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EFFECT OF Ti AND Sn ADDITIONS ON MECHANICAL PROPERTIES OF ALUMINUM- SILICON - COPPER ALLOY

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ABSTRACT: - This research is devoted to study the effect of adding alloying elements (Ti and Sn) with different percentages (1, 3 and 5) wt% on the microstructure, mechanical properties, and dry sliding wear resistance of Al-6.9wt%Si-1.7%Cu alloy.

The particle size of Ti powder is 200 µm, but the Sn adding as a small bits to the alloy. The microstructures were examined with optical microscope for the base alloy before and after adding alloying elements. This examination showed that the changing occurs on the morphology of grain, precipitated intermetallic compounds and other phases (TiAl, TiA_{l2}, Al_2Cu and β-Sn) determined by the x-ray diffraction. The mechanical properties studied in this research were the tensile strength, impact toughness, and hardness. The results depicted that the σu, σy and hardness increase with increasing the percentage of Ti, while they decrease with increase the percentage of Sn. On the other hand, the alloys with Ti additions revealed that El% decrease with increasing Ti additions, but El% increase with increasing the Sn addition to the base alloy. Also, the impact toughness, was examined, and it was found alloying element was lower than the base alloy for both elements (Ti and Sn). The pin-on-disk technique was used to determine the wear resistance for base alloy before and after adding the alloying elements. The wear resistance increased with increasing the percentage of the Sn, but it decreased with increasing the percentage of Ti at different applied loads (2.5, 5 and, 7.5) N at a constant sliding speed of (3.7) m/sec.
Keywords: Al-Si-Cu alloy, Mechanical properties, wear resistance, alloying elements Ti and Sn.

1. INTRODUCTION

Aluminum and its alloys are extensively used in industries, such as automotive, power engineering, combustion engine, pistons, and cylinder blocks [1]. Aluminum alloys are widely used in castings because they possess many desirable properties including high fluidity, low melting points, light weight, rapid heat transfer and good surface finish [2]. A number of workers has studied the effect of alloying elements on the microstructure, mechanical properties and tribo1logical properties [3]. Muzaffer et al. [4] studied the effect of Ti addition on the microstructure and mechanical properties of near eutectic Al-Si. They found that the hardness increases due to relative hard phase of Al_3 Ti intermetallic. Mallapur D.G. [5] investigated the effect of grain refinement of Ti and B and modification of Sr on the microstructure and mechanical properties of A356 alloy. They showed that the mechanical properties improve with grain refinement and modification. The addition of Ti and B reduces the size of α – Al dendrites.

The accelerated need for weight reduction, however, leads to higher mechanical and thermal loading of these aluminum castings in future vehicles, requiring improved Al–Si alloys. Therefore, in the last years, several investigations were carried out with the objective of improving the mechanical properties of Al–Si alloys [1]. Ti is added to refine the grain structure of aluminum casting alloys, usually in combination with smaller amounts of boron to give better grain refining efficiency. Titanium is a common addition to aluminum weld filler wire as it refines the weld structure and helps to prevent weld cracking [4]. Some improved corrosion properties can be obtained from increasing the Ti contents in aluminum alloys to a level above the normal practice for grain refinement. Tin (Sn) is a minor alloying element in Al alloys. In the past, it was added to increase the fluidity of casting alloys and presently it is added to alloys for bearings [5].Today, Sn is a necessary component in a bearing because of its excellent anti-welding characteristics with iron, (its low modulus and low strength). Since adding of Sn to Al–Si alloys or Si to Al–Sn alloys can meet many of the requirements to attain an acceptable balance of strength and soft surface properties [6].

Therefore, this paper work aims to investigate the effect of Ti and Sn addition with different percentages (1, 2 and 3) wt% on the microstructure, mechanical properties and dry sliding wear resistance of Al-6.9 wt% Si-1,7 %Cu alloy.

2- EXPERIMENTAL PROCEDURE

The chemical composition of Al-Si –Cu alloy is shown in table (1), while the chemical analysis of this alloy after the addition of alloying elements with different percentage of (1, 3 and 5) wt% from Ti and Sn is given in Table (2). The (Ti) powder with particle size (200µm) was heated to 600ºC and maintained at that temperature for about 2 hrs. A 200 gm from Al-Si alloy was melted in a graphite crucible at more than 100 ºC above liquids temperature at 720ºC. The slag was removed by degassing procedure by using calcium florid and argon gas. The calcium florid was added to the molten metal in crucible about 20 minute before adding the Ti powder, and then the slag, which was formed on the surface of molten metal was removed. The Ti powder after being heated at temperature 600°C for 2 hrs for each addition was distributed to very small amounts. Every amount of these quantities was wrapped with Aluminum thin foil, and then added slowly to molten alloy. After each addition of wrapped foil, the molten was quickly stirred by using coated and preheated mild steel plunger for 2-3 minutes at speed of 300 rpm to enable complete dissolution and homogenization. Afterwards the melt was poured into a preheated mold. The mold was heated in the furnace at 220ºC for 1 hr. Also, the alloying element Sn, as a small spherical shape bits was added in different percentages (1, 3, and 5) wt% to the molten Al-Si alloy. The Sn small bits were also put in the oven and heated to 60- 80ºC. Because of the low melting point of tin, Sn small bits they were maintained at that temperature for about 20 min. Tin bits were added to the 200 gm of molten Al-Si alloy after the degassing procedure (by using calcium florid and argon gas) and removing the slag. The small bits of Tin were distributed to every 2 - 4 small bits of Sn then wrapped with a thin foil and added slowly to the molten alloy and quickly stirred by the same process which was used with the titanium addition. Next, then the melt was poured into the preheated mold. 5-10 minutes after casting, the cast was removed out of the mold. The casting, produced after the addition of Ti and Sn, was analyzed with an optical emission spectrometer (model: AMETEK the materials analysis DIVI- ION), as shown in table (2). The samples were cylindrical in shape with 20 mm diameter and 10 mm height. In this case excitation is done by an arc or spark, and the analysis of the spectrum of frequencies of emitted electromagnetic radiation is done to identify the elements. The specimens were prepared by using wet grinding using a grinder machine (model: MOPAO 160E) and emery paper grades (220, 320, 500, and 1000), respectively under the running tap waters. These specimens were then polished by polishing machine model (UNIPOL 820) with 5µm and with 0.5µm alumina slurry. Finelly , the specimens were etched with Killer's solution (1 ml HF+1.5 ml HCL+ 2.5 ml HNO3 +95 ml distilled water).

The microstructures of the prepared Al-Si alloy with the different percentages of Ti and Sn additions were examined under a computerized optical microscope model (BEL engineering metallographic microscopes). The hardness value of all samples was determined by using a Vicker’s hardness testing machine. Tensile tests were carried out by a computer controlled electronic universal testing machine (Model: WDW-100) with a crosshead speed 1mm/min.

Figure (1). Shows the standard tensile test specimen according to the ASTM standard E8M – 00b [7]. .

The impact energy for samples was measured by using Charpy v-notched impact tests. The dimensions of standard Charpy test specimen are according to the ASTM standard E23 [8]. The model of impact machine set is (JB-300B). Pin-On-Disc machine was used to carry out the wear test experiment. A carbon steel disc was used as a counter face with hardness 35 RC. The disc rotational speed was (510 rpm) with a linear sliding speed of 3.7 m/sec.

The linear speed is calculated as follows:-

$$V = \frac{\pi DsN}{1000 \times 60} \qquad (2)$$

Where:-

V= Linear sliding speed (m/sec)

Ds= Sliding circle diameter (140) mm

N= Disc rotational speed (510) RPM

The formula used to convert the weight loss in to wear rate is:-

$$\text{Wear rate (weight loss)} = \frac{\Delta w}{s} \text{ (gm/cm)} \qquad (3)$$

Where:-

∆W= Weight loss of the sample (gm)

W1= Sample weight before the wear test (gm).

W2= Sample weight after the wear test (gm).

