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The Influence of Nickel Addition on the Mechanical Properties of AA6061 Fabricated By Stir Casting

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Abstract

With the growing demands of the airline industries, various efforts were taken to develop modern advanced structural materials. modern engine are require to have higher power capacity accompanied by reduction in fuel consumption. Therefore need arises to develop new material which will satisfy the requirement of modern engine Super high-strength aluminium alloys AA6061&Ni have attracted much attention in the aerospace fields due to their excellent combination of low density and high-strength Recently, attempts, including a chemical composition modification for an AA6061 and Ni alloy and employing new heat treatments, were made to further increase the properties of these alloys. The present work involves the effects of nickel addition on the strength hardness and impact strength of AA6061 alloys were investigated.

With the change in the composition of Ni as 0.4%and 2.3% investigated by conducting tests

1. strength
2. hardness
3. impact strength of AA6061

Keywords: Stir casting, Strength, Hardness, Impact strength, Pmmc, Mmc

1. INTRODUCTION

Super high-strength aluminum alloys (Al-Zn-Mg-Cu) have attracted much attention in the aerospace fields due to their excellent combination of low density and high strength[1, 2]. Recently, attempts, including a chemical composition modification or an Al-Zn-Mg-Cu alloy and employing new heat treatments, were made to further increase the properties of these alloys. Zhao and Tsuchida [3] found that adding chromium (Cr) or zirconium (Zr) into AA 7075aluminum alloy could inhibit the grain coarsening. Chaubey et al. [4] observed that an addition of cerium (Ce) into Al-Zn Mg-Cu alloy has resulted in up to 5% grain refinement of the cast dendritic structure as well as up to 38% refinement of heat-treated microstructure. However, the applications of the rare-earth metals contained in aluminum alloys are extremely restricted due to their high cost. Therefore, more attention has been paid to the transition metals which are cheap such as nickel. Previous research showed that nickel playsan important role in solid solution strengthening and can effectively improve the mechanical properties of Al-7Si alloys[5]. Farkoosh et al. [6] assessed the phase formation in an Al-Si-Cu-Mg-Ni alloy through adding nickel (0-1 wt.%); also, the

Al3CuNi phase has greater influence on the overall strength of the alloy compared to other Ni-bearing precipitates. At present, studies on Al-Zn-Mg-Cu alloys are developed which modified most of them by nickel with various techniques like a rapid solidification (RS) [7, 8]. While the researchers on the impacts of nickel additives which added to an Al-Zn-Mg-Cu alloy by another casting process, especially they were a joint effect, is very few.

In the present work, the influences of Ni on the mechanical properties of AA6061 produced by a Stir casting process were investigated. In order to optimize the Advances in Materials Science and Engineering

2. OBJECTIVE OF THE PAPER

The main purpose of this paper is to manufacture the particulate aluminium metal matrix composite (PAMC) with varying compositions of reinforcement particles of Nickel (0.4wt% and 2.3wt %) using stir casting method. Testing of PAMC material to carried out to evaluate its mechanical properties. (strength, hardness and Impact energy).

3. MATERIALS AND METHODS

3.1. Materials:

The base material for the investigation is wrought aluminum alloy (6061) as received in form of slabs with chemical composition as presented in Table 1. Nickel(Ni)with chemical composition as presented in table 2. was used as reinforcement.

Table 1. Nominal chemical compositions of AA 6061 matrix alloy(wt%)

Al	Mg	Si	Fe	Cu	Mn	Cr	Zn	Ti	Element
Remains	0.8-1.2	0.4-0.8	0-0.7	0.15-0.4	0-0.15	0.04-0.35	0.25	0.15	composition

Table 2. Nominal chemical compositions of Ni(wt%)

Ni	Fe	cobalt	Element
Remains	0.1	0.005	Composition

3.2. Procedure:

Stir casting is an economical process for the fabrication of aluminum matrix composites. There are many parameters in this process, which affect the final microstructure and mechanical properties of the composites. In this study, micron-sized Ni particles were used as reinforcement to fabricate Al-0.4 wt% Ni and Al-2.3wt%Ni composites at casting temperatures (850 C) and stirring periods (2 and 6 min).

