Investigated the effects of Different casting methods on the mechanical properties of 2014 Aluminum Alloy reinforced by Alumina.

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ABSTRACT

Aluminum alloy is one of the most widely used types of alloys in contemporary industries, and aluminum alloy is one of the alloys used in many fields. This study aims to compare three methods of casting to obtain the best mechanical specifications for adding silica to the aluminum alloy under study. Adding the pre-heated nanomaterial and then casting into metal molds, and the second method was by powder technology by adding the nanomaterial to the powder with the use of ultrasound, and the third method was the method of casting by gravity casting using gravity to complete the casting in metal molds, gravity casting did not appear Significant improvement While both of the previous two methods achieved a significant improvement in some mechanical properties compared to the non-reinforced material with nano-materials),

Keywords: Aluminum composite, Nano material, Stir casting, Powder metallurgy, 2014AA

Introduction

Aluminum" is a metal with a light silver color that can be easily shaped and pushed into thick plates. You can draw it on a wire or turn it into a box. Aluminum does not rust and satisfactorily withstands weather and chemical corrosion. Aluminum producers typically form aluminum ingots, which are aluminum with the addition of small amounts of other elements. The world uses more aluminum than any other metal except iron and steel. Aluminum is the most common metallic element in the Earth's crust. Due to its light weight, it is used in the manufacture of much part. [1-3]

Nanotechnology is the science that studies and deals with the properties of materials with one of the nano dimensions, allowing them to develop their properties and create new functions and uses for them. Structural properties of nano materials reinforced materials such as mechanical properties such as hardness, melting point and others mainly depend on the size of the material grains and crystal lattice according to the known physical laws, but nanotechnology enabled us to control these properties for any kind of materials without being bound by the laws of traditional physics, by dealing with Matter is in the form of a few small particles rather than large clumps, since a substance of this size gives us completely different properties than a large one.[4-6]

Zhu et.al, they examined samples of SiC/Al6082 nano composites made by two methods, the first is pressure casting and the second using stirred, the crystal lattice was studied as well as some physical properties of the based material under study. The examination result shows that the presence of SiC nano-materials is uniformly distributed in the crystal lattice of 6082 nano composite made by stir casting. The microstructure of the base material is clearly improved, and shape and size

of the grain are compared with that of 6082 AA without SiC addition. The absolute tensile stress, yield stress and elongation of SiC/6082 AA nano composites are improved, compared with 6082 without SiC matrix alloy. , while the strain strength of SiC/6082AA composites was meaningfully enhanced, the size of the nanoparticle-reinforced composites was reduced. In general, the highest tensile stress, yield stress and ductility of the alloy manufactured by pressure casting were increased, compared to that of metal composite got by gravity casting. Therefore, researchers preferred to use alloys manufactured by pressure to obtain better mechanical properties. [7]

El-Rayes et.al, Investigated A 3-pass, 100% overlap sample was produced using friction stir welding (FSP) to improve the mechanical properties of the 6082 aluminum alloy and the microstructure of the crystal lattice. A constant rotation speed and three different movement speeds were used for processing. Ultrastructure properties were addressed in relation to the particle construction and sharing of Phase 2 particles and physical properties were addressed in relation to the hardness and tensile strength of the treated area, which is related to the number and velocity of intersections. The combination of indicators that provided the highest extreme tensile stress was compared with two different additional velocities. (FSP) caused active re-crystallization of the crystal lattice in the agitated region, resulting in size-balanced grains with high-angle grain boundaries that augmented with cumulative velocity. The accumulated heat associated with multiple paths increased particle size, dissolution of inter-granular deposits, and fragmentation of phase (2) particles. On the other hand, increasing the permeation rate did not affect the particle size, but decreased the grain size and increased the grain surface integral. The hardness of the temple region and the results of the tensile test were in better agreement because cumulative more of passes softens and reduces the highest tensile stress, and increasing the pass velocity increases the load and stiffness. Accelerate the tool velocity was not significantly affect the average particle size, maximum tensile strength, or hardness value in the agitated area, but increased the ratio of average particle size to particle area.[8]