The total sliding distance (S) in cm was calculated as:-

$$S = V \times t \qquad (4)$$

Where:-

t= Running time (15 min) for each test

3- RESULTS AND DISCUSSION

3-1 X-ray Diffraction Examination

The charts obtained from the x- ray diffraction analysis of the base alloy (Al-6.9%Si-1.7%Cu alloy) and the same alloy with addition of Ti and Sn of different percentages (1, 3, and 5) wt% , as well as the obtained results are shown in Figure (2) ,(3),(4),(5),(6) (7) and (8), that give the picture about the intermetallic phases which can occur.

3-2 Microstructural Observations

Microstructures obtained from computerized optical microscope are shown in figures (9) and (10) forAl-6.9%Si-1.7%Cu with (1, 3 and 5) % additions of Ti and Sn, respectively. Figures (9) (a) and (10) (a) show that the microstructures of Al-6.9wt%Si-1.7wt%Cu alloy are α-Al and eutectic, the structure has a dendritic shape. Adding of alloying elements (Ti) in different percentages of (1, 3, and 5) wt% as shown in Fig (9) b-d, represents the changing occurs in microstructure. These additions cause the refining in α- phase and modification of eutectic structure. We observed that different intermetallic phases of (TiAl, TiAl2 and Al2Cu) can be observed with the presence of oxides like SiO2 in microstructure, inspected by x-ray diffractometer, as demonstrated in figure (8). When added in different percentages of (1, 3, and 5) wt% Sn , these optical micrographs represent that the refining occurs in grains α-structure and modification of eutectic phases, as shown in figure (10) (b-d). The x-ray inspection exhibites different intermetallic phases like the (β-Sn, and Al2Cu) with the presence of SiO2 and SnO2 oxides. This result agrees with those of researches [9]

3-3-Tensile Examination

From figures (11 to 12) shows the variation of ultimate tensile strength, yield strength and elongation values respectively for Al-6.9% Si with different percentages of Ti and Sn (1, 3,and 5) wt% additions.

For figure (11) that represents the relationship between ultimate tensile strength and weight percentages of Ti and Sn and figure (12) that represents the relationship between yield strength and weight percentages of Ti and Sn, the values of ultimate tensile strength (UTS) obtained from curves and the yield strength (YS) computed by 0.2% offset method are set according to ASTM standard E8M [10]. It is observed that UTS and YS for alloys with Ti additions increase with the increase in weight percentage of titanium. This may be due to precipitated (TiAl or TiAl2), because the increase in Ti content results in an increase in the volume fraction of the relatively hard-phases TiAl and TiAl2. While for the values of UTS and YS for alloys with Sn additions, it can be seen that 1 wt% Sn does not significantly improve the tensile and yield strength .It has a tensile strength and yield strength 146.7 Mpa and 37.79 Mpa respectively, since the original alloy has145.6 Mpa and 37.6 Mpa respectively may be due to the puny effect of Sn on the original alloy when adding 1%wt of Tin [11, 12]. On the other hand, the UTS and YS decrease with the increase in weight percentage of Sn (3 and 5) %, because the increase in weight percentage of Sn causes an increase in presence of β-Sn phase which act as a soft phase. On the other hand. Figure (13) shows that the ductility decreases with the increase weight percentage of Ti, because the microstructure has been changed, whereas the α-Al grains refine and the eutectic modify. Also, the presence of intermetallic hard phases, such as (TiAl and TiAl2) increase gradually with increasing the weight percentage of Ti which led to the gradually decreasing in the elongation. While for the alloys with Sn additions, one can notice that the ductility of all alloys increases with increasing the weight percentage of Sn because of the presence of the ductile β- Sn phase .This phase is always observed to precipitate within Al2Cu networks attached to silicon particles. Generally, Tin is used as a solid lubricant [13, 14].

3-4 Vicker Hardness Examination

The macrohardness tests of all the samples were conducted using a Vickers hardness testing machine. Figure (14) shows the variation of Vickers hardness number of Al-6.9wt % Si-1.7%Cu, with different percentages of Ti and Sn (1, 3, and 5) %. Figure (14) depicts that the hardness of Al-6.9wt%Si-1.7%Cu alloy increase with the increase in the weight percentage of Ti. This may be due to the changes in the morphology of grains that increase with increase in the weight percentage of Ti and increase in the volume fraction of precipitated intermetallic phases (Al2Cu, TiAl and TiAl2). But with addition of Sn the hardness reaches to a maximum value at 1wt% because of the little effect of Sn, represented by the precipitation of intermetallic phase (Al2Cu) only. After that, it decreases with increasing weight percentage above 1% of Sn, because of the morphology of grains changes to larger size, where Sn is in the form of black reticulate particles of (β-Sn). This phase is soft and always observed to precipitate within Al_2Cu networks attached to Si particles. Generally, Sn is as a solid lubricant [13, 14].

3-5 Impact Examination

The impact tests of all samples were carried out by Charpy v-notched impact tests. The results are noted in the corresponding curves and are drawn as shown in the figure (14).The results showed that the impact energy of two alloys with adding (Ti and Sn) decreases with increase in amount of Ti and Sn addition. Although the impact energy backs to increase at 5% of Ti and Sn , it is still smaller than that of the base alloy(Al-6.9%Si-1.7%Cu) , that can occur due to the precipitating of harder TiAl and TiAl2 phases for alloys with titanium addition which causes embrittling effect and microcracking [15,16]. For alloys with Sn addition, although the soft β-Sn phase may cause the decrease in impact energy, but the alloys with Sn additions have impact energy slightly larger than that for alloys with Ti additions.

3-6 Wear Examination

In this research three applied loads were used, (2.5,5,.and7.5) N in order to study the effect of loads on these wear resistance under constant sliding speed of 3.7 m/sec. Figure (16) shows that the wear rate increases with the increase in load and weight percentage of Ti. The cause of increase in the wear rate at increasing of applied load is due to increasing plastic deformation at tip of the specimen surface – asperities [17]. This can be explained by increase in the dislocation density and tiny increase in the hardness and brittleness of metal gradually [14, 18]. In addition to the effect of increasing applied load on the wear rate, the added alloying elements have an effect on the wear rate .In figure (16), it is noted that the Ti content increases as the wear rate of alloys increases

This may be due to the tendency for embrittlement and microcracking brought about by (TiAl and $TiAl_2$) particles. For alloys with (1, 3, and 5) wt%Sn additions, figure (17) reveals the results of the wear rate and depicts that on increasing the amount of Sn, the wear rate decreases. This may be due to the Sn which is a soft metal that is generally used in Babbitt alloys as a solid lubricant in plain bearings. The Sn metal solidifies along the grain boundaries of aluminum [19]. This Sn provides an interface between the pin and disc while sliding. As the pin wears the harder particulate is exposed, with the matrix eroding somewhat to provide a path for lubricant to flow between the rubbing surfaces. It provides an anti-frictional surface to reduce wear [19, 20]. Figures (18) to (19) represent the surface topography of different worn surfaces of (Al-6.9%Si-1.7%Cu), (Al-6.9%Si-1.7%Cu- 3%Ti) and (Al-6.9%Si-1.7%Cu-3%Sn) under low and high loads under dry sliding conditions. When noting the surface topography, the white color represents the high temperature caused by the friction. On the other hand, the black color represents the oxides layers which occurs on the surfaces. The surface that shows the highest wear rates is free from this layer. This clearly indicates that the wear rate can be related to the presence of this layer, which may act as a protective layer.

3-7. Conclusions

1) Modification of the silicon in eutectic structure and refining in the primary α-Al with increasing Ti and Sn amounts.
2) Yield strength and ultimate tensile strength increase with the increase in weight percentage of Ti, but decrease with the increase in weight percentage of Sn. The impact toughness decreases with increase in amount of both Ti and Sn.
3) The total elongation decreases with the increase in weight percentage of Ti. While, it increases with the increase in weight percentage of Sn.
4) Hardness of Al-6.9%Si-1.7%Cu alloy increases with the increase in amount of Ti present. While for alloys with Sn additions, although the hardness decreases with increase the Sn amount, but the all value of hardness are still larger than that for the base alloy (Al-6.9%Si-1.7%Cu).
5) The wear resistance increases with increasing the percentage of Sn. But it decreases with increasing the percentage of Ti.

