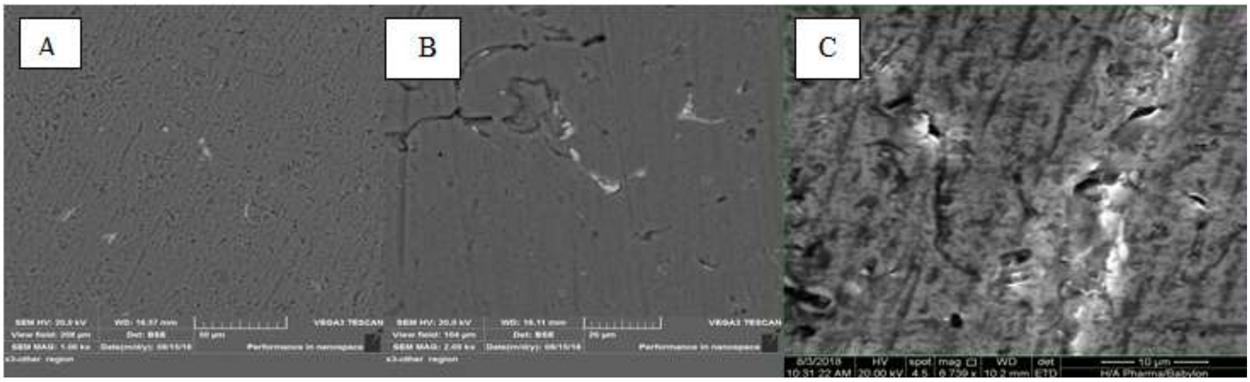

Figure 4 Microstructure of Alloys at 20µm magnification; (A) After Aging 16hr. ;(B) After Aging 20hr.; (C) After Aging 8hr

Figure (5) shows XRD pattern of alloy (A) it found that the aging heat treatment for 16 hr. lead to precipitate the intermetallic compound δ (AlLi), (Al_4Li_9) and (Li_3Al_2) this is accomplished by the decomposition of δ (AlLi) phase. Precipitate fine particles ɵ in the Al matrix will lead to increase the strength.

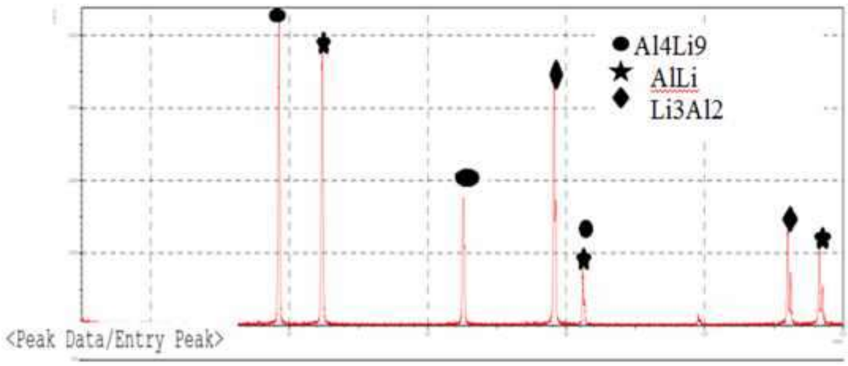

Figure 5 XRD Pattern for Alloy (A) Aged at 175°C for 16hr.

Alloy (B) it found that the aging heat treatment for 20 hr. lead to precipitate the intermetallic compound T1 (Al_2CuLi) and (Al_6CuLi_3) this is accomplished by the decomposition of T1 (Al_2CuLi phase. Precipitate fine particles T1 in the Al matrix will lead to increase the strengthening and Toughness control shown in Figure (6).

