

Investigation of Mechanical Properties of Aluminium Cast Alloy (6063) By Varying Chemical Composition

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Abstract - In this study, the mechanical properties of Aluminium Alloys obtained with changing various input parameters in casting were studied. Different input process parameters taken under consideration are grain fineness number, moisture content, and clay content. The different values of various parameters affecting the Hardness and Compressive strength of the final castings of different alloy have been observed. The results show that variation in input parameters improves the mechanical properties of Aluminum Casting.

Key Words: Casting, Grain Fineness Number, Moisture Content, Aluminium Alloy 6063, Hardness, Compressive Strength, Tensile Strength, etc.

1. INTRODUCTION

Aluminium alloys are used in transportation because of its unbeatable strength to weight ratio. Its lighter weight means that less force is required to move the vehicle, leading to greater fuel efficiency. Although aluminum is not the strongest metal, alloying it with other metals helps to increase its strength.

Aluminium Alloy 6063 is a casting alloy, with magnesium and silicon as the alloying elements. It is a medium quality alloy regularly alluded to as a design alloy. It is ordinary utilized as a part of multifaceted expulsions.

Pure aluminium is readily alloyed with many other metals to produce a wide range of physical and mechanical properties. There is an international accord recognizing the aluminium wrought alloy designation system. The alloy designation system is briefly described below (Higgins, 1998 a).

- First digit - Principle alloying element.
- Second digit - Variation of initial alloy
- Third and fourth digits - Individual alloy variations.

Aluminium Alloys Series	Chemical Compositions
1xxx	Pure Al (99.00%)
2xxx	Al-Cu Alloys
3xxx	Al-Mn Alloys

4xxx	Al-Si Alloys
5xxx	Al-Mg Alloys
6xxx	Al-Mg-Si Alloys
7xxx	Al-Zn-Mg Alloys
8xxx	Al + Other Elements

Table -1: Classification series of Aluminium Alloys

Aluminium Alloy 6063 is a casting alloy, with magnesium and silicon as the alloying elements. It is a medium quality alloy regularly alluded to as a design alloy.

2. LITURETUR REVIEW

Literature review has been conducted through books journals from various publications. Based on certain keys like casting, grain Fineness Number, moisture contents, Aluminium Alloy, Testing methods and Fabrication process involved are used to do the literature review.

About 36 literatures are collected from various international journals as a part of this research. These journals comprises of highly important data based on vast experimental observations like clay content, moisture contents, grain fineness number etc. These experimental results are taken for the survey and analyzed carefully for identifying a new feasible Aluminium Casting Alloy for better qualities to be used in aviation.

This segregation of journals are based on the aspects like Casting Processes, Testing Methods for compression, tensile and hardness, variation in chemical compositions and its effect on mechanical Properties of the Alloy. Many researchers have developed various new metals by variation in chemical compositions for different needs and properties.

From these literatures we found that Aluminum Alloy: 6063 is a costing aluminum alloy, with magnesium and silicon as the main alloying elements. The standard controlling its composition is maintained by The Aluminum Association. Al 6063 is mostly used in extruded shapes for architecture, particularly window frames, door frames, roofs, and sign frames.

3. EXPERIMENTATION

This section comprises of material selection for alloy and sample preparation with different chemical composition of the specimens prepared.

The attempt has been made to find the effect of different composition in alloy on the Tensile strength, Hardness and Impact strength of the castings produced by sand casting method.

3.1 Selection of Materials

In the present investigation 6063 aluminium alloy has been taken to make the castings. Aluminum Alloy 6063 ingot used for this study was obtained from a Aluminum Extrusion Company, Mittal Metalloys Private Limited, Ghaziabad, India and its chemical composition is given Table 2.

Chemical Element	Present By Weight
Manganese (Mn)	0.0% - 0.10%
Iron (Fe)	0.0% - 0.35%
Magnesium (Mg)	0.45% - 0.90%
Silicon (Si)	0.20% - 0.60%
Zinc (Zn)	0.0% - 0.10%
Titanium (Ti)	0.0% - 0.10%
Chromium (Cr)	0.0% - 0.10%
Copper (Cu)	0.0% - 0.10%
Other (Each)	0.0% - 0.05%
Others (Total)	0.0% - 0.15%
Aluminium (Al)	Balance

Table -2: Compositions of Aluminium Alloy 6063

It has high strength and low weight alloy used in aerospace engineering and application in high specific strength and low cost for shape forming. Aluminum alloys are used in engineering application such as engines for vehicle, helicopter and fan hubs etc. Due to its above feature it could also be used in making in engine blocks and other automotive parts.

3.2 Sample Preparation

The various elements Zn, Mn and Mg were to be preheated at 450⁰ C, 1100⁰ C, 1250⁰ C and 700⁰ C and Predefined quantity of Al 6063 was taken and melts in a open hearth furnace at 750⁰ C which is above its melting temperature (650⁰ C).

After mixing the four elements separately and melt was poured in mould for preparation of specimen. All test were as per ASME standards.