REFERENCES

1) Stadler .F, Antrekowitsch. H, Fragner. W, Kaufmann. H, Pinatel. E. R and Uggowitzer. P. J, ′The effect of main alloying elements on the physical properties of Al–Si foundry alloys″, J .of Materials Science and Engineering, A560, pp.481-491, 2013.
2) Okayasu. M, Ohkura. Y, Takeuchi. S, Takasu. S, Ohfuji .H, and Shiraishi. T, "A study of the mechanical properties of an Al–Si–Cu alloy (ADC12) produced by various casting processes", Mater. Sci. Eng. A 543, 185–192, 2012.
3) J. Kim, C. Daniel Marioara, R. Holmestad, E. Kobayashi and T. Sato, Effects of Cu and Ag additions on age-hardening behavior during multi-step aging in Al–Mg–Si alloys, Mater. Sci. Eng. A 560, PP. 154–162, 2013.
4) Muzaffer Zeren and Erdem. K , " Influence of Ti addition on the microstructure and hardness properties of near – eutectic Al-Si alloys , J. of Alloys and Compounds , Vol.450 , pp .255. 2008.
5) Mallapur. D.G, "Influence of Ti, B and Sr on the microstructure and mechanical properties of A356", International J. of Mechanical Engineering, Vol.1, pp.49, 2010.
6) Yuan. G. C, Li. Z. J, Lou. Y. X and Zhang. X. M, Jo. of Mater. Sci. Eng, A 280, pp.108, 2000.
7) (ASTM)E 8M – 00b, Standard Test Methods for Tension Testing of Metallic Materials, An American National Standard, Vol.8, pp 6,2000.

8) ASTM E23 Standard Test Methods for Notched Bar Impact Testing of Metallic Materials.
9) Mulazimoglu .M. H, Tenekedjiev. B. M, Closset .J. E and Gruzleski, ″Studies on the Minor Reactions and Phases in Strontium-treated Aluminum Silicon Casting Alloys″, J. of Cast Metals, Vol. 6, pp. 16-28,1993.
10) E8M-03,″Standard Test Method for Tension Testing of Metallic Materials(Metric)″,ASTM Annual Book of Standards West Conshohocken, Vol .3, No.1 PA, 2003.
11) Zhang. G.A and Wu. X. F , ″Effect of Sn Addition on Microstructure and Dry Sliding Wear Behaviors of Hypereutectic Aluminum–Silicon Alloy A390″, J. of Materials Science, Vol.46, pp. 7319-7327,2011.
12) Samuel .F.H, Samuel .A.M and Doty .H.W, "Factors Controlling the Type and Morphology of Cu-Containing Phases in 319 Al Alloy", J. of AFS Transactions, Vol.104, pp.893-903, 1996.
13) Mohamed .A.M.A, Samuel. F. H, Samuel. A. M, Doty. H. W and Valterra. S, ″Influence of Tin Addition on the Microstructure and Mechanical Properties of Al-Si-Cu-Mg and Al-Si-Mg Casting Alloys″, J. of Metallurgical and Materials Transactions A, Vol. 39, pp.490-501, 2008.
14) Sugishita J. and Fujiyoshi S., ″The Effect of Cast Iron Graphite Friction and Wear Performance″ ,J. of Wear ,Vol.77, pp. 181-193, 1982
15) Majed Jaradeh and Torbjorn Carlberg ,"Effect of Titanium Additions on the Microstructure of DC-cast Aluminum Alloys" , J. of Materials Science and Engineering, No .A 413–414 , pp. 277–282,2005.
16) Zeren. M and Karakulak. E,″ Microstructural Characterization of Al–Si–xTi Cast Alloys″, J. of Materials Science and Technology, Vol.25, No.10, pp.1211-1214,2009.
17) Polmear .I.J, ″Light Alloys: Metallurgy of the Light Metals″ ,J. of Technology & Engineering , vol. 23, p. 117, 1999.
18) Israa .A.K, ″The Effect of Lead Addition on the Wear Resistance of Al -16% Si Alloy Under Dry Sliding Conditions ″, J. of Engineering and Technology , Vol.24, No.1,, pp.56-64,2005.
19) Anli.M,Srivastava.V.C ,Ghosh.M.K andOjha.S.N ,″Influence of Ticontent on Tribological Characteristics of Spray Formed Al-Si Alloys″, J. of Wear, Vol.268, pp.1250-1256, 2010
20) Chaudhury. S. K. Singh. A. K, Sivaramakrishnan. C.S and Panigrahi S. C, ″Wear and Friction Behavior of Spray Formed and Stir Cast Al–2Mg–11TiO2 Composites″, J. of Wear, Vol. 258 (5-6), pp. 759-767, 2005.

Table (1) The chemical analysis of Al-Si-Cu alloy

sample	Si%	Cu%	Fe%	Mn%	Mg%	Cr%	Ni%	Zn%	Ti%	Pb%	Sn%	V%	Al%
No1	6.92	1.721	0.496	0.122	0.043	0.022	0.101	0.947	0.127	0.039	0.025	0.007	Rem

Table (2) The chemical analysis of Al-Si-Cu alloy after the addition of alloying element

sample	Si%	Cu%	Fe%	Mn%	Mg%	Cr%	Ni%	Zn%	Ti%	Sn%	Pb%	V%	Al%
Sample1	6.87	1.648	0.422	0.117	0.025	0.017	0.092	0.832	0.815	0.017	0.023	0.002	Rem
Sample2	6.90	1.693	0.463	0.110	0.031	0.013	0.089	0.754	2.560	0.021	0.031	0.001	Rem
Sample3	6.85	1.589	0.489	0.123	0.029	0.016	0.090	0.668	4.423	0.016	0.025	0.005	Rem
Sample4	6.92	1.610	0.461	0.113	0.049	0.015	0.086	0.896	0.115	0.942	0.029	0.003	Rem
Sample5	6.84	1.683	0.456	0.119	0.033	0.018	0.090	0.903	0.121	2.720	0.033	0.001	Rem
Sample6	6.89	1.636	0.445	0.111	0.023	0.020	0.082	0.837	0.113	4.834	0.019	0.005	Bal

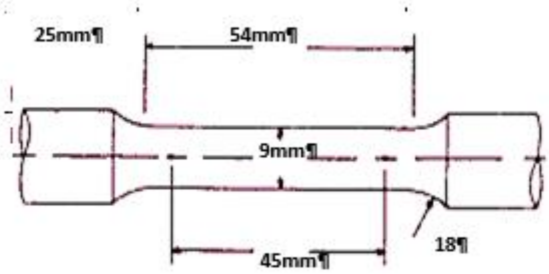


Figure (1): Standard tensile test specimen

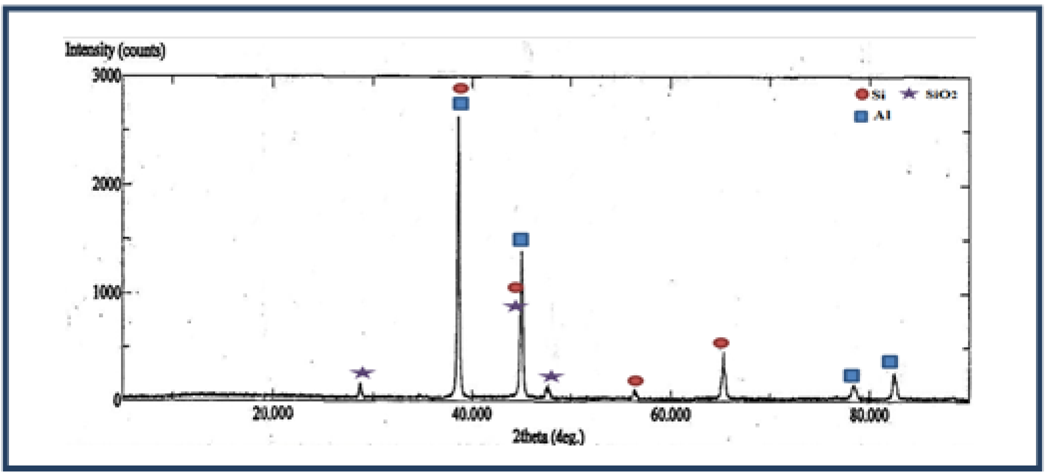


Figure (2): The results of x-ray diffraction for the base alloy (Al-6.9%Si-1.7%Cu) alloy