Figure: 3.2.1. Crucible Ni powder

A Coal fired crucible furnace was used for the melting operation. The stir casting set-up for the production of the composites was designed in accordance with Singla et al. (2009). Charge calculations following standard procedures were utilized to estimate the amount of the Al 6061 billets and Ni required to produce 0.4 and 2.3 weight percents (wt.%) Ni reinforcements in the composite.

Figure 3.2.2 Coal fired furnace

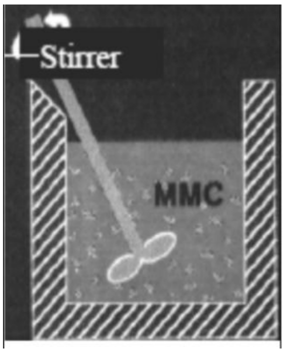

Figure 3.2.3 stirrer

The Al 6061 billets were charged into the furnace and melting was allowed to progress until a uniform temperature of 850o C (which is above the liquidus temperature) was attained. At this stage, Ni metal powder was added into the melt and manual stirring of the slurry was performed for 2 minutes. An external temperature probe was utilized in all cases to monitor the temperature readings of the furnace. After the manual stirring, the composite slurry was reheated and maintained at a temperature of 850o C +- 10o C (above the liquidus temperature) and then mechanical stirring was performed. The stirring operation was performed for 6 minutes at an average stirring rate of 400rpm. Casting was then performed on prepared sand moulds at a pouring temperature of 720o C. Composite slurry is poured in the metallic mould. Mould is preheated at temperature 500°C before pouring of the molten slurry in the mould.

Figure 3.2.4. Metallic Mould b

4. WHY NI IS ADDED ?

Nickel has been used in alloys that date back to the dawn of civilization. Nickel in elemental form or alloyed with other metals and materials has made significant contributions to our present-day society and promises to continue to supply materials for an even more demanding future

.Nickel is a versatile element and will alloy with most metals. Complete solid solubility exists between nickel and copper. Wide solubility ranges between iron, chromium, and nickel make possible many alloy combinations.

When we add Ni to Al the solid solubility of Ni in AA6061 does not exceed 0.04%. Over this amount it is present as an insoluble intermetallic usually in combination with Iron These intermetallic compounds retard the grain growth, lead to grain refinement, and result in further strengthening effects.

5. RESULTS AND DISCUSSIONS

We had successfully manufactured PAMC by using stir cast apparatus. We come to know that process parameter is playing a major role for uniform distribution of reinforcement. In order to determine its mechanical properties we had conducted some test and its result are illustrated as follows.

- The Aluminium Matrix composites with 0.4 and 2 wt% of NI & 6061 remaining is subjected to following measurements to evaluate its mechanical properties
  - Tensile Test
  - Hardness Test (Brinell's Hardness)
  - impact test

5.1. Tensile Test[10]:

A tensile test, also known as tension test is a mechanical test that can be performed on materials. Tensile test is relatively simple, inexpensive and fully standardized. In this test, a sample is subjected to a tension till breaking point or failure of a material. This result from the test which were conducted are commonly used to select a material for an application, for quality control, and to predict how a material will react under other types of forces.

Properties, which are directly measured via tensile test are ultimate tensile strength, maximum elongation and reduction in area. From these measurements the following properties can also be determined: Young's modulus, Poisson's ratio, yield strength, and strain-hardening characteristics.

Uniaxial tensile testing is the most commonly used test for obtaining the mechanical characteristics of isotropic materials. For anisotropic materials, such as composite materials and textiles, biaxial tensile testing is required.

A tensile specimen is a standardized sample cross-section. It has two shoulders and a section in between. The shoulders are large so they can be readily gripped, whereas the section has a smaller cross-section so that the deformation and failure can occur in this area.