3.3 Casting of Sample

Casting is a manufacturing process in which a liquid material is usually poured into a mold, which contains a hollow cavity of the desired shape, and then allowed to solidify. The solidified part is also known as a casting, which is ejected or broken out of the mold to complete the process. Casting materials are usually metals or various cold setting materials that cure after mixing two or more component together.

Steps involved in casting:

- Making mould cavity
- Material is first liquefied by properly heating it in a suitable furnace.
- Liquid is poured into a prepared mould cavity
- allowed to solidify
- Product is taken out of the mould cavity, trimmed and made to shape.

Type of Casting

This section describes exclusively Mould casting which can be divided into two main groups:

1. Sand casting
2. Die casting

Sand Casting

In sand casting, re-usable, permanent patterns are used to make the sand moulds. The preparation and the bonding of this sand mould are the critical step and very often are the rate-controlling step of this process. Two main routes are used for bonding the sand moulds:

1. The "green sand" consists of mixtures of sand, clay and moisture.
2. The "dry sand" consists of sand and synthetic binders cured thermally or chemically.

We were used Green sand casting for casting our samples.

The Parameter for Sample Casting is briefly described below :

- Grain Fineness Number- 45
- Moisture content- 2%
- Clay content - 10%
- Green strength - 74.3 N/m²



Figure-1: Casting of Aluminium Alloy



Figure-2: Samples after testing

3.4 Sample Testing

The samples were machined on lathe and grinding machine to prepared the specimens for Tensile, compressible and hardness testing. The most common tests performed on A6063 include Tensile (ASTM E8), Compressive (ASTM E9) and Hardness (ASTM E18).

Tensile testing provide useful information about the strength and ductility of a alloy. Compressive testing tells about the Compressive strength and brittleness of alloy. Hardness testing is also useful as it can often be correlated with tensile strength and can be done on smaller samples.

Tensile Testing

Totally, 5 samples were produced and tensile tests were carried based on ASTM standard. The casting specimen converts into the dimension 200 x 20 mm. From the samples, it can be inferred that each parameter have significant influence on tensile strength of the specimen A6063 aluminium alloy. UTM capacity used for such testing is 400 KN. Total 5 test carried out on UTM and all indicated values filled in table 3.

Compressive Testing

The compressive test specimens were prepared with dimensions according to the ASTM standards. Same UTM was used for this testing. The compressive test result is as shown in the table 4.

Hardness Testing

The Brenell hardness test method consists of indenting the test material with a 10 mm diameter hardened steel or carbide ball subjected to a load of 3000 kg. Specimens were prepared with dimensions according to the ASTM standards.

4. EXPERIMENTAL RESULT

After Sample Testing the following properties were measured.

- Tensile strength (N/mm²) or MPa
- Compressive strength (N/mm²) or MPa
- Hardness (BHN)

The effect of various Compositions observed on mechanical properties of A6063 aluminium alloy castings has been discussed in this section.

4.1 Tensile Test Result

The tensile test was carried out as per ASTM Standards. The results of tests are shown in the table. The percentage improvements are given.

Chemical Compositions of Samples Casting	Ultimate Tensile Strength (MPa)
Al 6063	190.2
Al 6063+Zn (0.15%)	191.5
Al 6063+Zn (0.15%)+Mg (0.8%)	194.3
Al 6063+ Zn (0.15%)+ Mg (0.8%)+Mn (0.10%)	195.8

Table -3: Result of Tensile Strength in MPa

4.2 Compressive Test Result

The compression test was carried out as per ASTM Standards. The results of the tests are shown in the table. It is observed from the table that compressive strength of the composite increases with the addition of these elements.

Chemical Compositions of Samples Casting	Compressive Strength (MPa)
Al 6063	90.6
Al 6063+Zn (0.15%)	91.5
Al6063+Zn (0.15%)+Mg(0.8%)	93.9
Al 6063+ Zn (0.15%)+ Mg(0.8%)+Mn(0.10%)	94.3

Table -4: Result of Compressive Strength in MPa

4.3 Hardness Test Result

The hardness test was carried out as per ASTM Standard. The results of the tests are shown in the table. It can be noted from the values that the hardness increases with addition of elements.

Chemical Compositions of Samples Casting	Hardness (BHN)
Al 6063	73
Al 6063+Zn (0.15%)	73.5
Al6063+Zn (0.15%)+Mg(0.8%)	75.2
Al 6063+ Zn (0.15%)+Mg(0.8%)+ Mn(0.10%)	75.4

Table -5: Result of Hardness in BHN

5. CONCLUSION

From this investigation we concluded that we can use Zn, Mn and Mg to increase the tensile strength, compressive strength and hardness of Aluminium alloy 6063 when it is mixed with the Aluminium alloy 6063 in a fractional percentage by weight.

The expected result of our research is that Aluminium alloy 6063 will act as a low cost substitute of conventional Aluminum products used in many industries and other small machine components.

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