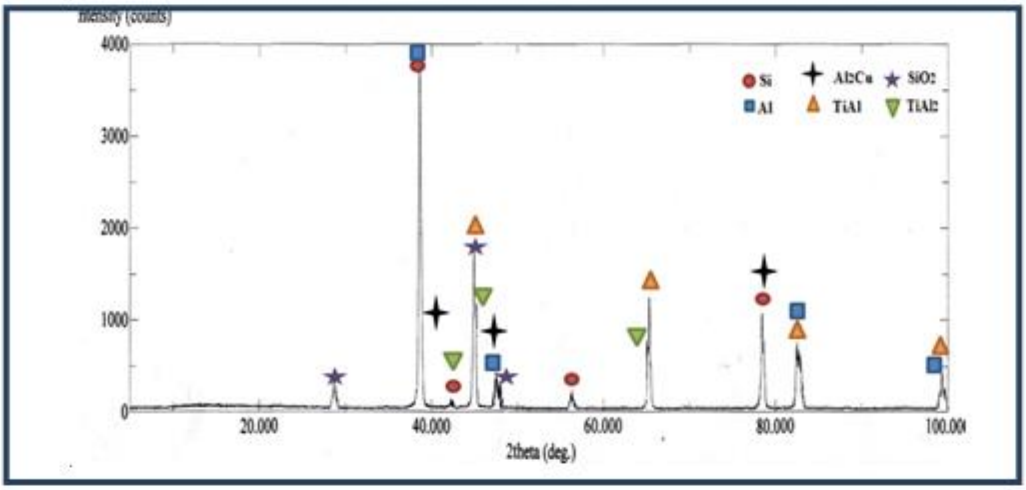


Figure (3): The_results of X – ray diffraction for (Al-6.9%Si-1.7%Cu) alloy after adding 1 wt % Ti.

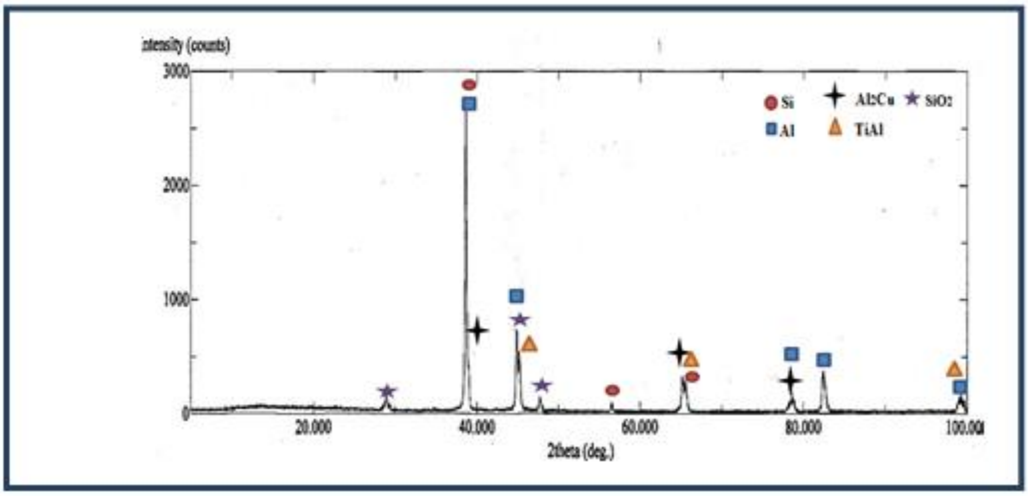
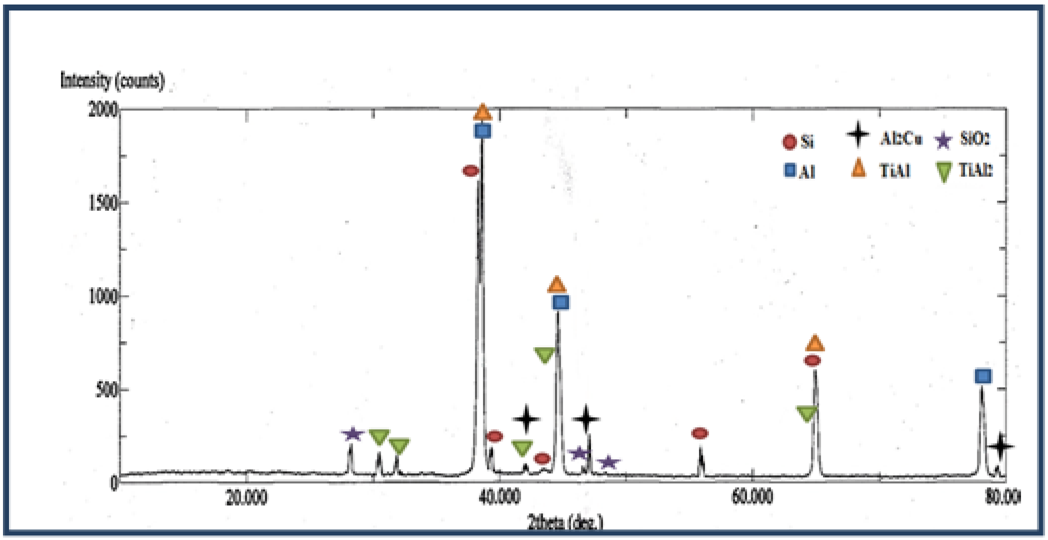


Figure (4): The results of X – ray diffraction for (Al-6.9%Si-1.7%Cu) alloy after adding 3 wt% Ti



. Figure (5): The results of X – ray diffraction for (Al-6.9%Si-1.7%Cu) alloy after adding 5wt% Ti

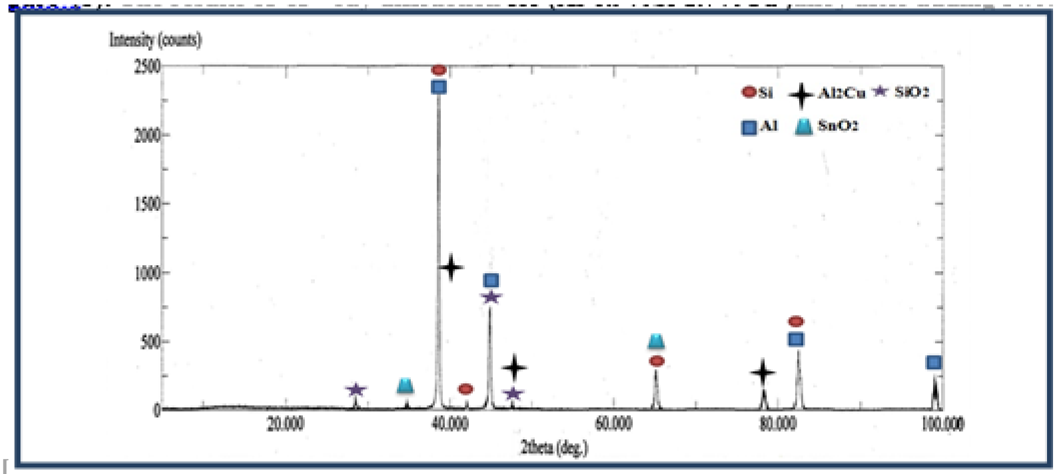


Figure (6): The results of x-ray diffraction for (Al-6.9%Si-1.7Cu) alloy after adding 1 wt% Sn.

