AN EXPERIMENTAL STUDY ON MECHANICAL PROPERTIES OF AL-CU-MG-SI ALLOY REINFORCED BY MICRO AND NANO CERAMIC PARTICLES

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“I declare that all the information within this thesis has been gathered and presented in accordance with academic regulations and ethical principles and I have according to the requirements of these regulations and principles cited all those which do not originate in this work as well.”

Mhmood Salim Hassoon HASSOON

ABSTRACT

M. Sc. Thesis

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Nowadays, due to the increasing need, the demand for reinforced aluminum alloys has increased due to its high efficiency and the distinctive properties it possesses, which are suitable for superior industrial progress and development, which are known as aluminum-based composite or composite materials. Engineering materials (aluminum matrix composite). It consists of two materials. Or more, of different properties, one of which may be a metallic alloy of aluminum, and the other may be a support material, either metallic, vitreous, or ceramic. In this paper, alloy-based composite materials (Al, Cu, Mg, MN, and Si) were studied. It was fortified with Nano Y2o3 (1.2.3 % Wt.) and MicroY2o3 (1.2.3% Wt.) and a mixture of Nano Y2o3 and MicroY2o3 (1.2.3% Wt.) in percentage, using the die casting method to obtain a hybrid aluminum with improved mechanical properties. In addition, we have performed mechanical examinations and tests on all prepared samples. Electron microscopy results showed the distribution of the supporting hybrid particles in a homogeneous manner, hence the success of the hybrid composite material by the casting method by mixing. The results showed improved impact toughness, yield stress, tensile strength and corrosion resistance because of the addition of reinforcing particles of micro-materials, and hybrid materials of Nano- and micro-materials. The best mechanical properties appeared when adding 2% MicroY2o3. Compared to the rest of the samples.

Key Word : Mineral matrix compounds; Nano y2o3 Micro y2o3; Mechanical properties.

Science Code : 91512

ÖZET

Yüksek Lisans Tezi

MİKRO VE NANO SERAMİK PARÇACIKLARLA GÜÇLENDİRİLMİŞ AL-CU-MG-SI-ALAŞIMININ MEKANİK ÖZELLİKLERİNİN İNCELENMESİ.

Mhmood Salim Hassoon HASSOON

Karabük Üniversitesi
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Günümüzde artan ihtiyaç nedeniyle, alüminyum esaslı kompozit veya kompozit malzemeler olarak bilinen, üstün endüstriyel ilerleme ve gelişmeye uygun, yüksek verimliliği ve sahip olduğu ayırt edici özellikler nedeniyle güçlendirilmiş alüminyum alaşımlarına olan talep artmıştır. Mühendislik malzemeleri (alüminyum matris kompozit). İki malzemeden oluşmaktadır. Veya daha fazla, farklı özelliklerde, bunlardan biri metalik bir alüminyum alaşımı olabilir ve diğeri metalik, camsı veya seramik bir destek malzemesi olabilir. Bu yazıda alaşım bazlı kompozit malzemeler (Al, Cu, Mg, MN ve Si) incelenmiştir. Nano Y2o3 (%1,2,3 Wt.) ve MicroY2o3 (%1,2,3 Wt.) ve Nano Y2o3 ve MicroY2o3 (%1,2,3 Wt.) karışımı ile basınçlı döküm yöntemi kullanılarak güçlendirilmiş ve elde edilmiştir. geliştirilmiş mekanik özelliklere sahip bir hibrit alüminyum. Ayrıca hazırlanan tüm numuneler üzerinde mekanik incelemeler ve testler gerçekleştirdik. Elektron mikroskobu sonuçları, destekleyici hibrit partiküllerin homojen bir şekilde dağıldığını, dolayısıyla hibrit kompozit malzemenin karıştırılarak döküm yöntemiyle başarısını göstermiştir. Sonuçlar, mikro malzemelerin takviye edici parçacıklarının ve Nano ve mikro malzemelerin hibrit malzemelerinin eklenmesi nedeniyle gelişmiş darbe tokluğu, akma gerilimi, çekme dayanımı ve korozyon direnci gösterdi. En iyi mekanik özellikler %2 MicroY2o3 eklendiğinde ortaya çıktı. Örneklerin geri kalanıyla karşılaştırıldığında.

Anahtar Kelime : Mineral matriks bileşikleri; Nano y2o3 Mikro y2o3; Mekanik özellikler

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SYMBOLS

ASTM	: American society for testing material
(MMCs)	: Matrix metal composites
(CMCs)	: Ceramic matrix compounds
ISO	: International standard organization
Y2O3	: Yttrium
(CMCs)	: Ceramic matrix composites
(PMCs)	: Polymer Matrix composites
(XRD)	: X-ray diffraction
(SEM)	: Scanning electron microscope
(SED)	: X-ray energy distributed spectroscopy (EDS)

PART 1

INTRODUCTION

Aluminum is the abundant metal in all countries. It is used as much as steel. In addition, because of the properties that compensate for the use of steel or other metals in some industries. [1]. It is a soft, flexible metal with high corrosion resistance, high electrical conductivity, and lightweight. Aluminum is widely used in metallic cables and electrical and thermal conductors, and it is an engineering metal whose strength-to-weight ratio is superior to that of steel.[2]. It has a large and wide number of modern uses of technological progress, such as aluminum cutting and forming, sheet and rod fabrication, and offers more efficient and cost-effective solutions, alloys are used in large-scale fields. It has high fluidity, good melting points, lightweight, high surface expansion and finish. [3, 1]

Aluminum and its alloys are characterized by good qualities through reinforcement with reinforcing materials, and these qualities are used in a wide range of fields. The main advantage of composite materials with aluminum when compared to pre-reinforced materials is

1. Aluminum has great strength and has high hardness, especially when some elements are added to it.
2. It has a low weight density.
3. It can maintain its properties at high temperatures.
4. It has a controllable thermal expansion coefficient.
5. It has high electrical conductivity. In addition, it has super adaptability.
6. Very good abrasion and friction resistance compared to its density. [4,5]

The properties of aluminum improve upon the addition of mechanical strengthening materials and give good results that benefit from increasing the properties of aluminum, including electrical conductivity, fatigue resistance, high hardness, tensile strength and high pressure resistance. Aluminum alloys have some defects when adding reinforcing materials, which may be a decrease in tensile strength, hardness or corrosion, depending on the additives and their properties. [5, 6] Aluminum forms a layer of oxide whenever it is exposed to air, which makes it resistant to corrosion. This layer gives aluminum resistance to acids and alkalis. It does not dissolve in alcohol or even water. It has some solubility in water under certain conditions. Its atoms are linked to each other in the form of a cubic face with an FCC axis.[6]. Aluminum has nine isotopes. Aluminum powder has the property of silver reflection, so it is used in the manufacture of high-reflective mirrors and in the manufacture of silver plating. Increasing the tensile strength of pure aluminum by blending it with other elements such as copper, silicon and magnesium to make aluminum alloys[7].

1.1. ALUMINUM APPLICATIONS.

Aluminum uses. Aluminum is one of the important chemical elements on which modern industry is based because of its properties that are rarely found in a single element, such as lightweight, strength, hardness, formability, and resistance to external influences such as corrosion. It is used in the transportation industry. Ships, aircraft and military missiles. The use of aluminum alloys in the field of construction. It is used in the manufacture of household appliances, door and window frames. . Electrical conductors industry. Jewelry industry. And the effect of aluminum on human health, as aluminum is a non-toxic element, and it does not have any negative or harmful effect on the body [8].

Due to the quality properties that this element possesses, aluminum is capable of accelerating and maneuvering ships. Aluminum is distinguished by its high current conducting. Thus, it can rightfully compete with copper. With almost the same electrical conductivity, it has become an economical alternative. It is actively used in microelectronics, in the manufacture of components for microcircuits. The application fields of aluminum are very wide. In particular, it became the first unique material for the manufacture of structures and large parts in aircraft. Weight reduction is another important aspect of aircraft design, as evidenced by the 20% improvement in the efficiency of the Boeing 787 achieved mainly by reducing the overall weight [9]. In addition, missile, food processing, kitchen and tool industries. It is also widely used in the automotive industry. The average vehicle currently produced in North America contains about 90 kg of aluminum[10] he formation of an insulating layer that can create a high temperature in the places of adhesion. There are certain requirements for using aluminum as a conductor. Aluminum alloys are economical in many applications; they are used in the automotive industry, the aerospace industry, and in building machinery, appliances, structures, cookware, and hoods.

For electronic equipment casings, as pressure vessels for Cryogenic applications, and in countless other areas[11]

1.2. CLASSIFICATION OF ALUMINUM ALLOY

Aluminum and various alloys can be divided into two main sections. The first section is the section for cast alloys, and the other section is the section for worked alloys. Both sections can be divided into the section of alloys that are treated with heat, and the other section is the section that is not treated with heat. Each section has its own uses and properties that are used, according to what is mentioned. Below, each in detail. [12]

1.2.1. Casting Alloy

Cast aluminum alloys have relatively lower melting temperatures compared to steel and cast iron, have small solubility in gases except hydrogen, good fluidity, and good surface finish. However, these alloys have a higher shrinkage (up to 7%) that occurs during quenching or solidification. Table (2.1) shows cast aluminum alloys. This group includes non-heat-treatable alloys and heat-treatable alloys and includes a range of 2 x x.x Al-Cu series, including 3 x x.x Al - Si + Cu or Mg series, and 4x x.x Al - Si series, including 5x x.x Al - Mg series, 6 x x.x, 7 x x.x Al - Zn, 8 x x.x Al - Sn. 2 x x.x, 3 x x.x, 7 x x.x and 8 x x.x alloys can be hardened by accelerated hardening, the properties obtained from heat treatment are high and better than the properties before heat treatment but the properties obtained are not as high as those of the produced alloys heat treatment [13]

1.2.2. Wrought Aluminum Alloy.

Forged aluminum ingots indicate that the ingot has undergone certain machining processes. Forged ingots are produced by thermomechanical treatment of ingots cast into mill products such as bars, plates, plate extrusions, bars and wires[14]. Table (2.2) shows the main classes of forged aluminum alloys. Like cast ingots, wrought ingots are also identified by a four-digit system. Aluminum ingots that are produced by forging or casting, according to the specifications of the relevant casting elements, are divided into ingots that are heat treated in order to improve their properties, and ingots that are not heat treated. Heat treated alloys are those alloys which are mainly hardened by solution treatment or by aging which is called precipitation hardening. As for those that are not heat treated, they depend mainly on cold hardening work.

1.2.2. A. Non-Heat-Treated Alloys

Through Table (1.1), we review the produced aluminum alloys. This table shows that the alloy has undergone certain manufacturing processes. Formed ingots were produced by thermomechanical treatment of ingots cast into mill products such as billets, slabs, plate extrusions, billets and wires. [15]. Alloys produced by precipitation hardening cannot be strengthened and their properties can be improved further when heat treated. However, they can be strengthened by cold work. They include alloys of 1 xxx of commercial pure aluminum, as well as a series of MN + Al 3xxx, and a series of SI +Al 4xxx, and heat treatment can be done to it and the rest It can be hardened by cold working. As for AL +Mg 5xxx alloy, it can be hardened by heat treatment. [13]

Table. 1.1. Cast Aluminum Alloys

Alloy Series	The main alloying element
1xx	99.0000 % Minimum **Al**
2xx	(Cu) Copper
3xx	SI+ CU and Mg
4xx	SI
5xx	Mg
6xx	Unused Series
7xx	Zn
8xx	Tin
9xx	Other Elements

1.2.2. B. Heat-Treated Alloys

Heat treatment to improve the strength of the alloy. Among these alloys are the 2x xx Al -Cu and Al - Cu - Mg series, and the series 6xxx Al -Mg -Si series, 7xxx Al - Zn - Mg and Al- Zn - Mg -Cu series and Al - 8xxx series of lithium-ion alloys. . Bullion 2×××7×××. This gives us a very high level of strength, and the use of these alloys in the manufacture of aircraft structures.[12]. Higher mechanical properties in these alloys are achieved by controlling the level of impurities, particle size, and hardening parameters such as the cooling rate[16] using a four-digit numerical designation system to identify aluminum alloys. And aluminum in the form of castings and alloy castings. The first figure shows the alloy group according to the main alloy element as shown in Table (1.2) [17]. The other two numbers identify the alloy of aluminum or indicate the purity of the alloy, and the last number indicates the shape of the alloy. Product: Casting (denoted by “0”) or alloy (denoted by “1” or “2” depending on the limits of chemical composition. The first number indicates the alloy group depending on the main alloying element [12]

Table 1.2. Wrought Aluminum Alloys

Alloy Series	The main alloying element
1xx	99.0000% Minimum AL
2xx	Cu
3xx	MN
4xx	Si
5xx	Mg
6xx	Mg+ Si
7xx	Zn

1.3. ALUMINUM ALLOY 2024

2024 aluminum alloy has good and high mechanical strength, excellent workability, and can be fabricated to resist corrosion without coating, making it preferred for vehicle and aircraft applications.