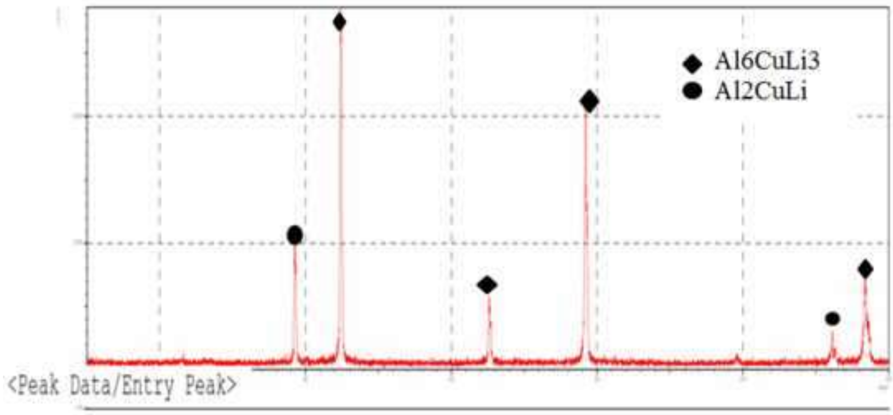

Figure 6 XRD Pattern for Alloy (B) Aged at 175°C for 20hr

Alloy (C) it found that the aging heat treatment for 8 hr. lead to precipitate the intermetallic compound (Al_2MgLi) , (AlCuMg) and ($LiMgAl_2$) this is accomplished by the decomposition of(Al_2MgLi) phase. Precipitate fine particles (Al2MgLi) will lead to increase the strengthening shown in Figure (7)

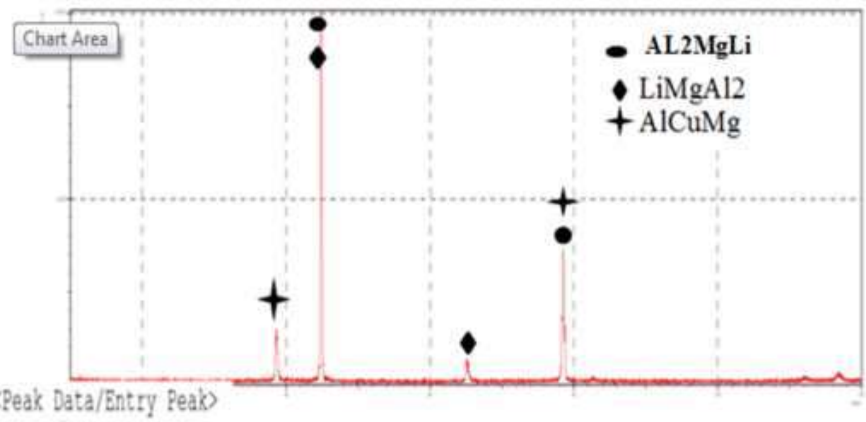

Figure 7 XRD Pattern for Alloy (C) Aged at 175°C for 8hr

3.2. Hardness Test

The treatment of the obstruction of this alloy at 175 ° C is shown in Figure (8) the relationship between the aging and hardening time is found. Where find the hardness of 16 hours is 97.3. This is due to the formation of the δ (AlLi).The spike during deposition is due to the impedance of slipping in soft sedimentation minutes, sometimes accompanied by an agitation field, resulting from the matching of the phase with the ground The period of time to reach the top of the hardness is due to the fact that the primary solidity phase δ´ in alloy A is the growth parameter, because of the low mismatch scale. Therefore, it does not occur until the appearance of the balanced phase δ.