Figure: 5.1.1. Before testing

Figure: 5.1.2. After testing

5.2. Hardness:

It is a measure of resistance that how resistant solid matter is to vary with change of permanent shape when a compressive force is applied. Some materials, such as metal, are harder than others. Hardness is dependent on ductility, elastic stiffness, plasticity, strain, strength, toughness, viscoelasticity, and viscosity.

In our project we used Brinell Hardness Test.

Figure: 5.2.1 Hardness test specimens

5.3. Impact testing:

In mechanics, an impact is a high force or shock applied over a short period of time when two or more bodies collide. Such a force or acceleration usually has a greater effect than application of lower force over a proportionally longer period of time. This effect depends critically on the relative velocity of bodies with one another. Charpy test is also known as the V-notch test, is a standardized high strain-rate test which determines the amount of energy absorbed by a material during fracture.

Figure: 5.3.1. Work pieces before testing

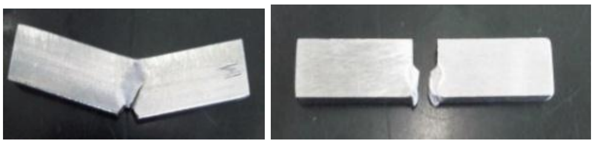

Figure :5.3.2. After testing

6. DISCUSSIONS:

Table 3: comparision of properties:

MATERIAL/ PROPERTY	AA 6061	AA 6061 and 0.4wt% NICKEL	AA 6061 and 2.3wt% NICKEL
ULTIMATE TENSILE STRENGTH	330	375.928	103.720
TENSILE YIELD STRENGTH	310 MPa	349.42 MPa	96.433 MPa
HARDNESS (BRINELL)	95 BHW	107 BHW	55 BHW
ELONGATION	12%	15.50%	2.56%
IMPACT ENERGY	20JOULES	22JOULES	2 JOULES

When compared to the base metal alloy the strength of 0.4wt% Ni added composite is increased. When we add Ni to Al the solid solubility of Ni in AA6061 does not exceed 0.04%. Over this amount it is present as an insoluble intermetallic usually in combination with Iron

These intermetallic compounds retard the grain growth, lead to grain refinement, and result in further strengthening effects**.**

When compared to the 2.3wt% Ni the strength decreased drastically this is because as the Ni content increases the intermetallics increases.

Increase in intermetallics decreases the overall strength of the composite due to this the strength decreases

The electro negativity of Al is 1.6 and that of Ni is 1.967 the difference in the electro negativity causes the formation of ionic bond

The percentage of elongation of the metal increases when we add 0.4wt% of Ni

And reduceses drastically when we increase % of Ni to 2.3wt%

The impact energy also increases when we add upto 0.4wt% Ni and reduceses if we increase the wt% of Ni to 2.3wt%.

7. CONCLUSION

As the percentage of Ni increase to 0.4wt% the properties like Strength ,hardness and Impact energy are increases compared to base AA6061.If further we increase the Ni content to 2.3wt% there is a drastic reduction in the properties compared to baseAA 6061 and 0.4wt%.as shown in above reports.

By this we are knowing that addition of Ni to AA 6061 up to certain amount(0.4%) increases the properties beyond that there is a drastic reduction in the properties like strength, hardness and impact energy

8. **APPLICATIONS:**

1. AA6061 & Ni aluminum is used extensively as a construction material most commonly in the manufacture of aircraft and automotive components.
2. The 6061and Ni alloy is well-suited to the construction of yachts, motorcycles, bicycle frames, scuba tanks, camera lenses, fishing reels electrical fittings, couplings and valves.
3. It’s used in the construction of aluminium cans, and the inside foil wrapper on food containers is often made with 6061 aluminum alloy and Ni.
4. Aluminium -magnesium-silicon-nickel alloys are also used in wide-span roof structures for bridge decks and arenas.
5. Trucks, canoes, railroad cars, furniture, pipelines

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