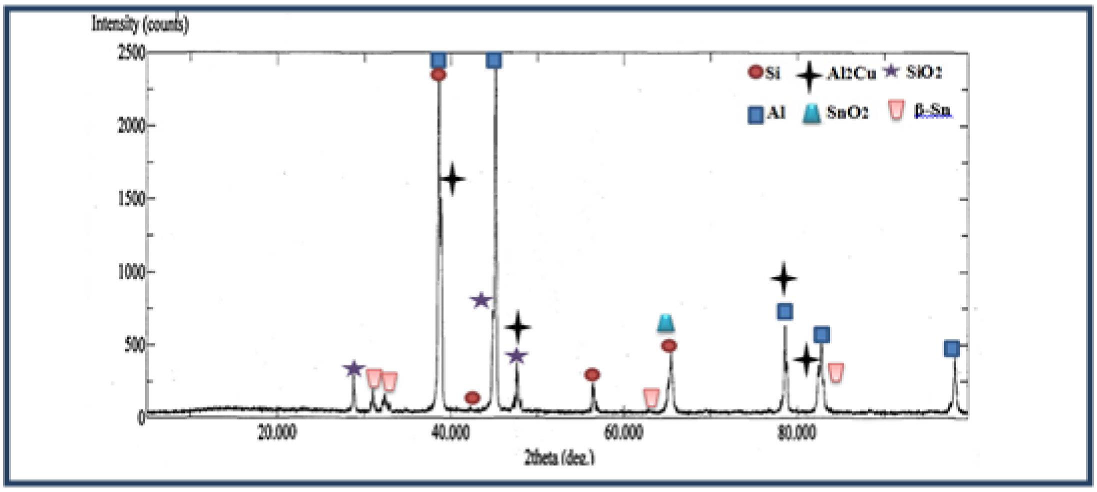


Figure (7): The results of x-ray diffraction for (Al-6.9%Si-1.7Cu) alloy after adding 3 wt% Sn

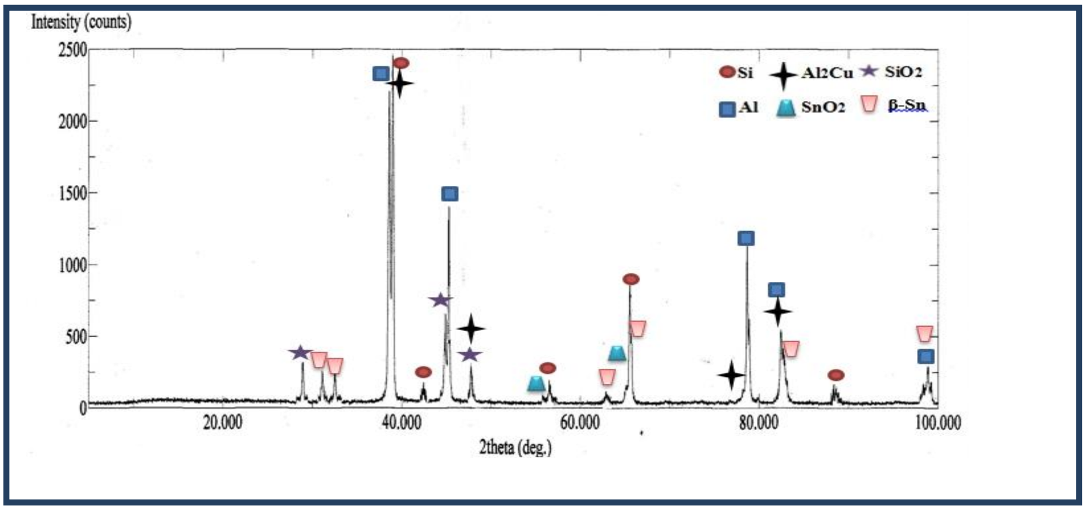
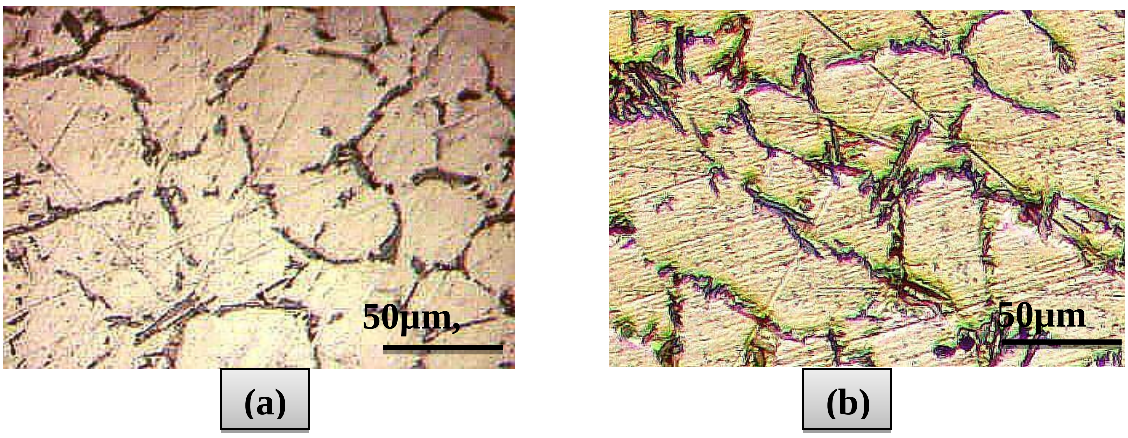


Figure (8): - The results of x-ray diffraction for (Al-6.9%Si-1.7Cu) alloy after adding 5 wt% Sn.



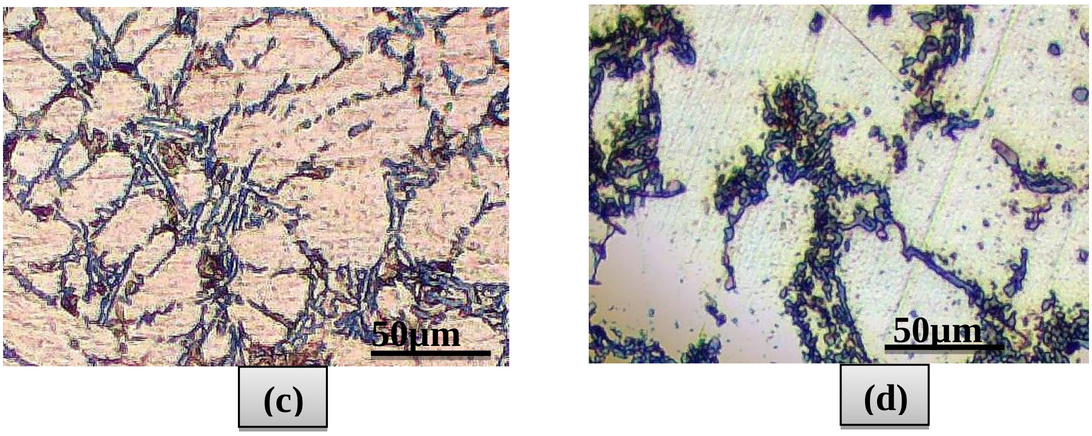


Figure (9): Optical micrographs of Al–6.9%Si-1.7%Cu and Al–Si–-Cu- xTi alloys. (a) Al–6.9Si-1.7Cu,