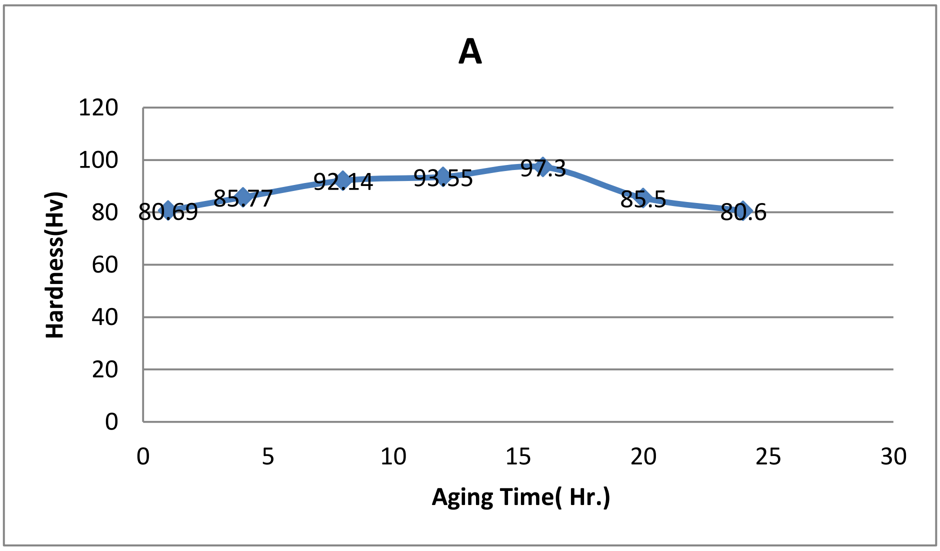

Figure 8 Hardness test of alloy A

Figure (9) shows the relationship between the hardness and the aging time of alloy B at 175 ° C. We find that it reaches the top of Hardness 22 hours at a value of 119.79, an increase in the hardness of this alloy returns to phase T1 (Al_2CuLi). The long period of time to reach the top of the hardness is due to the basic phase of the" is limited growth. As well as a low match so does not occur too over aging until the appearance of the equilibrium phase, so it surpassed the alloy in the value of hardness compared to the alloy A.

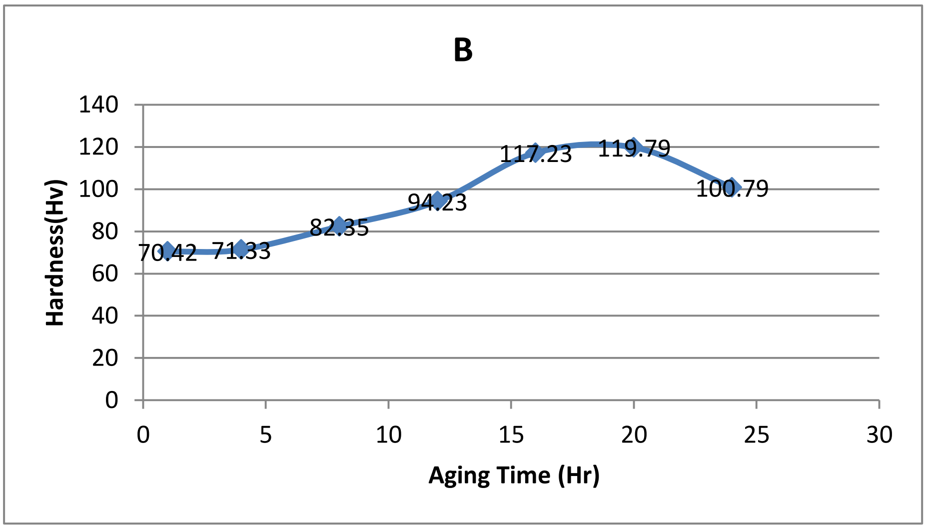

Figure 9 Hardness test of alloy B

Figure (10) shows a relationship between the hardness and the aging time of alloy C at 175 ° C, which reaches up to the peak of hardness in 8 hours, which are 152.96. The superiority of this alloy in hardness is that it involves more than one solid element such as Li, Cu, Mg, which is the phases of the solidity (δ´, ɵ, T1). The difference in the period of time to reach the peak of hardness is due to the phase of the basic hardness (δ, ɵ') in the alloy C limited growth. Because of the low degree of mismatch, so does not occur excessive aging in the appearance of the stages of equilibrium and other phases. Therefore, we see that the alloy C higher hardness compared to the basic alloy Al-Li.