It has particular strength in structural applications. It has excellent heat treatment mechanism. Alloy 2024 combines high strength with corrosion resistance. Used in trucks, aircraft body applications, auto parts, cylinders and pistons, machine parts, recreational equipment, bolts,,[11]. Aluminum 2024 is strong because copper, manganese, and magnesium greatly increase the strength of aluminum alloys, and a high percentage of copper significantly changes the properties of aluminum in alloy 2024 due to its corrosion resistance, tensile strength, and many other properties. Small amounts of silicon, iron and zinc [18]

1.3.1. Aluminum Alloy 2024 Physical and Mechanical Properties

The mechanical properties can be used to know the type of aluminum alloy. . 2024 is easily manufactured which makes it very portable[19]. Its density is 2.77 g/cm3, which is slightly higher than that of pure aluminum (2.7 g/cm3). Aluminum 2024 has good workability, and can be exploited and used in many applications.. [9]

With regard to aluminum alloy 2024, it has some properties that give an idea of the workability, strength and potential uses of the material.,[20]

Aluminum alloy 2024 has a tensile strength of 324 MPa, which makes it acceptable for high-strength structural materials [21].

- Shear strength, meaning resistance to shear stresses, also known as "cutting" stresses. The shear strength of aluminum alloy is 2024 (283) MPa.
- Fatigue strength is a measure of how well a material can resist fracture under this fatigue, and the fatigue strength of aluminum 2024 is 138 MPa, calculated as 500,000 loading cycles below the yield point [23].
- In aluminum alloy 2024, the amount of tensile elasticity (deformation) can be known by knowing the modulus of elasticity and the modulus of shear. The modulus of elasticity is 73.1 GPa. The shear modulus is 28 GPa.[22].

Aluminum 2024 has a tensile strength of 324 MPa, which makes it attractive for a high-strength structural materials..[21]

1.3.2. Aluminum Applications 2024

Aluminum 2024 is used in many industries, but some common applications for this alloy are in aircraft and aerospace parts Gears, piston cylinders, car and bicycle tires, tennis racket. It has many diverse uses[23] Matrix metal composites (MMCs) show novel properties not available in free metals, such as high strength with light weight, good thermal expansion, good corrosion resistance,.[24] MMCs are produced by known methods, namely liquid and solid state processing. Wettability, low density, grain agglomeration and undesirable interactions are very important issues and fundamental to MMC production and fabrication, all of which lead to a reduction in material properties..[25]

1.4. COMPOSITE MATERIAL.

Composite materials are among the important materials at present, which are used on a very large scale, especially in the past three decades, and are a combination of two or more materials, each with properties that differ from the others. We get the best strength and hardness from mixing different materials, and we have high resistance to fracture and part of it to tensile, depending on the type of matrix and additives, and some additions may lead to a decrease in properties wear resistance and bending. Composite materials have replaced metals mainly in many important applications in the industry; This is because they have the strength of metals in addition to being lighter in weight and have better and higher properties than the original metal .[26].

1.4.1. Components of composite materials.

Composite materials are composed of two or more basic materials.

1. The Matrix.
2. Reinforcing materials that consist either in the form of fibers or in the form of particles.

The fibers increase the mold's life, strength, and hardness, in addition to making it more resistant to cracking, breaking, or collapsing. The mold, in turn, protects the fibers from damage when subjected to external pressure.[27]

1.4.2. Classification of composite materials

1. Polymer Matrix Compounds (PMCs): The plastic is reinforced with glass fibers to obtain durable, high-strength glass. It is called glass fiber reinforced plastic, and it is widely used in the automotive glass industry [28]
2. Metal matrix composite (MMCs).. Metals such as manganese, iron, copper, magnesium and many other materials are used as briquettes. [29].

3. Ceramic matrix compounds (CMCs). A type of borosilicate glass is used in parts of aircraft engines. Its ability to withstand high temperatures is high in addition to being light in weight.

1.4.3. Metallic matrix composite materials

When the binder is a pure metal or one of its mixtures, we get a composite material with a metallic binder. The performance of this material depends on the nature of the two materials included in its composition, the chemical composition, the crystalline structure, , its size, the volumetric ratio of the reinforcing material, and the production technique [30]

Composite materials with metallic matrix have entered the fields of transport media, industrial and thermal control, and systems packaging

Electronic and its growth has surpassed that of the aerospace industries. Thus, the introduction of new materials in military and civilian aircraft fell behind the introduction of these materials in the industrial sector. For example, the composite materials market has arrived

In the field of thermal control and electronic packaging systems alone to five times the industrial market in space in 1999. This gap appears likely to expand the continued growth of applications of metallic matrix composite materials in the thermal control and transmission media market .[31]

Attention focused on this growth of materials due to achieving the required high specifications of structural or functional materials that traditional materials could not meet. The advantage of composite materials appears when taking into account the cost-performance relationship.

The possibility of mixing several sets of metallic-ceramic-non-metallic materials gives an opportunity to obtain unlimited mixtures.

Its properties are mainly determined by its basic components[32]

Light metal reinforcement allows it to be used in situations where weight reduction is a priority

The main condition for its development is the improvement of mechanical and thermal properties.

The objectives of strengthening light metals are summarized in:

- Increased maximum tensile strength and yield strength at normal and elevated temperatures,
- Increased creep resistance at high temperatures of conventional mixtures,
- Increased fatigue resistance, especially at high temperatures,
- Improve thermal shock resistance,
- Improve corrosion resistance,
- Increase Young's modulus,
- Reducing thermal expansion.
- In summary, optimizing the specific properties (specificity/weight) can expand the fields of use of these properties

- Materials and replacement of joint materials The composite material must have a specific functional property available in the material to be strengthened and reformulated, an example of this Increasing the operating life of the spot welding electrodes by reducing their combustion,

1.4.4. Use of composite materials.

It is widely used in military and civilian airframes and in automobiles in place of pure metals. Because of its high strength when compared with the base metal before adding, the light weight can reduce more than 40% of the vehicle weight coupled with the use of steel; This in turn leads to less fuel consumption, and is environmentally friendly in addition to being economical.[29]

Composite materials have been a major reason for solving metal problems such as fracture, stress life, hardness, ductility, and strength. For example, tennis rackets were previously made of wood, were heavy in weight, and were always prone to breakage; therefore, it has been made of lightweight aluminum and graphite composite materials, and this gives the racket good strength to withstand twisting or breaking, is comfortable for the player, and does not tire from the high weight. Composite materials are also used in the bridges, as they reduce the weight by five times compared to that of steel and give very high efficiency.[33]

As a result of the high demand for compounds, the shift has become from basic alloys to them.[34]

1.4.5. Methods of manufacturing metal matrix compounds.

Composite manufacturing techniques are broadly categorized as liquid phase and solid phase processing. When using the liquid-phase state, it is thoroughly mixed in the mineral substrate phase and divided before casting or during the casting phase until a homogeneous mixture is obtained. This is when in the liquid state; the molten metal is poured following or by the usual casting methods. In the solid state, MMCs are produced by reducing the temperature below the temperature at which the matrix is melted so as not to cause any damage to the casting components. There is another method called reactive treatment (on-site treatment), through this method, the matrix is strengthened by causing chemical reactions by adding elements that enter into the components of the alloy and in various concentrations according to the need to prepare the alloy. It is prepared before the casting process begins in the prepared molds.[35]

1- Method (solid state): This is done by mixing metal powders, then placing them in molds before mixing them well, then placing them in molds and pressing them with special presses and this may be in several ways, including static hot pressing or what is called hip extrusion. It is possible to make it strengthened with fibers and compressed. [36]

2- Method (liquid state): Stir casting process. Through this process, the components of the ingot are mixed well during the melting process so that a high homogeneity of the ingot can be obtained and we get rid of the possibility of defects in the casting, and this process helps in hardening the ingot.[37]. For fabricating a metallic matrix, the stir casting method is used, especially in matrices reinforced with nanoparticles or micro particles. Through this process, the mineral materials are mixed by stirring and stirring for the purpose of homogeneous mixing and solidification. This occurs by breaking down the properties of the base materials used in the manufacture of metallic compounds. Ceramic materials have a high density compared to aluminum and some metal matrix alloys, where the density of nanoparticles Y2O3 is (4.469 g / cm3) while aluminum is 2.7 g / cm^3. This makes the nanomaterials settle at the bottom of the powder, so that the stirring process makes the particles homogeneous and distributed inside the molding, and the stirring must be in a correct way. This method is very cost effective.[38] .

The reinforcements in decay are.

- Adding particles to a highly stirred molten cast
- Injecting ceramic additives by means of injection devices. The injection gun can be used to insert the ceramic materials into the ingot or to place them by wrapping them in aluminum foil and inserting them into the melting powder so as to ensure that they are covered and that the nanomaterials do not burn.
- scattering of pellets connected to each other [39]

There are several factors that we need to take care of when throwing away the materials to be added, namely: [40]

- It is difficult to perform an investigation in order to obtain an accurate and good homogeneous distribution of reinforcing materials.
- Getting wet between the main materials (between reinforcing materials and raw materials).
- Porosity in a cast metal composite matrix.
- The occurrence of a chemical reaction between the alloys of the base material and the reinforcing materials. [41]
- An interactive treatment process. In this matrix and consolidation process, it occurs as a result of a chemical reaction.[42].

When MMCs are made, they are made at high temperatures, so that good diffusion occurs at the matrix interface, and when they cool in the surroundings, stresses called residual stresses will be produced due to mismatches in the matrix, fibers, amorphous materials, waste, and some impurities may lead to deformation within the matrix when manufactured [43]

1 .5. APPLICATIONS ON COMPOSITES

- There are many applications of compounds, a part of which can be written, and the properties of compounds can be used to satisfy the need for it. Among these applications we mention the following
- High performance cutting tools produced from tungsten carbide. It is made of a matrix of cobalt bonded to tungsten carbide. Bronze can be used in place of tungsten carbide, and appears with slightly different specifications...[44]
- The armor of the tank may be made of hardened steel, especially boron nitride, which has a high weight. It is possible to take advantage of the composite metal matrix, which gives a lighter weight than steel and has the same potential for protection.
- And its properties are less at high temperatures. Used in sports cars, it is high performance and is a kind of silicon carbide matrix reinforced with carbon fiber due to its high temperature.
- He also worked on developing a kind of aluminum matrix to make disc brakes lighter, and this in turn leads to weight reduction by twice that of cast iron while obtaining the same rigidity and cost is lower. Although the cost of metal compounds is higher, the need for lower weight justifies the cost [44]

PART2

LITERATURES REVIEW

2.1 INTRODUCTION

In this research project, we will address a number of recent researches that have been studied previously, especially in the field of developing aluminum alloys, each according to the method of casting and stirring, and their effect on different types of Nano- and micro-powders of micro and Nano sizes on the mechanical properties. Microstructural properties of aluminum alloys.

2.2. LITERATURE REVIEW ON NANO AND MICRO ALUMINUM ALLOYS

We will discuss a number of recent researches that dealt with the development of aluminum alloys manufactured in different ways in order to obtain an improvement in the properties of these alloys and the effect of adding types of ceramics and nanomaterials on improving them. Characteristics most of which can be exploited in wide areas and many areas that lead to developments that serve society in the field of improving industry, agriculture, transportation, developing cars, aircraft, medical devices and other areas of life. Below we present a selected part of these previous studies for the purpose of knowing what the previous researchers have reached and keeping up with them with recent developments.