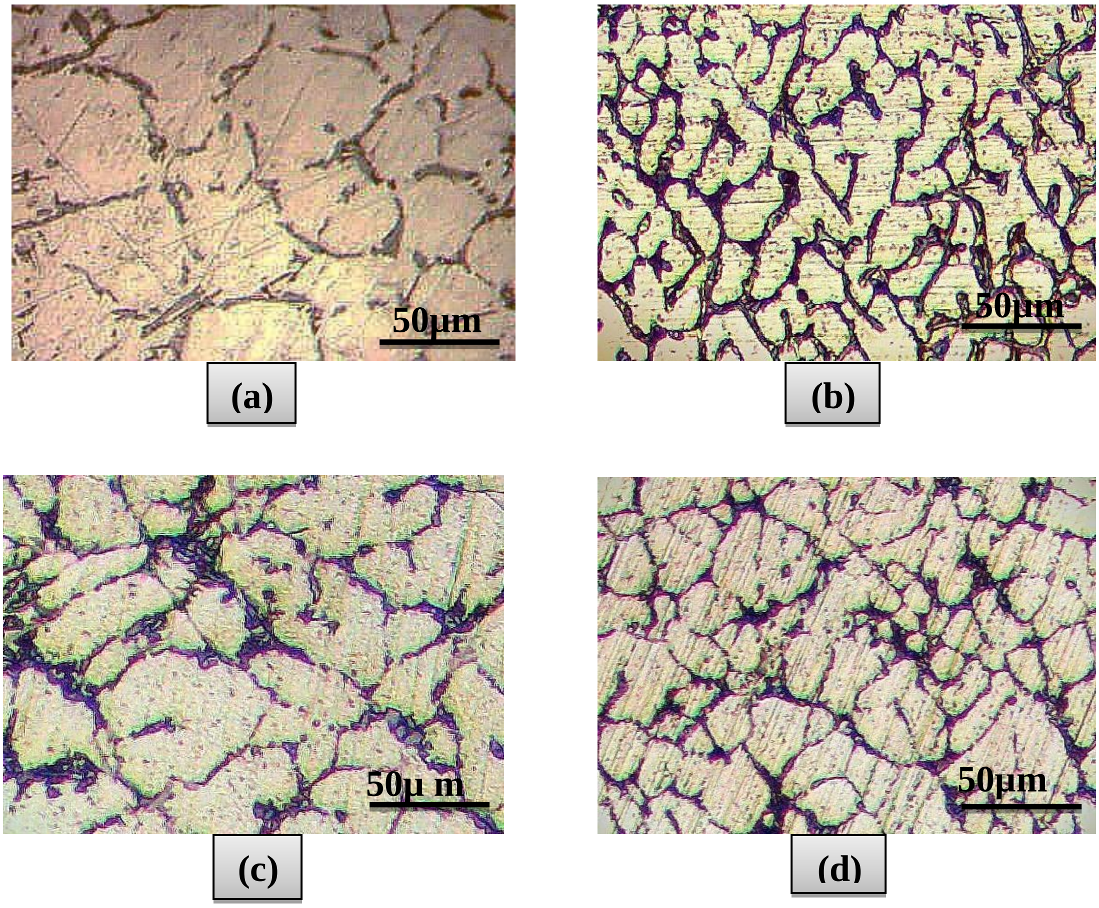


Figure (10): Optical micrographs of Al–6.9%Si-1.7%Cu and Al–Si–xSn alloys. (a) Al–6.9Si-1.7Cu, (b). Al–6.9Si-1.7Cu-1Sn, (c) Al–6.9Si-1.7Cu-3Sn, (d) Al–6.9Si-1.7Cu-5Sn.

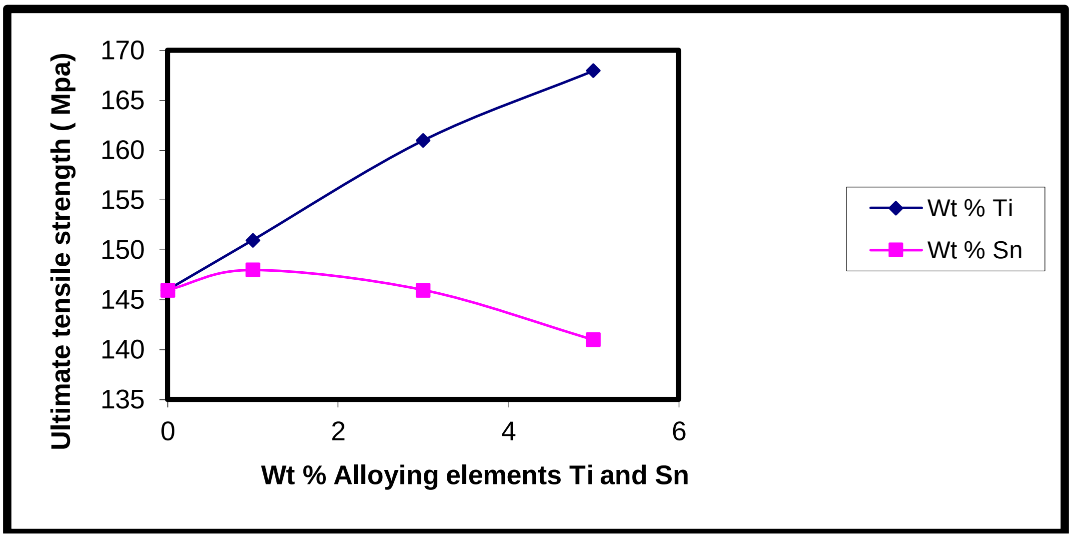


Figure (11) : Effect of Ti and Sn additions with different percentages (1, 3 ,and 5) wt% on the Ultimate Tensile Strength (in Mpa) of Al-6.9%Si-1.7%Cu alloy.

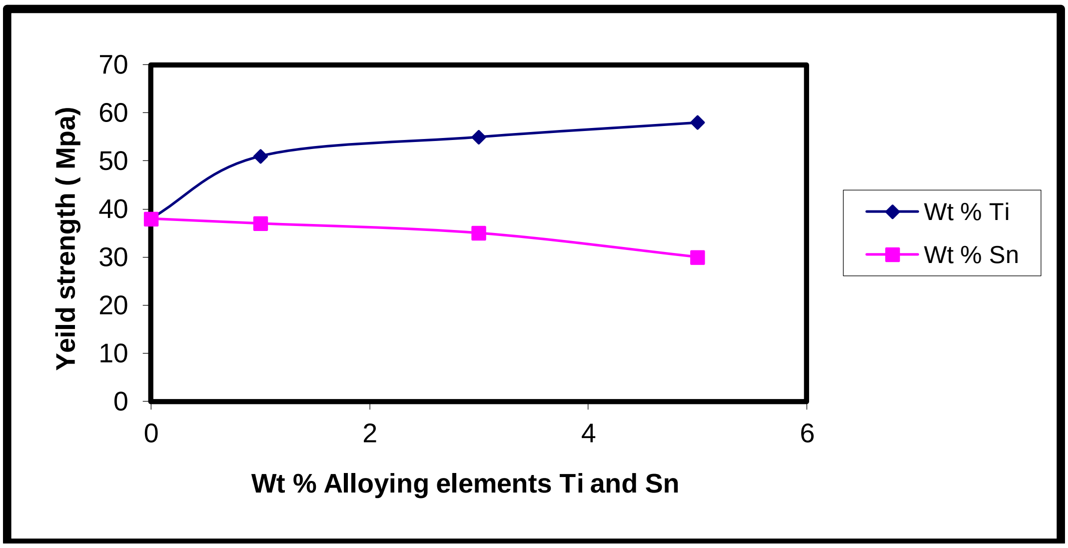
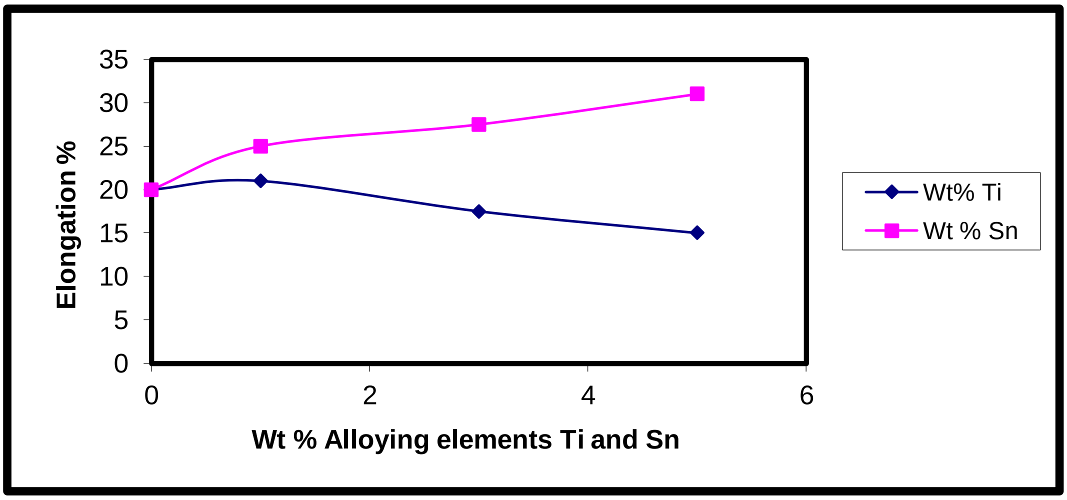