Alizadeh et. al, They studied the use of two different methods of casting process, namely, induction casting and pressure casting, to produce an alloy reinforced with nano-material Si and Al5083 matrix base, with weight ratios of 20, 25, and 30%. The results of the physical properties, microstructure and corrosion conduct of the alloys made by each of the above-mentioned casting methods were compared with those resulting from the combined casting of the two methods above. The fallouts showed that the composite casting process improves the distribution of the SiC nanomaterial by reducing the accumulation and agglomeration of SiC nano material and decreasing the sample porosity in the sample. These structural changes have shown a tendency towards improving mechanical properties. The SiC samples made by the composite casting method have increased BHN hardness and compressive strength as well as the corrosion impedance of the tests produced by the composite method of the casting is enhanced due to the wear debris small size and the smaller wear area. The most obvious corrosion mechanism for the nano composite samples was the removal of the tribology layer, while for the aluminum base alloys, the most pronounced corrosion was the adhesive wear.[9]

Zyguła et. al, Selective Laser Melting (SLM) technology has recently gained popularity. The growing demand in the manufacturing industry to reduce manufacturing costs makes processes based on Laminated Modeling (AM) even more attractive. The SLM process allows parts to be manufactured with minimal post-processing requirements. For this reason, this technology is mainly used in aviation, automobiles and medical. Manufacture of parts by the SLM process has a high risk of porosity and requires tightly defined parameters, especially when using aluminum alloys. The purpose of the study was to assess the possibility of substituting conventional casting of small series

details with a new SLM process under fixed manufacturing conditions. This study includes a comparison of selected mechanical and physical properties of Aluminum alloys obtained by SLM process and casting. The materials that were (T6 heat treated) as received were examined. Both billet types have undergone tensile, hardness, and impact tests before also after chooses heat treatment. For SLM materials, the relative density is also shown. The microstructure of the cast and SLM samples was analyzed using a light microscope. The results of the study suggest that an important feature is the proper assortment of limits for the manufacture of parts by the SLM process. [10]

Gudipudi et. al, studied the addition of B4C in aluminum alloys and obtained AA6061-B4C compound, and it was found that adding an amount of nano- reinforce would not be a good choice for some mechanical properties due to the presence of problems in the stir casting process such as agglomeration, uneven distribution of the promoter and surface wetting during stirring. The researchers considered that ultrasound may be a suitable alternative to take advantage of the changes in the crystal lattice that lead to the improvement of mechanical properties. Good B4C distribution was achieved and the microstructure was improved. A significant improvement was observed in the specific tensile strength and compressive strength. [11]

Anbuchezhiyan et.al, investigated the mechanical properties of hollow glass-reinforced magnesium alloys in the vacuum pressure casting process. Particle size, mass fraction and stirring speed were considered as correlation indicators for analyzing mechanical properties such as hardness, compressive strength and porosity. , The best casting process parameters were found among the selected process variables such as granule size and stirring speed rate. The highest stresses value indicates that particle size has a significant influence on the determination of mechanical properties, as it is important in determining the porosity ratio.. [12]

Li et. al, non-electrostatic nickel plating and copper plating technology is used to create a new nickel-copper composite inner layer on the surface of metal base alloy, limiting the formation of brittle phases and improving the shear strength. The researchers used the surface-enhanced coating method to support the surface layer of aluminum alloy, and it was found that the coating, especially nickel based on electro less plating process, has achieved satisfactory results, manufactured in composite casting. The influence of the (nickel-copper) material intermediate layer on the microstructure, physical properties and corrosion strength of the bimetallic metal was verification. The results showed that the Ni-Cu composite intermediate layer efficaciously stopped the formation of brittle and hard Al-Mg metal compounds .Interface layer of 356AA bimetallic unaccompanied by (Ni-C). Composite intermediate.[13]

Pazhouhanfar et. al, studied the aluminum matrix composites reinforced with Al-TiB2 nanoparticles with different strengthening ratios (3, 6, 9 wt%) using the stirred casting process. After determining the variables of the casting process, such as the preheating temperature, the speed of the stirring rotation, and the time required to perform the previous steps. The microstructure composition and mechanical properties were measured. The microstructure resulting from the scanning process of the resulting compound showed a uniform distribution of reinforcements within the matrix, and showed a clear correlation between the matrix and the nano-reinforcements material. This is the result of improving the wettability by preheating the addition of TiB2 powder to the molten material. , the ultimate tensile strength of the compound was improved by increasing the through-fracture of the TiB2-reinforced particles without significantly changing the elongation.[14]

This study aims to shed light on the effect of the type of casting process in terms of the use of stir casting, powder casting, or gravitational casting on the main mechanical properties of aluminum alloys reinforced with aluminum dioxide and the impact of the casting method compared to the same properties with the basic alloy without nano-additives.