- **Mona K. Abbas et al. (2014)** In a study to The sliding dry wear behavior of (Al-Si) matrix was studied and evaluated using nanoparticles of Al_2o_3 at a wetting rate of 4 wt.%, addition of TIO 2 at a wetting rate of 4%, and a hybrid addition of (AL_2o_3 + TIO $_2$) at a wetting rate of 4%. The mechanical grinding technique was used for preparing the samples. Of the matrix and reinforcing material. By cold pressing and sintering for 90 minutes at 520 °C. Hardness tests were performed using the Vickers apparatus. SEM examination was performed. Abrasion testing was performed with a pin disk and at room temperature. And using different times to measure the extent of wear. It was found that the wear coefficient increased with increasing load and increasing slip time, and found that the nanocomposites showed a lower wear rate than the original alloy. [45]

- **Muhammad .Osame e t. al (2010)** in this research, it was found that the composite materials were prepared from a matrix of aluminum and silicon alloys supported by Y2o3 nanomaterials with a ratio of (2, 4, 6, and 8%). The superimposed material was prepared by the vortex method, and it was mixed with the nanomaterials while it was placed in the melt and mixed with a mechanical mixer, and then it was poured into special metal molds prepared for this purpose with a cylindrical shape. After that, microscopic examinations were conducted and the hardness test was carried out using the Vickers test. The results showed a homogeneous distribution of particles and an increase in the hardness rate. A decrease in the corrosion rate was obtained in a good and beneficial manner. The best results were obtained when the proportion of yttrium was added by 8% .[46]

- **Kapil Kumar et al. (2014)** Studied the fabrication process of metallic matrix nanocomposites (MMNCs) using the stir casting method. As a result of this process, an inhomogeneous distribution of nanoparticles was produced, which has a very high porosity in the matrix. To overcome this situation, a mechanical stirred molding, an electromagnetic stirred was used, and this mixed process produced a 2024 aluminum alloy nanocomposite by wetting 1% $A\ l_2o_3$ by injection method and introducing an argon gas catalyst in order to improve the wettability. Refinement was performed by grinding the carbide nanoparticles. Several tests were performed, including SEM test and EDAX test, as well as tensile test. It was determined through microscopic images that the nanoparticles were homogeneously distributed throughout the matrix. In terms of tensile strength, a high increase of up to 43% was obtained when compared to the original alloy[47]

- **S.Vinoth kumar et al .(2014)** In this paper, a matrix of 2024 aluminum alloy is reinforced with nanocomposites of graphite and silicon carbide (SiC) with a high ratio of (5% to 10% by wt). The methodology is mixing, pressing, and sintering. Optical microscopy, X-ray diffraction, and dry slip corrosion behavior were performed. The results showed that the hybrid nanocomposites had less loss than unreinforced SiC alloys, and the results showed the best improvement when using 5% and 10%. It also showed that graphite is a solid and effective lubricant for the aluminum matrix[48]

- **Tanwir Alam et al. (2017)** in this study, compounds from a metal matrix of Al, Mg, and Cu have been strengthened with two Nano-ceramic particles. These particles are characterized by high mechanical properties as well as physical properties. These ceramic materials can improve and modify the properties of the produced alloy. This ceramic material includes carbide, nitride, oxide, and the disturbing in this matter. Synthesis of these materials due to the low wettability in the reinforcement stage with the molten metal together to produce carbon nanotubes, and aims in this research and cannot be synthesized by ordinary casting methods..[49]

- **Shakoor Manohar R Mattli et al. (2019)** has studied In this research, a study was carried out by the foundry method of manufacturing aluminum by adding Nano -yttrium by mechanical casting method and conducting the sintering process by microwave. The effect of different levels of yttrium oxide was known by examining the microstructure. It was found that an increase in nanocomposites increased by increasing parts of the size of yttrium in the matrix However, a decrease was observed in the porosity through the SEM examination, and the XRD examination revealed a homogeneous distribution of yttrium particles in the aluminum matrix, an increase in hardness, then a decrease with the increase in the amount of yttrium, and an increase in the compressive strength and yield strength.[50]

- **Penchal Reddyet et al. (2017)** in this study. The matrix of aluminum and the reinforcement with Al_2o_3 particles at a rate of 5%, 10% and 15%. Microwave sintering was used, then the hot extrusion process was carried out, and then the effect of reinforcement was studied on the microstructure, mechanical and physical properties, and the thermal effect. The results show that with the increase in the concentration of ceramics, the improvement of the mechanical properties increases. Including hardness as well as yield strength, tensile and compressive strength. While there is a decrease in the ductility of thermal expansion. The examination of the XRD and the SEM and EDS images show a uniform distribution of particles in the aluminum matrix. Because of this reinforcing action, the tensile strength increased by 33% compared to the pure composite. The result of the composite appeared the extruded has high tensile strength compared with the original aluminum matrix. The low heat rate is due to the strong interface bonding in aluminum and Al_2o_3 compounds..[51]

- **Zadeh M. Hossein et al. (2013)** has studied in this paper; a study was carried out in an aluminum matrix, which was reinforced by adding Al_2o_3 particles. Al_2o_3 was grinded with a high-powered ball mill. In addition, a time period of up to twenty hours. Then 1 wt. % of Al2o3 particles were added to the original matrix of aluminum during the smelting process. An examination of the microstructure was carried out and the properties and effect of powder addition were identified Mechanics conducted through particle addition process and X-ray diffraction (XRD) study. Evidence of results. There is an expansion of atoms diffraction patterns, evidence of Al_2o_3 atoms, and evidence of microstructure. There is a reduction in particle size because of the Al_2o_3 particles being distributed over the matrix parts in a non-homogeneous manner. This decrease is due to the presence of solid particles, the increase in the amount of hardness, and the increase in the wear resistance of the aluminum composite with Al_2o_3. It's very clear.[52]

- **M. Sameezadeh et al. (2019)** has studies In this study, nanocomposites were prepared by milling from metal particles of $MoSi_2$ at a rate of 0 to 5% and using a metal matrix of aluminum alloy 2024, and they were mixed and cast using a mechanical metal casting method. It was prepared by combining the powders that were installed and cold pressed. Then a heat treatment was performed under T6 conditions. The tests were carried out and the effect of adding MoSi2 metal particles was shown and the effect of heat treatment and then hardness using the Brignell test and the dry test for pin corrosion on a steel disk. Evidence of the results of the examination heat treatment increased the hardness of all hot-pressed samples and led to their improvement, and that the hardness with age improved with age. It decreases after the manufacture of metal castings with an increase in the volume fraction of $MoSi_2$ particles. This is due to the cause of high-density disintegration that occurred during the manufacture of the ingot and the increase in the hardness of the composite materials by increasing the volumetric fraction of the MoSi2 particles, which has a size of 3-4%. Then a decrease occurs, and the reason for this may be due to agglomeration that occurs in the particles. The wear test showed that the corrosion resistance decreases for all samples of the T6 condition, which is higher than the other case, and it increases with the increase of the MoSi2 content. And by examining the electronic scanning of the microstructure of the worn-out corroded surfaces, the mechanism of corrosion was known on the basis that it is an abrasive corrosion accompanied by mechanical corrosion of the adhesive. [53]

- **Ramesh Kumar et al. (2019)** have studied in this research, the main matrix of aluminum alloy 6082 was reinforced with Nano Y_2o_3 and it was manufactured using the FSP friction stir method. The mechanical tests were carried out, the optical microstructure was examined OM, the electron galactic structure was examined (SEM), and the X-ray diffraction (XRD) was examined. By knowing the results obtained from through various tests and analyzes, we conclude that the Nano Y_2o_3 particles have a very high and significant effect on the composition of the microstructure, as well as hardness, an increase in the amount of tensile value, and a significant improvement in the corrosion resistance of aluminum alloy 6082. This is all associated with a change in the composition of the microstructure.[54]

- **Jiqiang Chen et al. (2021)** In the course of this research the effect of addition of SC and Y_2o_3 nanomaterials and microscopic images on the microstructure and its effect on the mechanical properties were studied. For aluminum AL 5.5 SI, by means of electron microscopy and light microscopy, the change in the microstructure was identified, hardness and tensile tests were performed, and annealing heat treatment and its effect on the microstructure and its effect on the properties of the alloy were studied. There was an improvement in the mechanical properties of the Al-Si alloy, and the test results showed that the addition of Y_2o_3, SC significantly improved the tensile strength as well as the yield strength of the alloy. SC-Al-Si was strengthened by 45% and 71%, respectively, when compared with the Al-Si alloy. The annealing treatment results show that it is mainly related to the deposition of Si.[55].

- **Semegn Cheneke et al.(2019)** Has studied in this research, a matrix of aluminum 2024 reinforced with 2% titanium boride (TiB_2) and varying amounts of Y_2o_3 (0.5, 1, 1.5%) was studied. X-ray diffraction (XRD), SEM, optical microscopy and scanning electron microscopy were performed. Mechanical tests were conducted to examine the hardness, tensile strength and fracture toughness, and it was found that the amount of tensile strength and hardness increased by approximately 25%, 45% and 57% when adding an amount of 1.5% Y_2o_3 and when adding 2% TiB_2. It was found that the percentage of the tensile and hardness values increased by up to double the amount. But the porosity increased in the samples, which led to a decrease in elongation, especially when Y_2o_3 was added. .[56]

- **Neeraj kumar et al.(2021)** Has studied. In this research, using the method of powder metallurgy and hybrid microwave sintering, aluminum composites Zno - Y_2o_3 were synthesized. The Nano hardness was determined by sensing the depth of the Nano indentation and the elastic treatment of the composite material. The results of the tests show the existence of homogeneity and interconnection in the surface and between the thermal analysis of the materials to obtain the decomposition of the surface and the behavior of the two layers. Hardness and flexibility. [57]

- **Ch. S. Vidyasagar et al. (2019)** has studied In this research, the development of a matrix of aluminum alloy 7075 with proportions (0.1%, 0.5% by weight) was studied using reinforced and reinforced casting, rolling and heat treatment under the condition of 0.5TaC. The process of examining the microstructure was carried out. The addition of TaC in the matrix reinforcement led to a refinement of the grains due to the effect of coloring. An increase in the mechanical properties was observed as a result of the addition of TaC. The highest hardness was observed as it reached 96 Hv, the yield strength reached 171 MP, and the tensile strength reached 205 MP. The Rheo casting process increased the condensation and particle distribution. The homogenizing treatment was used, and this led to the precipitation hardening [58] .

- **Mootaz A. et al. (2021)** In the study of this research, composite materials of Al6063 aluminum alloy reinforced with different nanoparticles of small Al_2o_3 nanoparticles and weight ratio of 5.7% and 5.2,5,7,10 wt. % by mixed casting in order to obtain the mechanical properties of the hybrid and improved aluminum. The castings were hardened, and mechanical tests were carried out for all samples, and electron microscopy was conducted for the samples, and it was found that the mixed waves are distributed homogeneously. Success has been achieved for hybrid materials through alloy casting. The results showed that after aging treatment and laboratory tests, yield stress and impact strength as well as tensile strength obtained high and large results as a result of adding reinforcing particles, where the best mechanical properties were obtained when adding AL_2o_3 by 5.7% when compared to the rest of the samples and the reinforcing strength increased by 85%.[59]

PART 3

EXPERIMENTAL STUDIES

3.1. MATERIALS

In this study, pure aluminum and pure copper were used in different proportions for each sample, as well as magnesium, manganese and silicon were added as the main materials. The proportions of the components for each alloy are shown as indicated in the used table (3.1) For the purpose of this work, the quantities were measured using a very accurate balance. The main minerals were supplied from China. The permanent mold casting method was used without the use of pressure, and as shown in the pictures below, the types of metals used were melted in a gas furnace prepared for this purpose, and using a silica powder, pure Al was added. Less than one hour was the waiting time when the temperature reached 750°C. After that, copper, silicon, manganese and magnesium were added after wrapping them with aluminum foil so that they would not burn. Also, after the temperature dropped to half, the rest of the materials were added. During the casting process, stirring and mixing is done with an electric mixer in order to obtain complete homogeneity of the ingot materials inside. Ingot No. 1 was cast without any additions of Nano-Y_2O_3 or micro- Y_2O_3, and then Nano- Y_2O_3 was added according to the ratios to three samples at rates of (1, 2, 3%. Wt. Micro- Y_2O_3) was also added to three samples at rates of (1, 2 and 3%.Wt Nano- Y_2O_3) or the microliters, after being wrapped in aluminum foil, are added to the other materials in the crucible. Meanwhile, the molten metal in the pot was stirred continuously. In the first sample, chemicals were added for the purpose of expelling impurities, and in the rest of the samples, no chemicals were added for the purpose of expelling impurities for fear of expelling yttrium, since these materials treat yttrium as impurities and work to expel it from the alloy. After completing the seven samples, here other samples were made with percentages (1, 2, and 3%.Wt Nano-Micro Y_2O_3) by mixing Nano and Micro particles together.