Figure (12): Effect of Ti and Sn additions with different percentages (1, 3, and 5) wt % on the Yield Strength (in Mpa) of Al-6.9%Si-1.7%Cu alloy.



.**Figure (13):** Effect of Ti and Sn additions with different percentages (1, 3, and 5) wt % on the Elongation of Al-6.9%Si-1.7%Cu alloy .

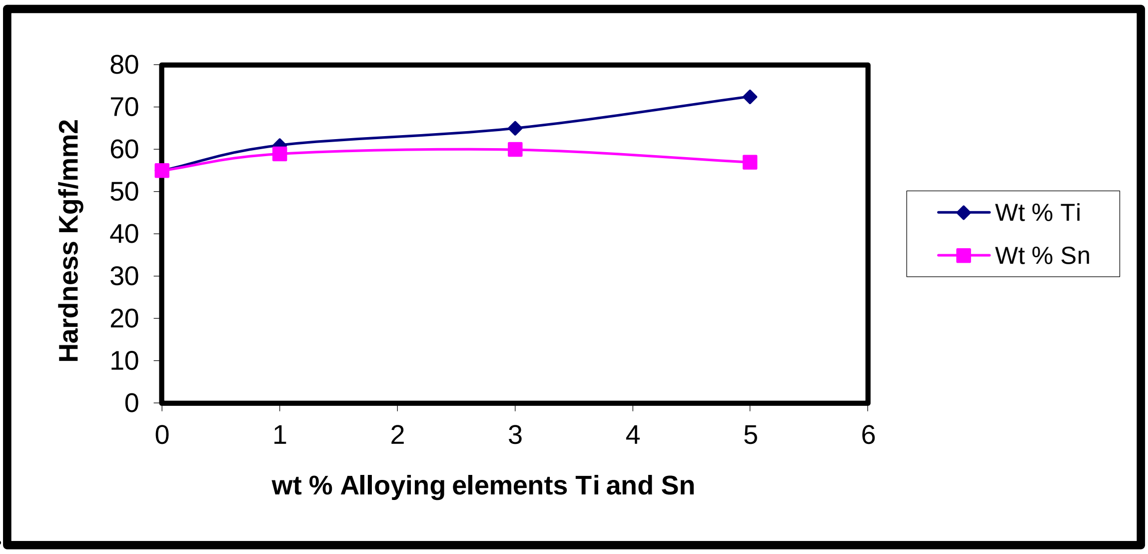


Figure (14): Effect of Ti and Sn additions with different percentages (1, 3, and 5) wt% on the macrohardness of Al-6.9%Si-1.7%Cu alloy

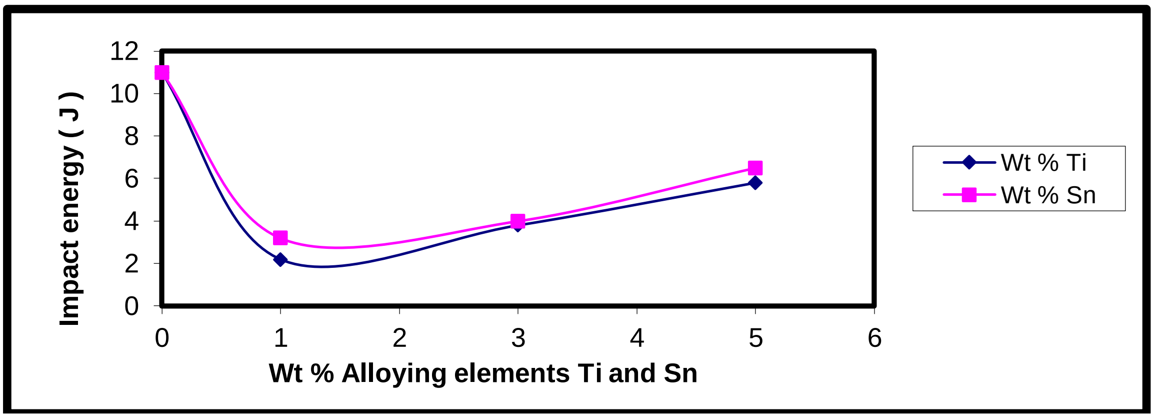


Figure (15): Effect of Ti and Sn additions with different weight percentage (1, 3 and 5)wt% on the impact energy of Al-6.9%Si-1.7%Cu .

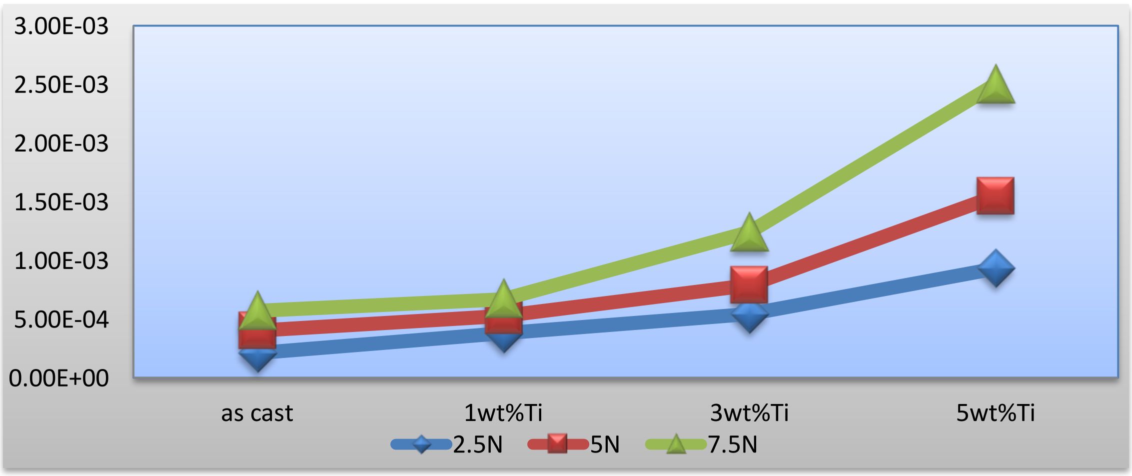


Figure (16): Effect of 1%, 3%and 5%Ti additions on wear rate of Al-6.9%Si- 1.7%Cu.