2. Materials and method

2.1 Base Aluminum Alloy

The choice in this study was on aluminum alloy No.2014, which is one of the basic alloys used in many industries such as furniture, building structures, transportation and food industries. Table No. shows the chemical composition of the above-mentioned .

. Tablet 1.Chemical composition of 2014 AA

Elements	Ref.[15]%	Actual %	Elements	Ref.[15]%	Actual%
Manganese (Mn)	0.4 -- 1.2	0.8	Silicon (Si)	0.5 -- 1.2	0.7
Copper (Cu)	3.9 -- 5.0	4.2	Magnesium (Mg)	0.2 -- 0.8	0.4
Iron (Fe)	0.0 -- 0.7	0.20	Zinc (Zn)	0.0 -- 0.25	0.16
Titanium (Ti)	0.0 -- 0.15	0.10	Zirconium (Zr)	0.0 -- 0.2	0.1
Residuals	0.0 -- 0.15	0.15	Chromium (Cr)	0.0 -- 0.1	0.1

Table 2 also shows Mechanical properties of the base alloy adopted in this study, before adding nano materials based on the standard performance criteria of aluminum alloys according to the international classification and compared to the alloy studied as a base alloy for the production of alloys of composite materials.

Table .2 the material properties of 2014 AA. Ref.[15]

	property	Units	Quantity
1.	Tensile Strength: Ultimate (UTS)	MPa	210
2.	Tensile Strength: Yield (Proof)	MPa	110
3.	Elastic Modulus	GPa	72
4.	Elongation at Break	Percentage	16
5.	Brinell Hardness	Unites	55
6.	Poisson's Ratio	Unites	0.33

2.2 Reinforcement Material

Aluminum oxide (Al2O3) is a metal oxide based nanomaterial that is used in a variety of industrial applications. It can be prepared by hydrolysis of Al2O3 lakeside and particle calcination in the presence of stabilizing agents. Al2O3 based nanoparticles can be used in a wide range of applications such as improving the mechanical properties of metals, flooring materials and abrasives. Wastewater treatment, aerospace and ceramics

2.3 Preparation method

In this work, two methods were adopted for the casting of the samples to be examined: The first method is stir casting by cutting the base alloy into cube pieces whose side length is from to a centimeter m, and then put them in the stir casting device for a minute with stirring and at a temperature of one degree Celsius, added Then the reinforced material that was heated in another container to a temperature higher than room temperature to the molten base of the base alloy with continuous stirring process, and then pouring the final product into metal molds to obtain the required samples. As for the second method of casting, it is using powder technology by using grams of the base alloy material, which has previously been ground until the standard degree of fineness adopted in this type of technology, and then mixed with the required weight percentage of the hardening material and placed in an ultrasonic vibrator to find homogeneity between the different materials and then in the laboratory mold Final to get the required samples.[16-19]

3- Results and Discussion

3.1 Tensile Test

The tensile test is one of the basic tests approved for diagnosing engineering materials and the ability of these materials to withstand performance conditions under different working environments. The tensile test can be relied on as being more reliable than the rest of the tests, as well as having clear indicators for a wide range of mechanical properties. The test was done by (G k8 A) type of machine; Figure no.1 shows a graph of the stress-strain results of a variety of plumbing methods being investigated. And table 4 shows the ultimate tensile stress, yield stress and elongation for different casting technique.