Table 3.1 Shows weight fraction materials compositions of 2024 -Al alloy and metal matrix composite (MMCs)

N	AL	CU	MG	MN	SI	Y2O3	MICRO	Y2O3+ MICRO
1	93.1%	4.4%	1.5%	0.6%	0.4%	0%	0%	0%
2	92.1%	4.4%	1.5%	0.6%	0.4%	1%	0%	0%
3	92.1%	4.4%	1.5%	0.6%	0.4%	2%	0%	0%
4	90.1%	4.4%	1.5%	0.6%	0.4%	3%	0%	0%
5	92.1%	4.4%	1.5%	0.6%	0.4%	0%	1%	0%
6	91.1%	4.4%	1.5%	0.6%	0.4%	0%	2%	0%
7	90.1%	4.4%	1.5%	0.6%	0.4%	0%	3%	0%
8	92.1%	4.4%	1.5%	0.6%	0.4%	0.5%	0.5%	1%
9	92.1%	4.4%	1.5%	0.6%	0.4%	1%	1%	2%
10	90.1%	4.4%	1.5%	0.6%	0.4%	1.5%	1.5%	3%

Figure 3.1. Copper aluminums

Figure 3.2. Micro Yttrium Nano yttrium

Figure 3.3. Magnesium

Figure 3.4. Silicon

3.2. MELTING AND CASTING PROCESS

The smelting process was carried out in a special forge using a gas furnace and crucible. The maximum temperature that the furnace can reach is about -1200 degrees, at which twenty ingots of aluminum, copper, magnesium, manganese and silicon were prepared. Then Nano Y_2O_3 and Micro $Y_2O_3$are added to it with different weight ratios as shown in Table (1-3) using an 8 kg silicon crucible in a melting furnace. As shown in Figure (3.5), the aluminum wires were weighed and the corresponding quantities of casting elements were calculated to obtain the required weight ratios using an electronic balance for this purpose. To make sure the aluminum has melted, use a laser thermometer. Melting took place at 750 °C. To measure the melting point temperature during the process of dissolving the powder, a thermometer is used by shining a laser beam from a distance. As shown in the figure (3.6). The amount of molten heat was measured at the moment it was poured using a laser thermometer. After that, the casting process took place at 700 degrees Celsius in an iron metal mold with dimensions of 140 * 220 mm, after heating the mold to a temperature of 250 degrees Celsius to prevent the occurrence of hot cracks.

Figure 3.5. Casting mould, melting crucible and gas furnace.

Figure 3.6. Casting temperature scale and the special model for making test samples

After ensuring that the solidification process of the molten metal was complete, the casting was taken out after being left for a short period of time until it solidified completely and cooled in the mold. After that, the cutting process and mechanical work were performed to obtain the required shape for the samples to perform the examination. . Such as tensile, cutting, hardness and Impact tests. Figure (3.6) shows the shape of the final castings intended for them.

3.3. DEVICES AND EQUIPMENT USED TO PREPARE SAMPLES

The impact test samples were prepared by a Russian-made Rapp 700 mill, as shown in Figure (3.7). . The tensile, wear and hardness test samples were prepared using the Spanish Gyr gh-1440 tornos lathe in the University of Technology laboratories, as shown in Figure (3.8). Figure (3.9) shows what was obtained from the tensile, shock and corrosion test models.

Figure 3.7. Rap mill 700 milling cutter, Russian made

3.3.1. Examination models

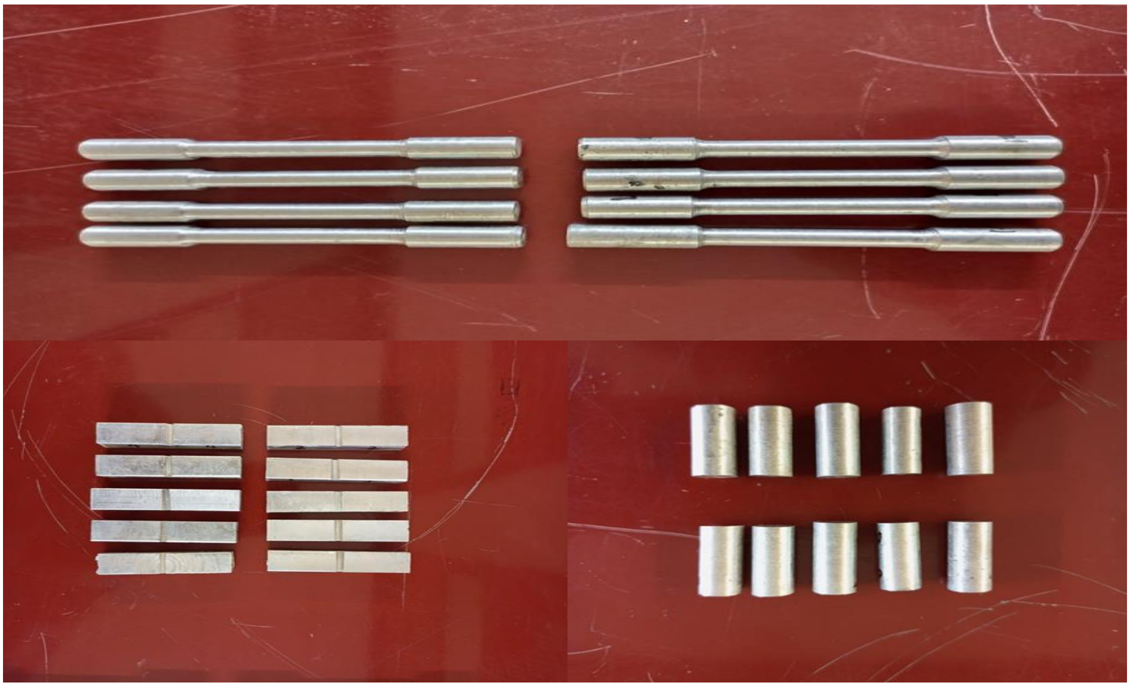

Figure 3.8. Hardness, tensile, wear, impact and microstructure test specimens

3.3.2. Tensile test

Through the machine produced by Laryee Technology CO. LTD tensile test was carried out and it is controlled by the computer and at room temperature with a force of up to 50 KN as shown in Figure (3.9). It was carried out using a dynamic tester. 10 samples were taken for the purpose of conducting the research requirements

Figure 3.9. Laryee tensile tester with a force of 5KN

3.3.3. Tensile test model

The sample was formed according to the international specifications of ASTM E8, with a measuring length of 50 mm and a length of 25 mm. With a diameter of 12.5 mm so as to hold the sample on both sides with a radius of 10 mm for tensile strength analysis. As shown in Figure (3.10).

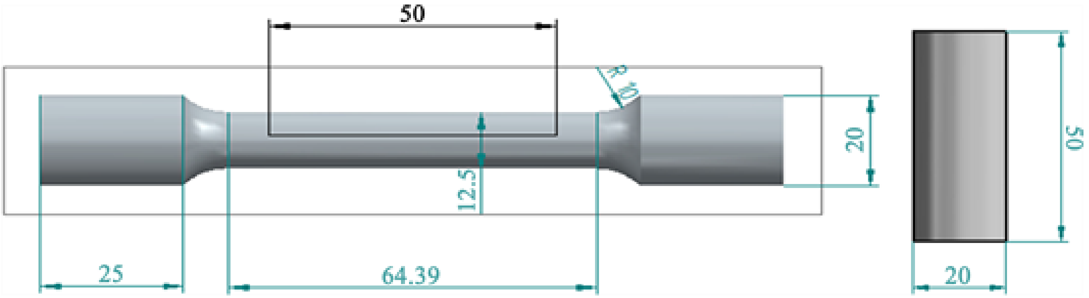

Figure 3-10 .Tensile test model

3.3.4. Hardness test

It was conducted using a digital precision hardness tester (HVS-1000) as shown in Figure (3.11), by using the diamond pyramid in the Vickers method, and at least 3 measurements were taken from each sample and up to five measurements

Figure 3.11 Vickers hardness tester

3.3.5. Impact test

Impact testing is performed according to the Chirpy method. (XJU Series Charpy Impact Test Machine) according to (ISO-180).It was broken at (5.5J) pendulum impact energy and (3.5m/s) impact velocity As shown in Figure (3.12). Through the test the state of the metal is determined, which is the property of the metal's resistance to fracture when subjected to sudden stresses. This property, as well as its opposite, which is brittleness, can be easily and accurately observed and calculated in the test[60]. Therefore, this test is not for soft metals. In this test, samples of uniform standard shape and dimensions (10 x 10 x 55 mm) are used ... and they have a 2 mm slit in the middle of one of their sides and at an angle of 45 Figure (3.14). The figure (3.13) shows the image of the device used and the standard dimensions from the sample. In this test, in the Chirpy test, we place the sample in a horizontal state so that the slit is opposite to the direction in which the pendulum falls on the sample upon impact .[61]

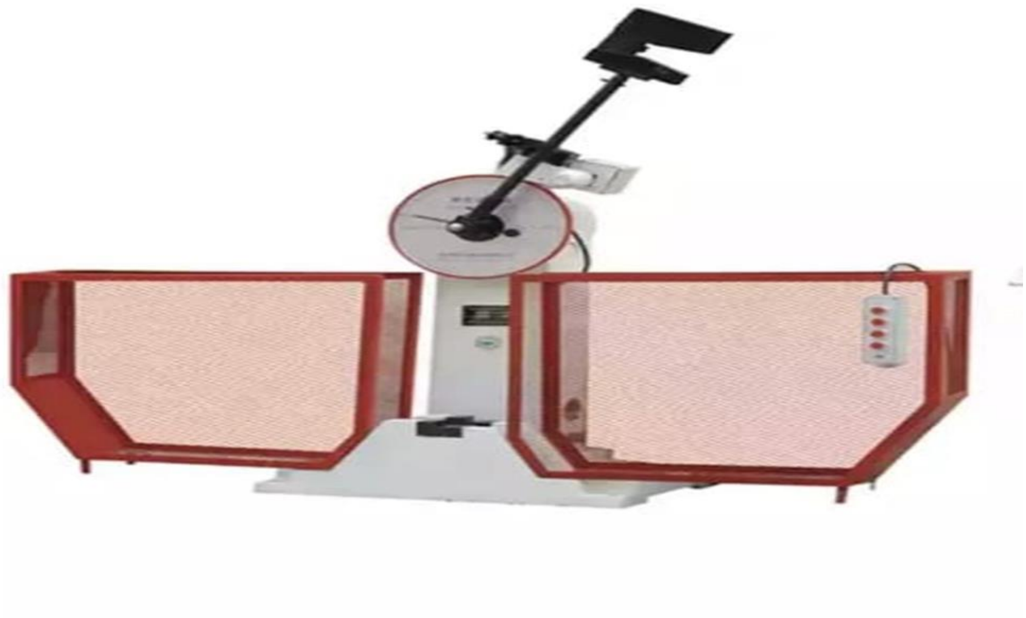

Figure .3.12a Sharpie impact test

Figure 3.12.b Sharpie impact test

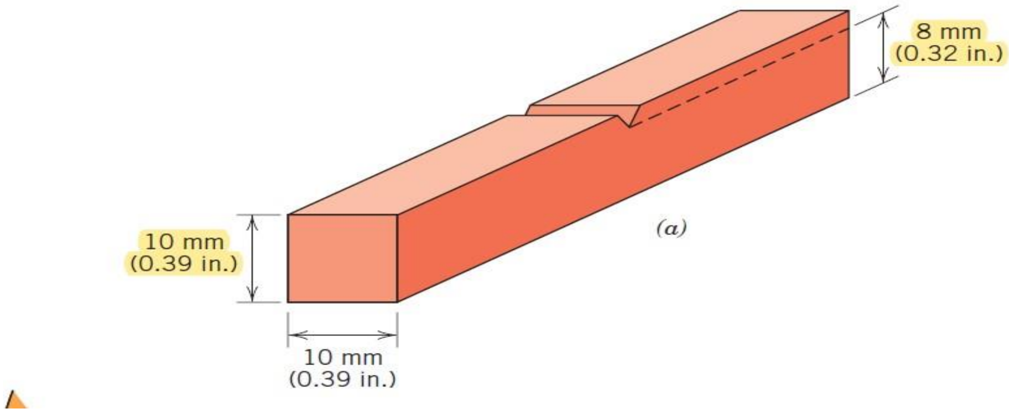

Figure 3.13. Impact tested according to the Chirpy Test

3.3.6. Microscopic characterization

The surface of the specimens was prepared for microscopy in the heat treatment laboratory by sanding it with gradient smoothing papers. (Using a type-MoPao160E-8600 polishing device, the purity of silicon carbide is 180 - 200 - 400 - 600 - 800 - 1000) and as shown in Figure (3.15), then it was chemically treated with solutions. . An EMZ-5TR light microscope was used in the heat treatment laboratory and shown in the figure. (16 .3) for the purpose of showing the microstructure of a group of samples that were previously prepared

Figure 3.14. MoPao 160E - 8600 Grinder Polisher

3.3.7. Electron microscope

Figure 3.15.Optical microscope, stereomicroscope, Japanese-made EMZ-

The microscope shows the microstructure of research samples, it is a kind of stereo microscope, Japanese-made EMZ-5TR. As shown in Figure (3.16) it was used to show the microstructure of aluminum alloys reinforced with Nano-yttrium and micro-yttrium in different proportions for each sample.