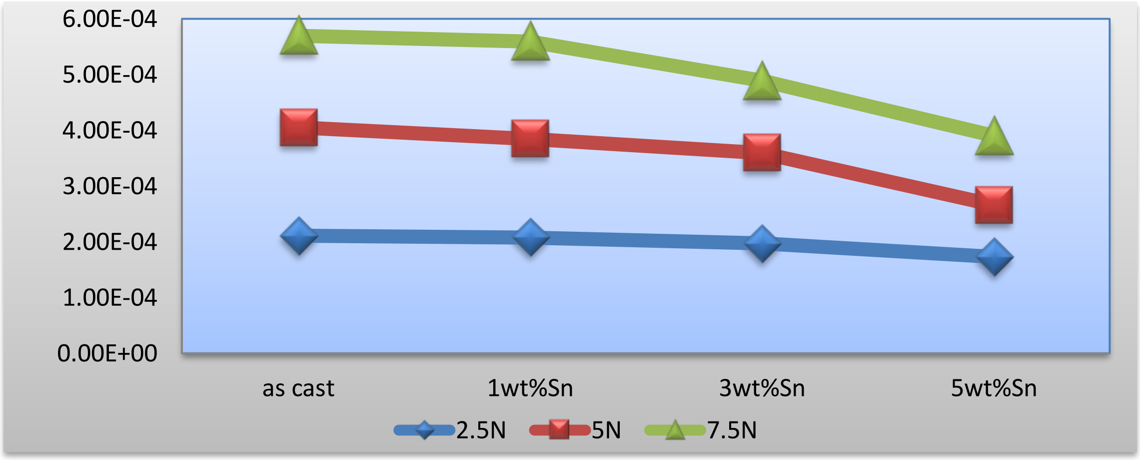


Figure (17): Effect of 1%, 3%and 5%Sn additions on wear rate of Al-6.9%si- 1.7%Cu

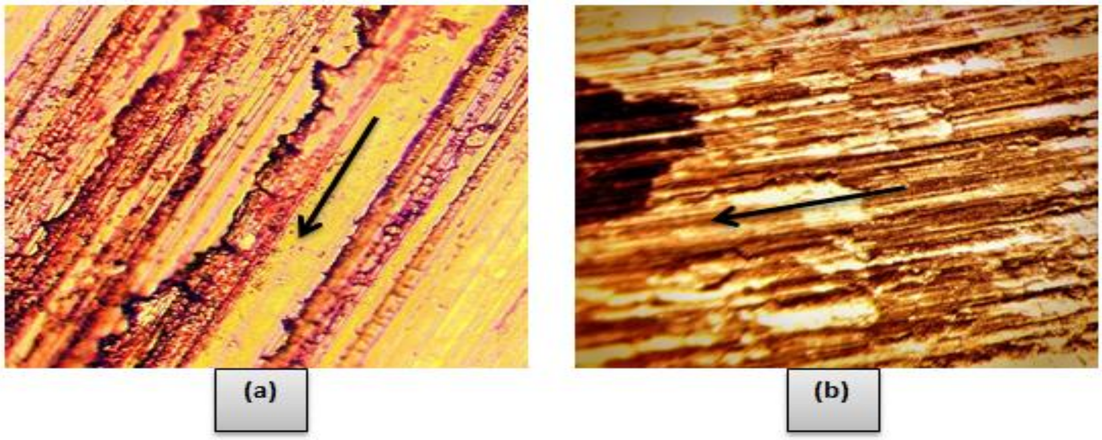


Figure (18): Optical micrographs of the surface topography of different worn surfaces under low and high loads of (2.5 and 7.5)N and under dry sliding conditions for Al–6.9Si-1.7%Cu-3%Ti alloy, a- 2.5N, b- 7.5N, Mag.125.

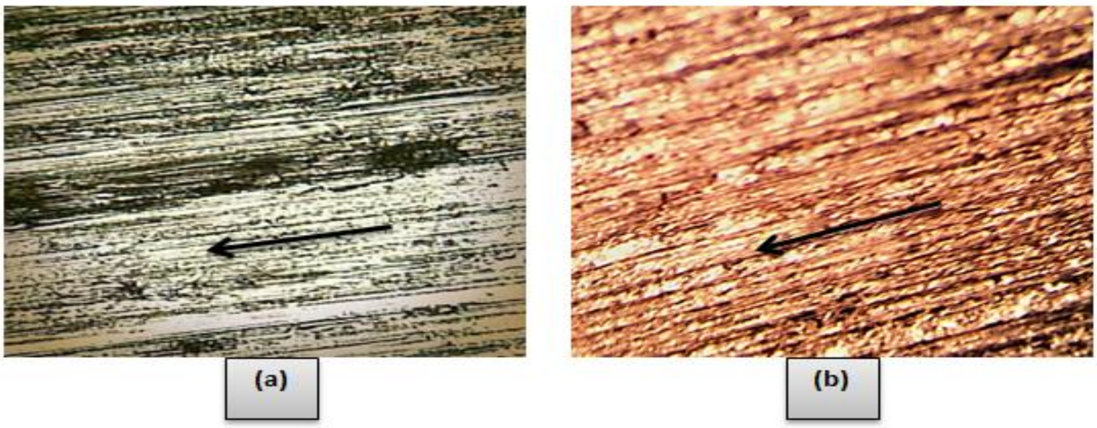


Figure (19): Optical micrographs of the surface topography of different worn surfaces under low and high loads of (2.5 and 7.5)N and under dry sliding conditions for Al–6.9Si-1.7%Cu -3%Sn alloy, a- 2.5N, b- 7.5 N .Mag .125X.

تأثير اضافة Ti و Sn على الخواص الميكانيكية لسبيكة الومنيوم – سليكون – نحاس

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الخلاصة

يهدف البحث الحالي الى دراسة تاثير اضافة القصديروالتيتانيوم بنسب مئوية وزنية مختلفة (1,3,5) % على البنية الدقيقة والخواص الميكانيكية ومقاومة البلى الانزلاقي الجاف لسبيكة الومنيوم–6.9–سيليكون–1.7نحاس.
لقد كان حجم دقائق مسحوق التيتانيوم المضافة 200.ميكروميتر و ولكن تم اضافة القصدير بشكل قطع صغيرة الى السبيكة .
تم اجراء الفحص المجهري باستخدام المجهر الضوئي للسبيكة قبل وبعد اضافة العناصر السبائكية حيث بينت حدوث تغير في شكل الحبيبات كما حدث ترسيب مركبات كيمياوية واطوار اخرى TiAl, $TiAl_2$, Al_2Cu and β-Sn عند اجراء فحص بالاشعة السينية . الخواص الميكانيكية التي تمت دراستها هي مقاومة الشد ومتانة الصدمة والصلادة. حيث اظهرت النتائج ان مقاومة الشد ومقاومة الخضوع والصلادة تزداد مع زيادة نسبة التيتانيوم المضاف بينما تقل بزيادة نسبة القصدير المضاف. ومن ناحية اخرى فأن المطيلية تقل عند زيادة نسبة التيتانيوم المضاف لكنها تزداد بزيادة نسبة القصدير المضاف. كما بينت نتائج اختبار متانة الصدمة ان السبائك المضاف اليها عناصر سبائكية تكون متانة الصدمه لها اقل مما هو عليه للسبيكة الاساس.النتائج اظهرت ايضا ان الصلادة تزداد مع ازدياد نسبة التيتانيوم المضاف, اما بالنسبة للسبائك المضاف لها قصدير فان الصلادة تصل الى اعلى مستوى لها عند الـ 1% قصدير ومن ثم تبدا بالنقصان تدريجيا مع زيادة نسبة القصدير المضاف, ولكن جميع قيم الصلادة للسبائك المضاف لها قصدير تبقى اكبر من الصلادة للسبيكة الاساس. لقد تم استخدام تقنية المسمار على القرص لبيان مدى مقاومة البلى للسبيكة الاساس وللسبيكة بعد اضافة العناصر السبائكية حيث تبين ان مقاومة البلى للسبيكة المضاف اليها عنصر القصدير تزداد مع ازدياد نسبة عنصر القصدير بينما تقل مقاومة البلى مع ازدياد نسبة التيتانيوم المضافة عند تسليط احمال مختلفة (2.5,5,7.5) نيوتن وسرعة انزلاق ثابته 3.7 م/ ثانية.

الكلمات المفتاحية: الومنيوم –6.9% سيليكون–1.7 نحاس, العناصر السبائكية القصدير والتيتانيوم, الخواص الميكانيكية, مقاومة البلى.