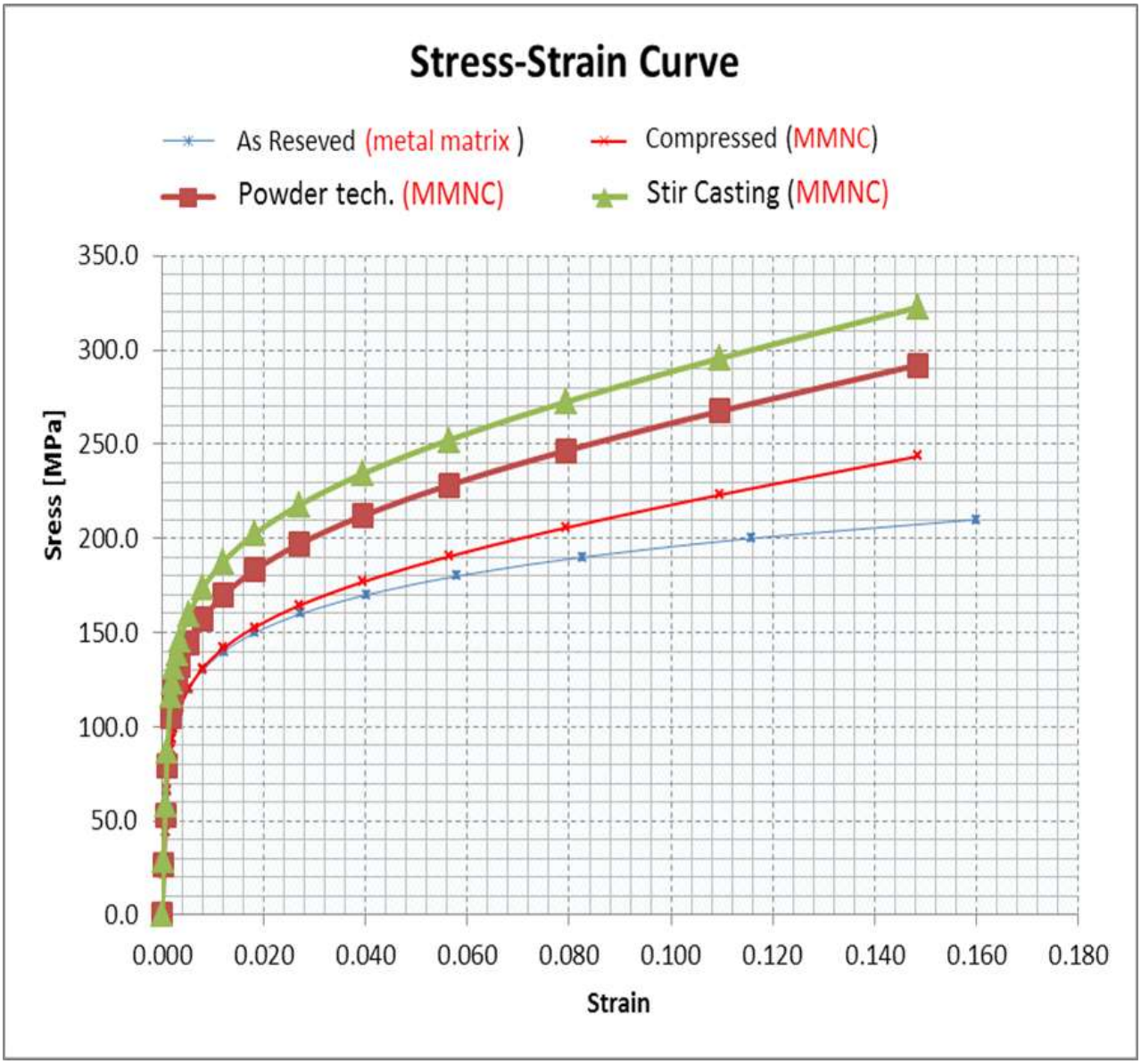

Figure 1 the stress –strain curves for different casting methods.

Table 3 the ultimate tensile strength, yield strength and elongation for several casting technique

.

Property	As reserved	Compered	Powder tech.	Stir Casting

Ultimate Stress (MPa)	210	238	251	313
Yield Stress (MPa)	110	122	132	151
Elongation %	16	15	14.5	14.5

The practical results obtained from Table No. can be drawn for each of the highest stresses that the examined materials can bear, whether they are composite materials or the base material, and the types of plumbing mentioned above, as well as the yield stress.