3.3.8. Scanning electron microscope (SEM)

For the purpose of determining the chemical compositions included in the manufactured alloy, the SEM and SED examination device (q150r rotary-pumped sputter coater/carbon coater) was used for the purpose of knowing the microstructure more clearly than the light microscope. In addition, the SED examination for the purpose of knowing the chemical compositions included in the components of the alloy. This device is one of the examination devices at Karbuk University. As shown in Figure (3-19)

Figure 3.16. SEM and EDS scanner

3.3.9. Wear test

The wear test was applied using a rotating disc made of cast iron, which is the closest in hardness to the alloys. In addition, the samples are fixed by means of an arm in a parallel way above the sample to be tested for wear as shown in Figure (3.18), then a load of 10 Newton's is placed to obtain a hardness range of three points of the hardness values for each sample, then it is compared to conclude the final result. The weights are fixed before the test using a very accurate scale. During the first test, the weight is measured after 5 minutes have passed, and the time is set using a very accurate clock as shown in Figure. (3.17) . Thus The second test is done after 10 minutes, then 15 minutes later, and the weight is determined at each stage for comparison. To find out the corrosion rate from the equation mentioned below, we weigh each sample before starting the test, then we carry out the weighing process after the test ends, using the sensitive Denver measuring device. (±0.0001g) accuracy.

Wear rate (W r) = Δ w / 2πr n ρ t (gm\cm) [62]

W rate = W. D / H v ……………………………………………………........ (1) [62]

D = Sliding distance 2 π R N …………………………………………..(2) [63]

They were.

R = disc radius = 6.5 cm

N = no. RPM of turntable wear device = 950 RPM.

Corrosion resistance, specific corrosion resistance can be obtained.

Specific WR = WR /10…………………………………………........................ (3) [62]

F = 10 Newton's

Wear resistance = 1 / W rate ……………………………………….………............(4) [62]

ρ = density

Figure 3.17. Denver bully precision check weight scale

Figure 3.18. Sliding wear teste device

PART 4

RESULTS AND DISCUSSIONS

4.1. MICROSTRUCTURE

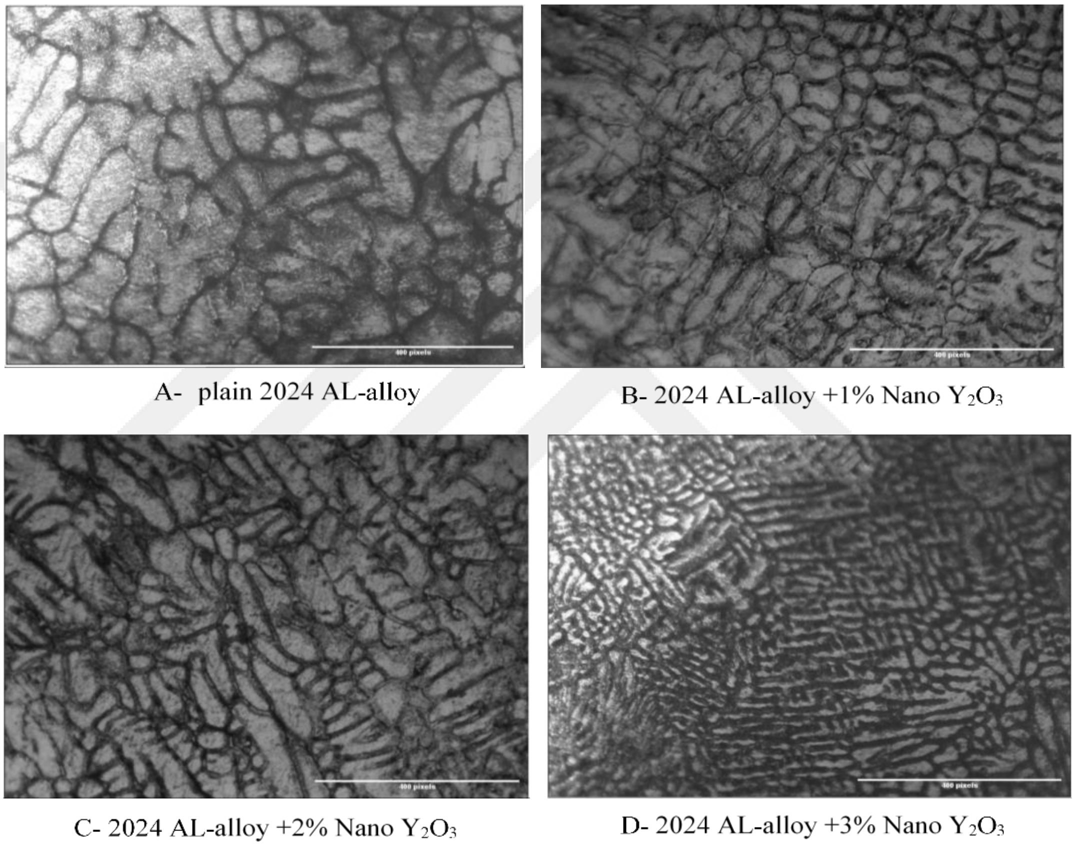

Figure (4.1): microstructure of A) plain 2024 AL-alloy, (B,C,D) 2024 AL-alloy with (1,2,3)wt.% Nano size Y_2O_3 respectively

Figure 4.1. Microstructure of A) plain 2024 AL-alloy. (B, C, D) 2024 AL-alloy with (1, 2, 3) wt. % Nano size Y_2O_3 respectively

Figures (4.1), (4.2), (4.3), show the microstructure of plain 2024 Aluminum alloy and three groups of composites of with (1, 2, 3) wt.% (Nano size, micro size, mixture of both Nano and micro size) Y_2O_3 / 2024 Aluminum al

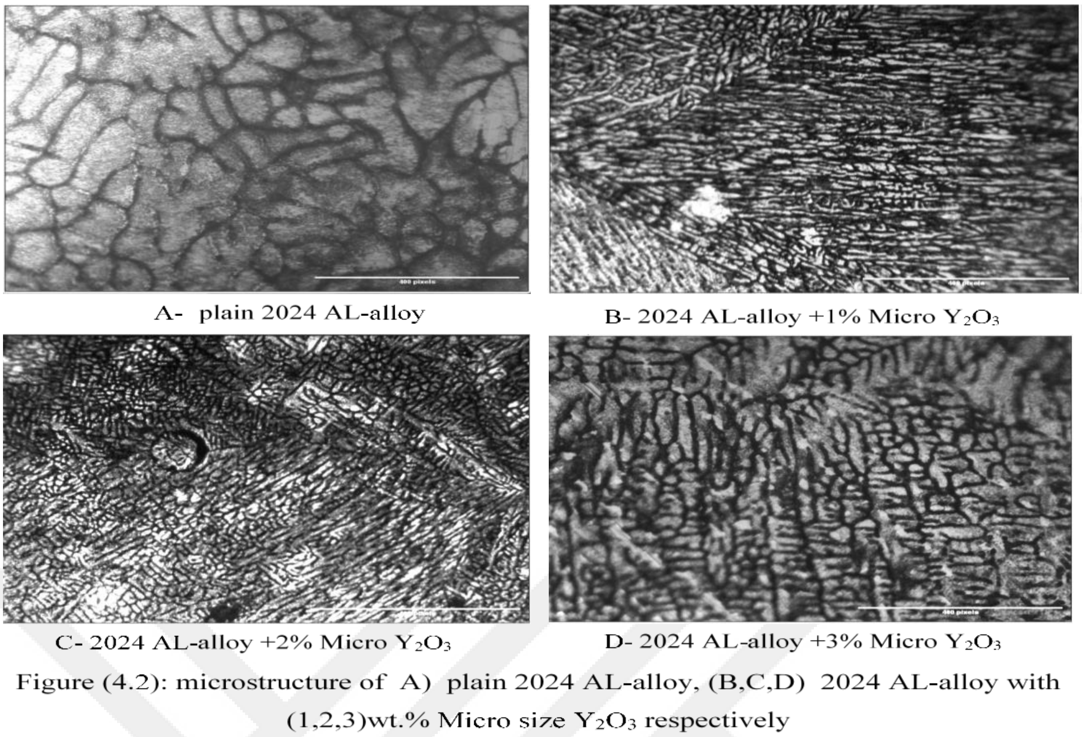

Figure 4.2. Microstructure of A) plain 2024 AL-alloy. (B, C, D) 2024 AL-alloy with (1, 2, 3) wt. % Micro size Y_2O_3 respectively

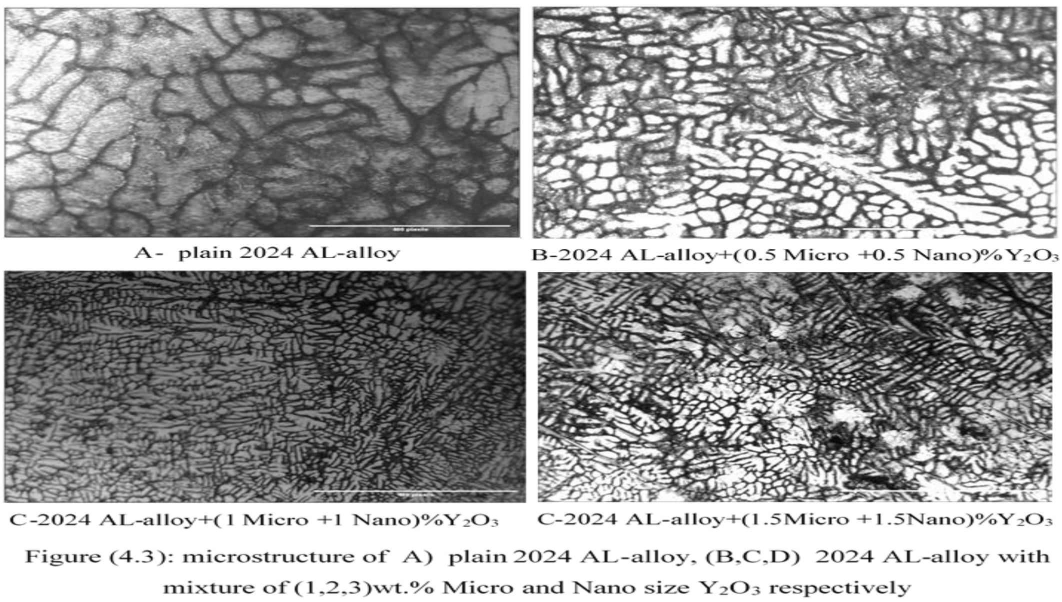

Figure 4.3. Microstructure of A) plain 2024 AL-alloy. (B, C, D) 2024 AL-alloy with (1, 2, 3) wt. % Nano and Micro size Y_2O_3 respectively

Table 4.1 show average grain diameters of plain 2024 Aluminum alloy and three groups of composites of with (1, 2, 3) wt. % (Nano size, micro size, mixture of both Nano and micro size) Y_2O_3 / 2024 Al - alloy.