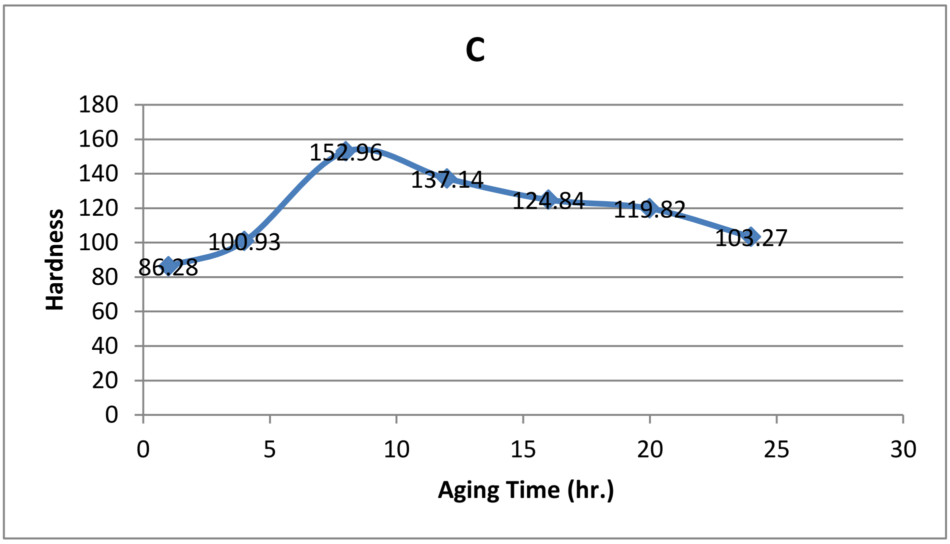

Figure 10 Hardness test of alloy C

3.4. Tensile Test

The results of the tensile test and mechanical properties (tensile load, percentage of deformation and Ultimate tensile strength) of the prepared alloys are listed in Table (2)and Through Figure (11, 12 and 13).alloy A was found to be tensile strength (62 MPa) due to the precipitation of a phase (Al_3Li) in the ground which prevents slippage and breakage. Lithium atoms were found to shrink due to the lithium element. As for the alloy B, where the tensile strength increases to (78 MPa) the reason is the existence of the element of copper, which works to resistance and the Hardness and formation of phase (Al2CuLi). It is observed that alloy C is superior to previous alloys where tensile strength is reached (124 MPa). This is due to the presence of a magnesium element which creates a non-cutable (non-cut) phase (Al_2MgLi) that cans dispersion the slide and also Strengthens the no-precipitation zones.[16]

Table 2 Tensile properties of the prepared alloys

No	Alloy	Tensile load (KN)	Deformation (mm)	Ultimate Tensile Strength (MPa)
1	A	2.49	42.0	62
2	B	4.63	35.0	78
3	C	9.33	35.0	124