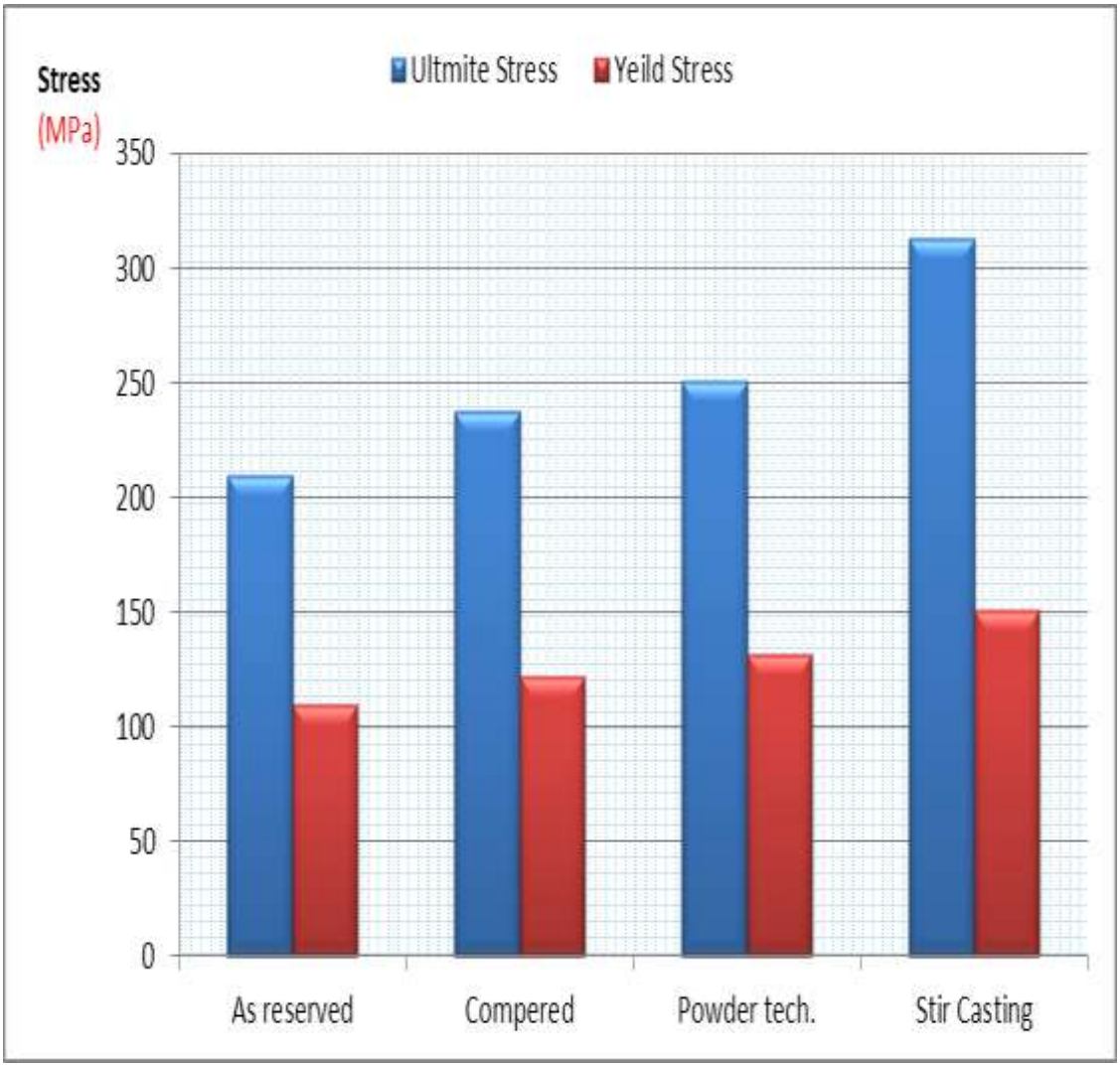

Figure 3 some mechanical properties vs. different types of casting

Depending on the practical results obtained from the stress-strain curve and from figure 3 for the materials under study, it was found that the mechanical properties resulting from the stir casting process are close or slightly better than the results achieved by using powder technology. It is clear that using the process of stirring with pouring led to an orderly distribution of nano materials away from the agglomeration process of the

additives, helping the reinforced nanomaterial to take the most appropriate locations within the points of the crystal lattice and thus improving the mechanical properties by increasing the density of dislocations and reaching a crystal network capable of bearing stresses Higher without the emergence of fracture leading to failure of the tested samples

4-Conclusions

A main set of conclusions can be reached on the above research topic:

1. The choice of the type of casting process is one of the factors that have a high correlation with the quality of the final product
2. It was not possible to notice a clear or significant change to the gravitational casting method from the original samples without the presence of nano materials, which means that the use of this method is not feasible to improve the mechanical properties of the material or the efforts made in the process.
3. Both the method of powder casting with the use of ultrasonic waves, as well as the method of stir-fry casting He indicated that there is an improvement that can be distinguished in the performance characteristics..
4. The stir casting technique obtained the best database of mechanical properties compared to the samples without additives, where the higher tensile stress that the material could bear was improved by 49 percentage and this is can considered an acceptable performance percentage to improve the maximum tensile stress.
5. The main conclusion that we obtained from this study, it is better to use the stir casting method when it is required to produce a nano composite material to obtain the best mechanical properties

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