N	A l	C U	M G	M N	S I	Y2O3	MIC RO	Y2O3 +MIC RO	grains size
1	93.1%	4.4%	1.5%	0.6%	0.4%	0%	0%	0%	1920
2	92.1%	4.4%	1.5%	0.6%	0.4%	1%	0%	0%	1414
3	92.1%	4.4%	1.5%	0.6%	0.4%	2%	0%	0%	1409
4	90.1%	4.4%	1.5%	0.6%	0.4%	3%	0%	0%	1583
5	92.1%	4.4%	1.5%	0.6%	0.4%	0%	1%	0%	1562
6	91.1%	4.4%	1.5%	0.6%	0.4%	0%	2%	0%	1172
7	90.1%	4.4%	1.5%	0.6%	0.4%	0%	3%	0%	1487
8	92.1%	4.4%	1.5%	0.6%	0.4%	0.5%	0.5%	1%	1583
9	92.1%	4.4%	1.5%	0.6%	0.4%	1%	1%	2%	1470
10	90.1%	4.4%	1.5%	0.6%	0.4%	1.5%	1.5%	3%	1443

Table 4.1. Chemical composition (%.wt.) of the metal phases in the studied alloys

It can be seen that average grains size have reduction with increasing weight fractions of Nano, micro or mixture of both sizes of Y_2O_3, the reason behind this, may be related to increasing nucleation rate during solidification with increasing ceramic Y_2O_3 particles, which offer more sites to start grains nucleation during solidification process, where the surfaces of these particles reduction activation energy required to nucleation. in other words, grains nucleation from molten metal at preexisting surfaces (heterogeneous nucleation), are much easier than with absent surfaces of impurities (homogenous nucleation) under same circumstances of cooling rate and processing conditions that specimens exposed, so the present of suspending ceramic Y_2O_3 particles within molten metal will increase nucleation rate at expense of grains growth of preexisted grain, or may obstructing grains growth when its presents at grain boundaries, this leading to finer final structure comparing with plain 2024 Al-alloy specimen[64],

Table (4.1) confirm the decreasing of grain size with increasing particles ceramic content. We mention here that the particle size of Nano Y2O3 is 30 nm and the particle size of Micro Y2O3 is 40 nm.

, also it is worth to mention that Y_2O_3 micro size additives showed more effected grain size reduction comparing with Nano additives, that may be related to difficulties of obtaining to uniform distributions of Nano particles within metal matrix as their high tendency to acclamation comparing with micro size particles. This results agree with many similar works. [65, 66, 67]

The grains size was calculated by using a program called (image j). Through this program, the size of each grain is calculated in the section whose image was taken from the examination of the microstructure, and through it we take the average grain size for each sample. Through Table No. (4.1) it was known that the grain size less when adding the Nano- Y_2O_3 and the micro- Y_2O_3.

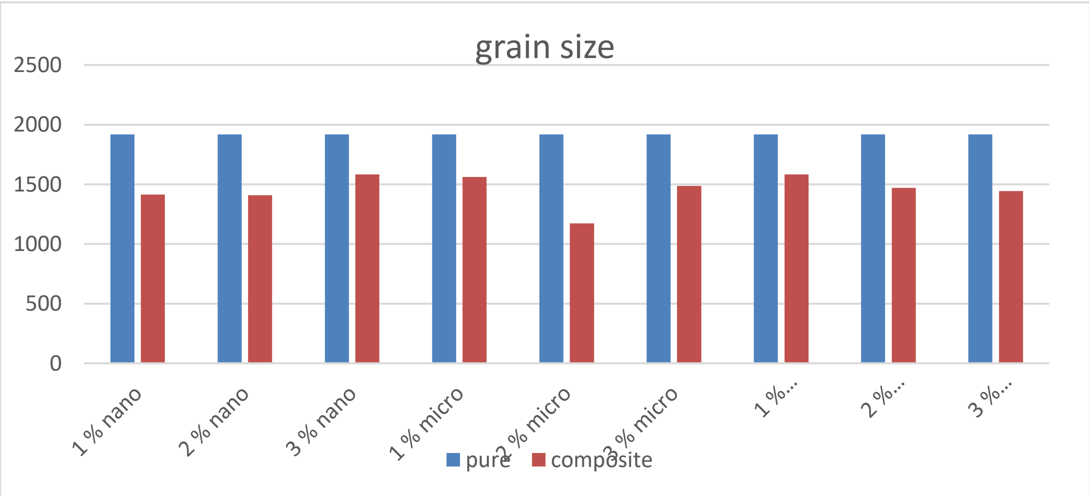

Figure 4.4. The grain size of samples of 2024-Al alloy and of samples (1, 2, 3% Wt. Nano Y2o3), (1, 2, 3% Wt. Micro Y2o3),(1,2,3% Wt. Nano, Micro Y2o3).

4.2. SEM ANALYSIS OF AL–Y2O3 NANOCOMPOSITES

SEM and EDS images of Al–2024 alloy and Al- Y_2O_3 Nano composites are shown in following figures. The contents of the yttrium are within metallic matrix individually and in relatively smaller groups and distributed with acceptable manner. EDS analysis confirms the present of yttrium element addition to other alloying elements; Al, CU, Mg and Mn. Figure 4.1 shows SEM- secondary electron image for pure 2024 Al-alloy

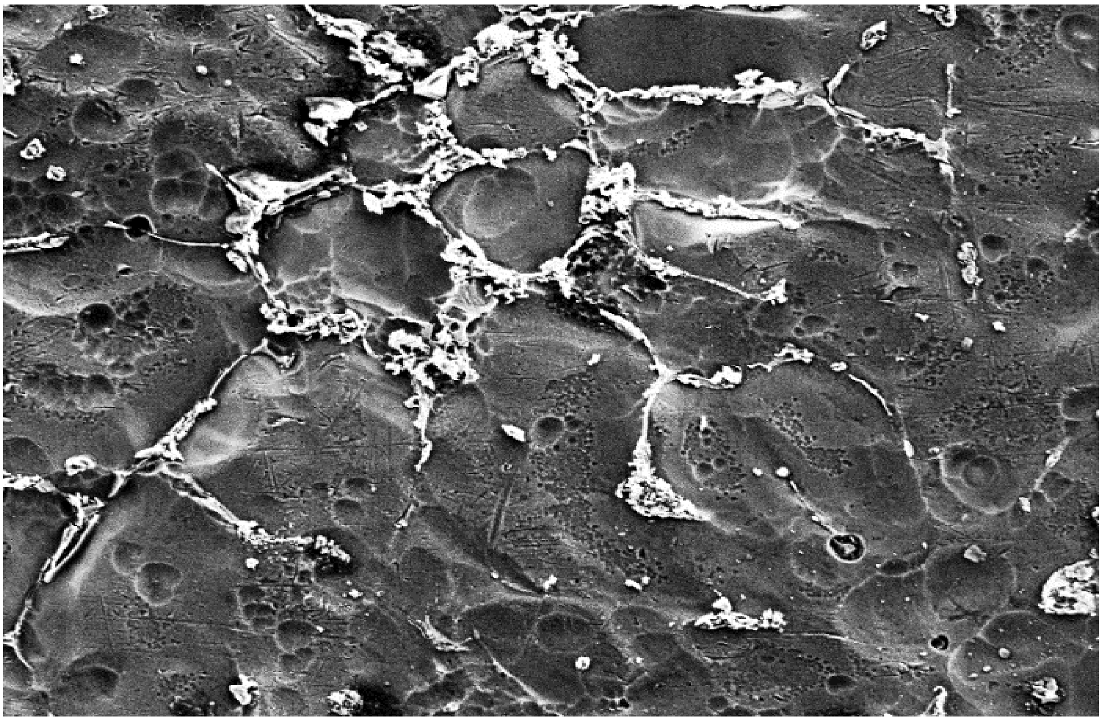

Figure 4. 5. SEM micrographs of net 2024 Al alloy

Figure 4.6. Shows SEM- secondary electron image for 2024 Al-alloy / 3 wt. % Nano Y_2O_3

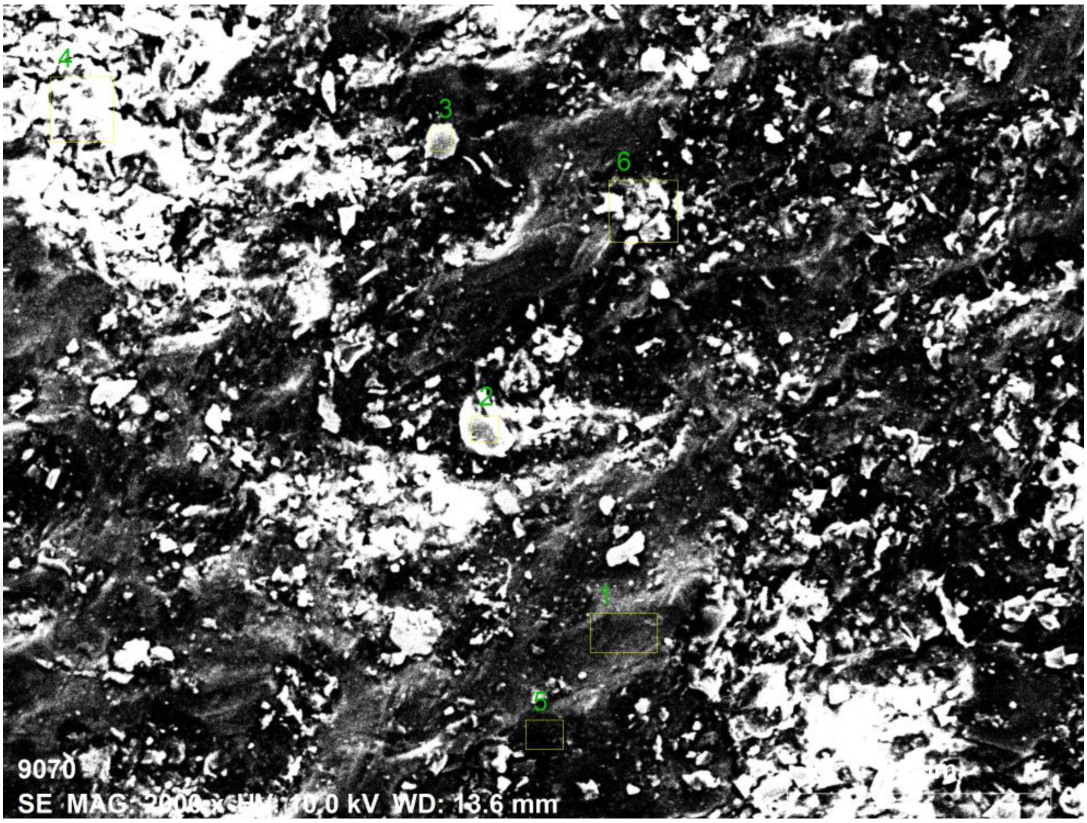

Figure 4.6. SEM image of 2024 Al alloy/3 wt. % Nano Y_2O_3

Table 4.2 shows EDS analyses elements details at pointed sites

Mass percent (%)

Spectrum	O	Mg	Al	Si	Mn	Cu	Y
1	12.32	1.74	81.70	0.07	0.80	3.28	0.10
2	13.71	11.85	27.18	0.71	0.00	46.55	0.00
3	25.18	9.69	21.87	0.33	0.00	42.93	0.00
4	60.43	6.97	17.68	0.13	0.00	14.65	0.14
5	30.30	2.73	62.87	0.00	0.18	3.91	0.00
6	48.32	5.65	25.83	0.36	0.57	19.17	0.11
Mean value:	31.71	6.44	39.52	0.27	0.26	21.75	0.06
Sigma:	19.21	3.91	26.28	0.26	0.34	18.87	0.07
Sigma mean:	7.84	1.60	10.73	0.11	0.14	7.70	0.03

Figure 4.7shows SEM- secondary electron image for 2024 Al-alloy / 3 wt. % Micro Y_2O_3