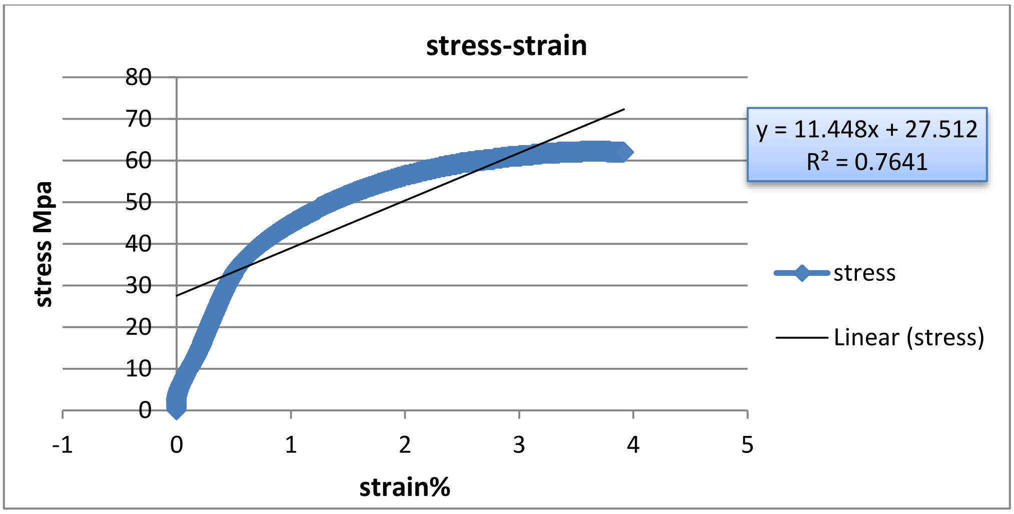

Figure 11 Tensile Strength curve of A alloy

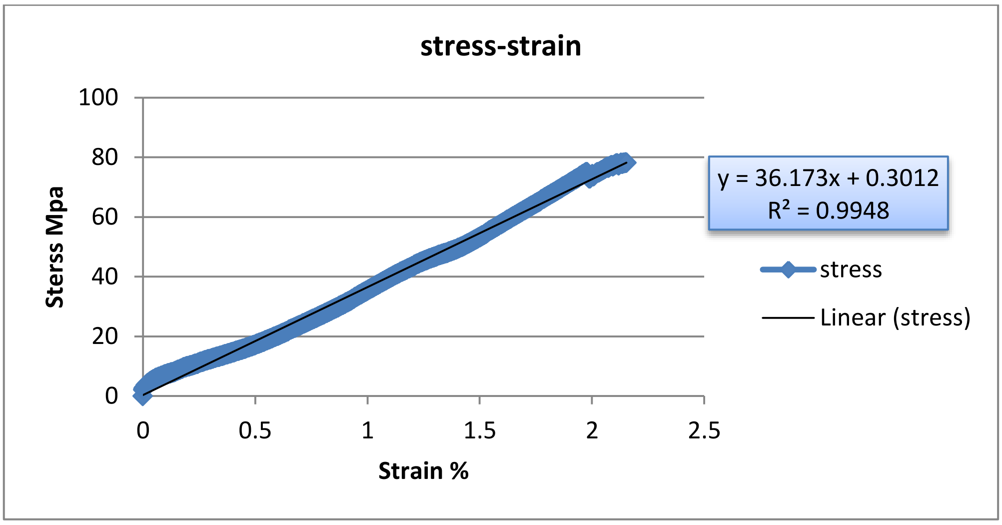

Figure 12 Tensile Strength curve of B alloy

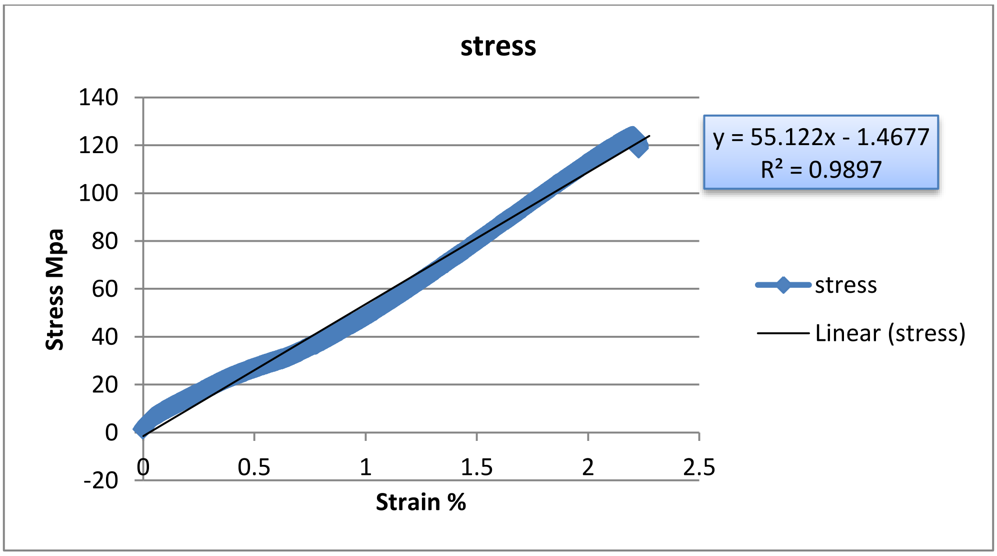

Figure 13 Tensile Strength curve of C alloy

4. CONCLUSIONS

- The addition of copper (3.2%) to the aluminum- lithium alloy improves strength.
- Found from analysis SEM and XRD precipitation fine particles from Al_3Li and Al_2CuMg which enhances tensile strength and hardness.
- It found that the hot rolling by 3% before aging increases the resistance and reduces the ductile.
- Addition of (0.6%) of magnesium to the aluminum-lithium alloy, decreases the ductile by a small amount, increases the strength and hardness.

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