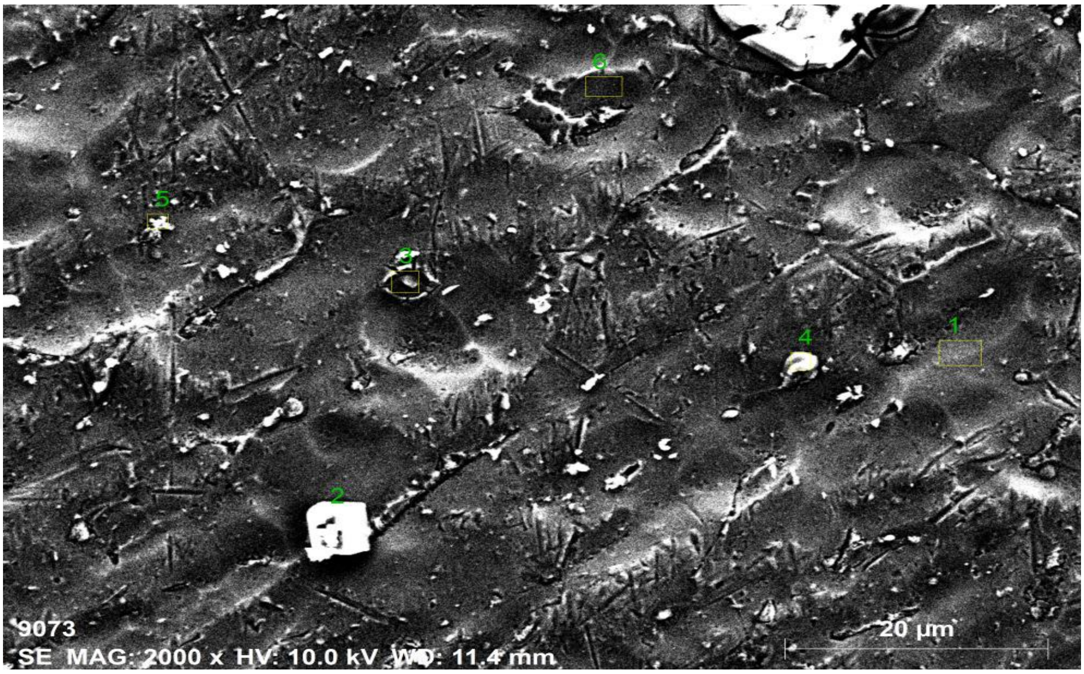

Figure 4. 7. SEM image of 2024 Al alloy/3 wt. % Micro Y_2O_3

Table 4.3 shows EDS analyses elements details at pointed sites

Mass percent (%)

Spectrum	O	Mg	Al	Si	Mn	Cu	Y
1	4.47	1.80	91.24	0.31	0.00	2.18	0.00
2	78.99	0.85	7.42	0.37	0.00	12.37	0.00
3	23.09	1.73	72.83	0.00	0.00	2.12	0.22
4	60.35	2.19	28.10	0.46	0.14	8.53	0.24
5	27.86	3.41	57.13	3.69	0.00	7.91	0.00
6	8.17	2.17	86.78	0.00	0.00	2.88	0.00
Mean value:	33.82	2.03	57.25	0.81	0.02	6.00	0.08
Sigma:	29.71	0.83	33.48	1.43	0.06	4.24	0.12
Sigma mean:	12.13	0.34	13.67	0.58	0.02	1.73	0.05

Figure 4.8 shows SEM- secondary electron image for 2024 Al-alloy / 3 wt. % Micro and Nano Y_2O_3

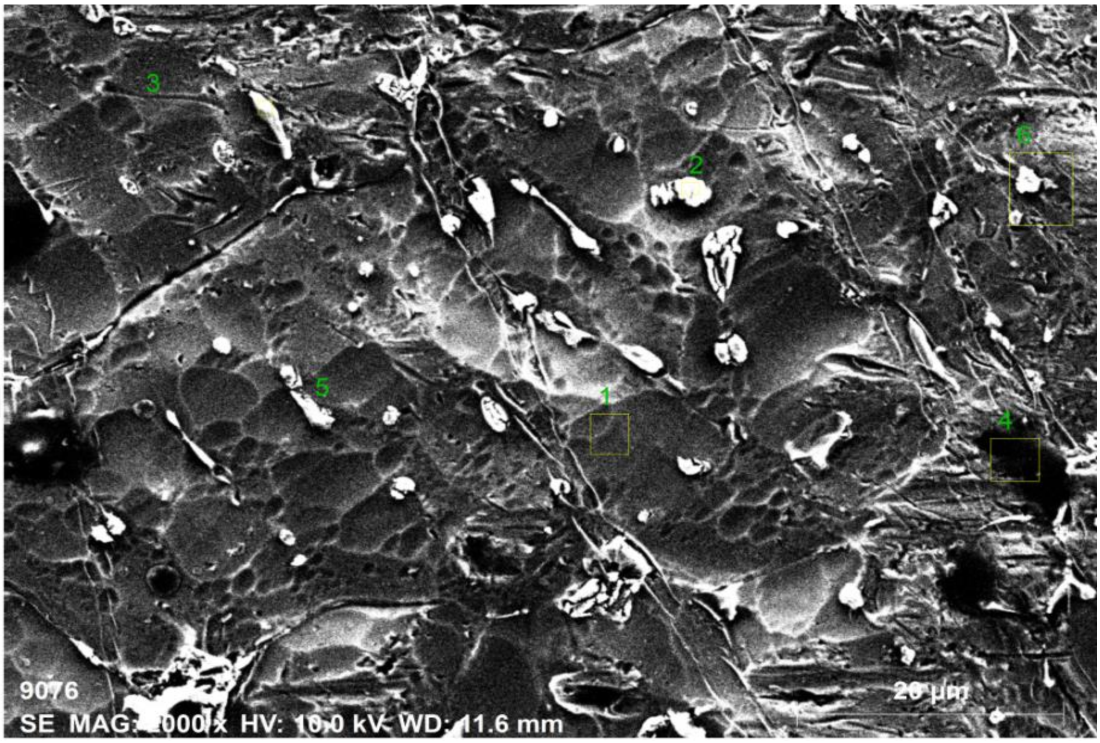

Figure 4. 8. SEM image of 2024 Al alloy/3 wt. % Micro and Nano Y_2O_3

Table 4.4 shows EDS analyses elements details at pointed site

Mass percent (%)

Spectrum	O	Mg	Al	Si	Mn	Cu	Y
1	3.21	1.83	91.70	0.00	0.00	3.25	0.00
2	41.94	4.51	18.31	0.92	0.00	34.12	0.19
3	7.81	1.77	77.43	2.25	3.84	6.89	0.00
4	41.57	7.04	48.00	0.25	0.58	2.18	0.37
5	31.64	5.13	35.77	0.39	0.27	26.54	0.26
6	12.50	2.39	77.83	0.01	0.33	6.94	0.00
Mean value:	23.11	3.78	58.17	0.64	0.84	13.32	0.14
Sigma:	17.38	2.13	28.55	0.86	1.49	13.53	0.16
Sigma mean:	7.10	0.87	11.66	0.35	0.61	5.52	0.07

4.3. HARDNESS

Table 4.5. Hardness test using the Vickers device

Model number	1	2	3	4	5	6	7	8	9	10
Hardness values	73.5	90.8	124.2	97.0	103.7	116.6	85.36	87.56	81.50	84.06

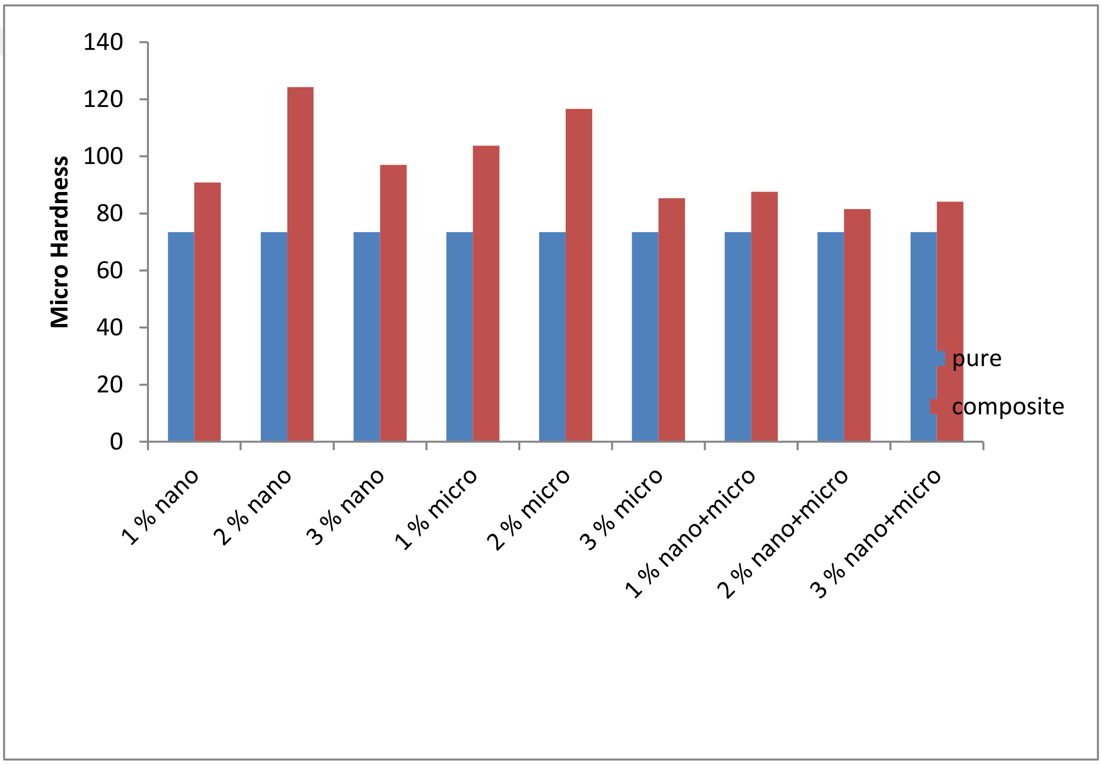

Figure (4.9). Vickers micro hardness samples of 2024-Al alloy and of samples (1, 2, 3% Wt. Nano Y2o3),(1, 2, 3% Wt. Micro Y2o3),(1,2,3% Wt. Nano, Micro Y2o3),

It can be seen that the hardness of Al 2024 alloy has increased after the addition of ceramics (Nano .Micro, and mix Nano, Micro). The interpretation of these particles may be due to the role of reducing the particle size, as shown by the microstructure images. The resistance of the material increases in general with the decrees

In the particle size. Ceramic particles also impede the movement of dislocations responsible for the flow of formation Article. [68]

Also, the highest values of hardness can be observed at concentration (2%wt) of Y_2O_3, while the samples that have a hardness higher than the pure metal (Al2024 pure) and less than 2% are less than that, as the hardness values increased by 30% and reached the limit of 50%. This can be explained by the possibility of occurrence Agglomerations of nanoparticles as well as a lack of homogeneous distribution [68]. In general, micro-y2o3 can be added to get better results than adding y_2o_3, due to the possibility of larger y2o3 agglomerations

4.4. TENSILE STRENGTH

In Figure (4.10) the stress-strain behavior is shown during the tensile test of Alloy 2024 and other alloys of composite materials, which consist of (1%, 2%, 3% Nano y2o3), (1%, 2%, 3% micro).), (1%, 2%, 3% Mix Nano and Micro Y_2O_3). Figure (4.4) and Figure (4.11) show the maximum stress and tensile strength of the samples.

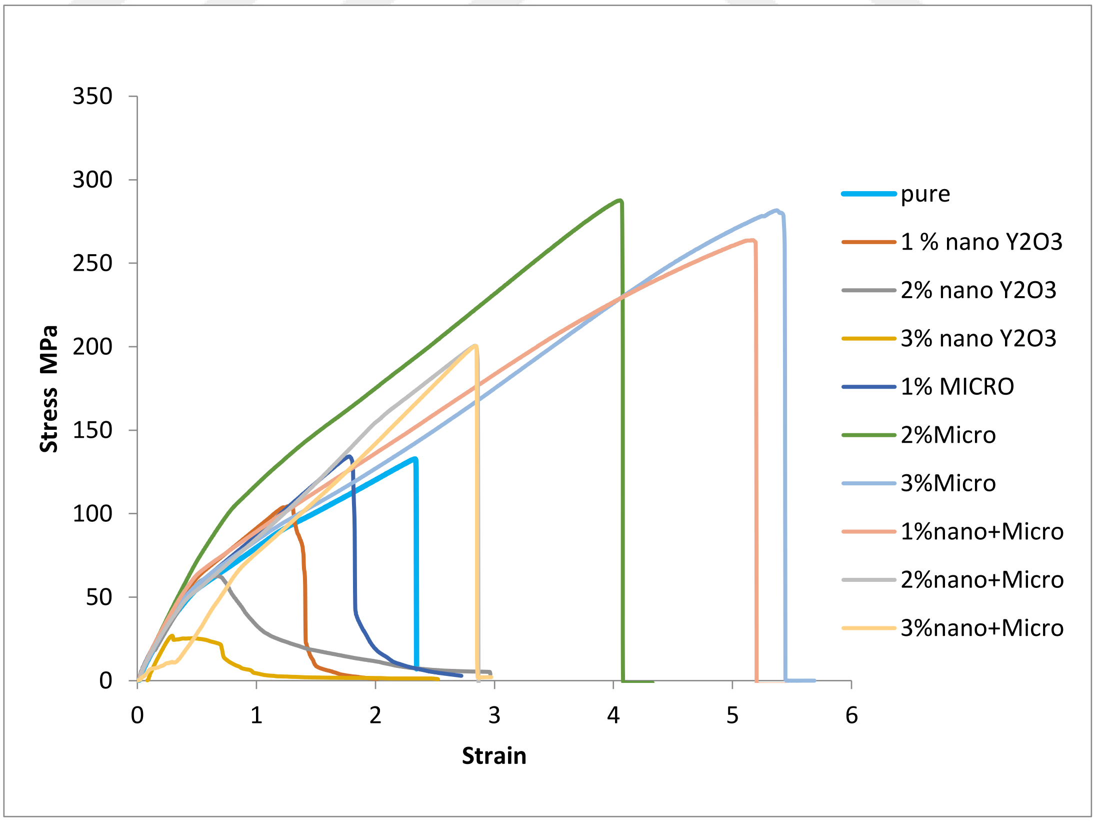

Figure 4.10. Tensile strength samples of 2024-Al alloy and of samples (1, 2, 3% Wt. Nano Y2o3), (1, 2, 3% Wt. Micro Y2o3), (1, 2,3% Wt. Nano, Micro Y2o3).

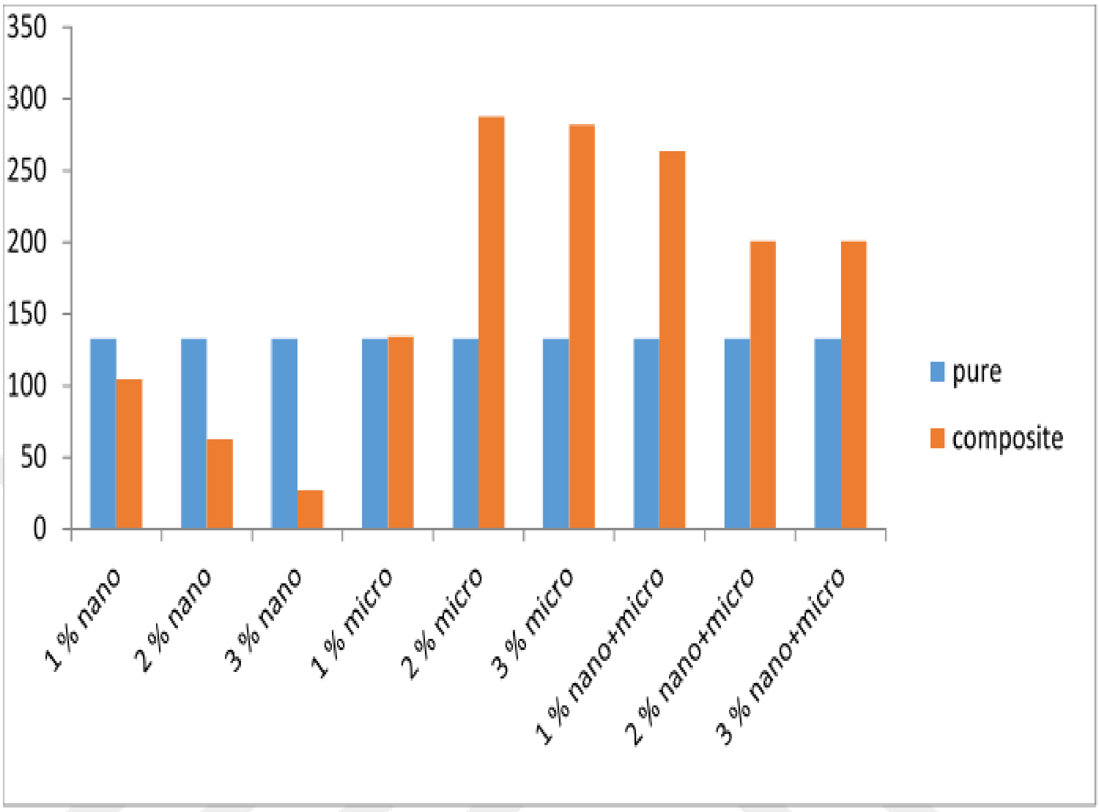

Figure 4.11.the tensile strength (Mpa)

In Figure (4.4), the stress-strain behavior is shown during the tensile test of Al Alloy 2024 and other alloys of composite materials, which consist of (1%, 2%, 3% Nano y_2o_3), (1%, 2%, 3% micro).), (1%, 2%, 3% Mix Nano and Micro Y_2O_3), and Figure (4.11) shows the maximum tensile strength of the samples. It can be noticed that adding (MicroY_2o_3) particles to the Al alloy 2024 raising tensile strength, where increased by 115% of the tensile strength when adding micro 2%, meanwhile the addition of nanoparticles y2o3 led to a decrease in tensile strength by 50% or more, adding a mixture of Nano and Micro y2o3 also improve tensile strength, but less than that in the case of adding micro y_2o_3. Also its possible to notice a difference in the strain rate at failure point for each case[69]. The explanation for this behavior may due to the improvement in microstructure grain size where adding Y_2O_3 cause downsize crystal size as previously seen in the microstructure images. However, the decreasing in strength when adding Nano scale may related to the occurrence of agglomerations of the Nano particles with each other as difficult to control distribution within matrix by stir casting method.[70]

4.5. IMPACT TEST

Table (4.6) and Figure (4.13) shows the impact strength results under impact tests for 2024 Al-alloy and the Y_2O_3 / 2024 Al-alloy with Nano, Micro, and mix of Nano and Micro Y_2O_3

Table 4.6. İmpact test

Model number	1	2	3	4	5	6	7	8	9	10
Impact test values(j/m^2)	24.5	16	21	22.5	27.5	21	35	22.5	17.5	15

The results showed that the best-recorded results when adding micro Y_2O_3, the weakest impact strength were when adding nanoparticles, meanwhile adding mix of Nano and micro size could decrease impact strength. These results agree with the tensile tests results where adding Nano particles Y_2O_3 cause decline of mechanical properties. However, contrary to what was expected, the sample whose impact strength was (27.5 J / m 2) and which contained 2% micron had low impact strength, the reason behind that dropping may related to existence of cracks or defects in samples structure during the manufacturing process, which led to weaken the strength in these samples. The pictures of the fracture surface of the samples after implement the test, figure (4.13), show rough surface of the fracture, and this indicates that structure undergoing plastic deformation before fracturing take place by impact

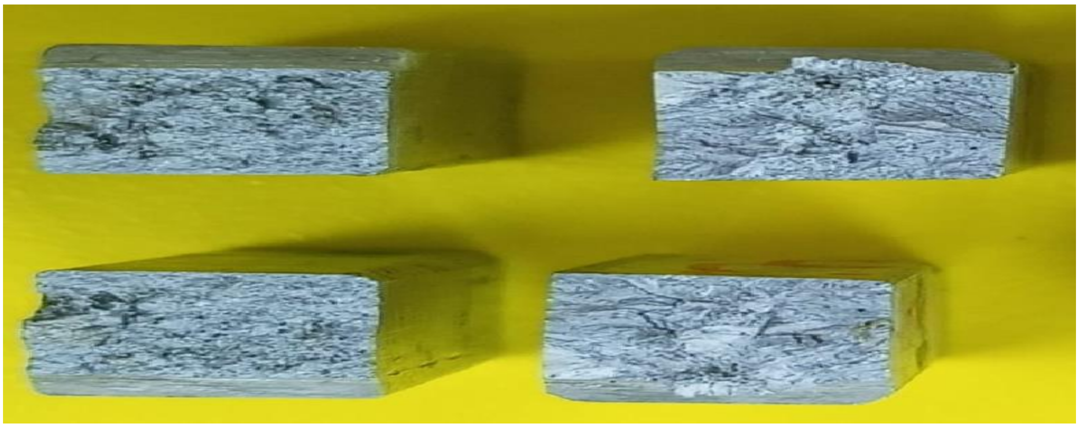

Figure.4.12. samples Impact strength after fracture It is noted through the fracture

4.6. WEAR OF ALLOY

4.6.1. Wear and hardness test

Table (4.6) and Figure (4.12) show the wear rate of 2024-Al Alloy and other composites materials, which consist of (1%, 2%, 3% Nano y_2o_3), (1%, 2%, 3% micro). (1%, 2%, 3% Mix Nano and Micro Y_2O_3.

Table 4.7. Wear rate for the alloy

Alloy	At 5 minutes	At 10 minutes	At 15 minutes
1	107.06	214.120	320.430
2	65.896	131.790	197.644
3	67.460	134.920	201.750
4	76.160	152.320	227.94
5	69.030	138.060	216.901
6	72.380	137.620	206.015
7	90.243	180.210	270.150
8	92.175	184.140	275.700
9	86.371	173.640	260.076
10	94.465	188.780	283.207

In general. The wear resistance improved when adding y_2o_3 particles in all cases, this

Improvement is consequence of development in microstructure grain size and increasing of surface hardness. The best recorded results obtained, less wear rate, were obtained upon (65.896 at 5 min), (131.790 at 5 min), (197.644 at 5 min) when added (1 wt. % Nano Y_2O_3). This increasing in wear resistance when adding Nano y_2o_3 may be due to the high concentration of Nano y_2o_3 particles at the surface during the casting process, which has high comparing with metal

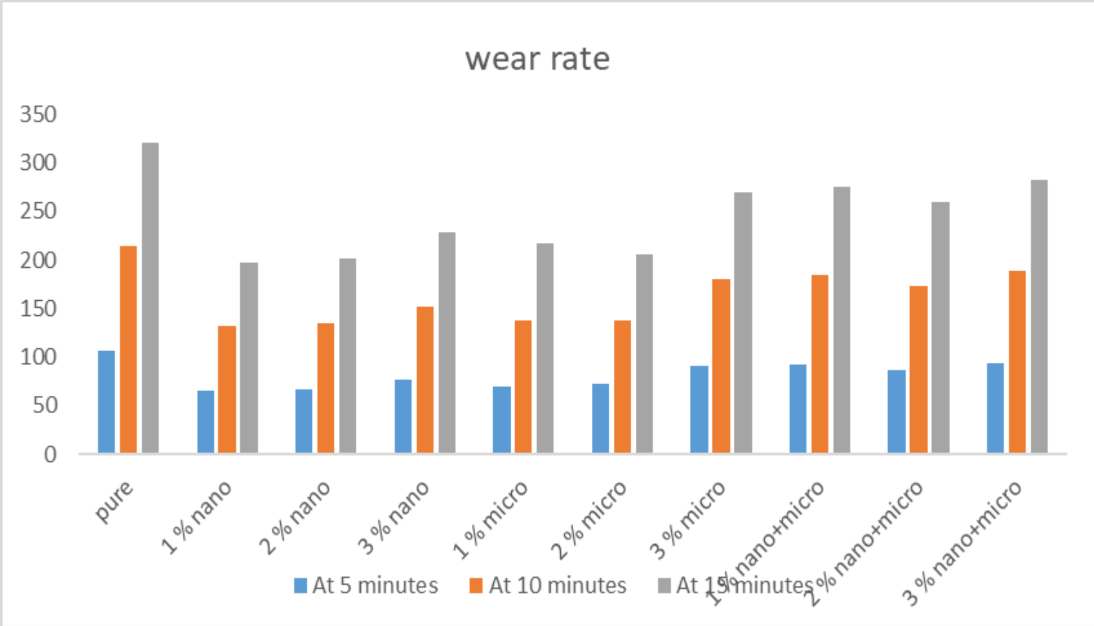

Figure 4.13 wear rate samples of 2024-Al alloy and of samples (1, 2, 3% Wt. Nano Y2o3), (1, 2, 3% Wt. Micro Y2o3), (1, 2, 3% Wt. Nano, Micro Y2o3).

PART 5

CONCLUTIONS

- Improving mechanical properties by adding micro (hardness, tensile strength, impact and wear resistance). The best tensile strength was obtained when adding 2% microelements. It is possible to improve the properties by 80% when adding 2% microelements.

- The addition of nanoparticles led to a decrease in some mechanical properties (impact and tensile strength) and improved wear resistance and hardness.

- Adding a mixture of nano-y_2o_3 and micro- y_2o_3 to the alloy improved the properties to a lesser degree than adding micro- y_2o_3.

- The addition of Nano- y_2o_3. Or micro y_2o_3.improves the microstructure of the aluminum Alloy. It reduces the particle size of the microstructure.

- Adding Nano - y_2o_3 to aluminum alloy 2024 and preparing it by steer casting method is bad and gave not good results and is not suitable for prep Aeration by method of composites.

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RESUME

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