# OPTIMIZATION AND CHARACTERIZATION OF ALUMINIUM ALLOY AA6063

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## ABSTRACT

The recent years, there is a rapid increase in the utilization of Aluminium metal. The main application of Aluminium metal is automobile, aerospace, agriculture and many other industrial applications for the manufacturing of different parts and components, because of their essential properties such as high strength, low density, and good wear resistance compared to any other metal. The present study deals with the addition of reinforcements such as silicon and magnesium to the Aluminium matrix in stress and thermal proportions. Each reinforced material has an individual property which when added improves the properties of the base alloy of aluminium. An effort has been made to review the different combinationsof the composites and how they affect the properties of the different alloys of aluminium.

## 1.1 INTRODUCTION

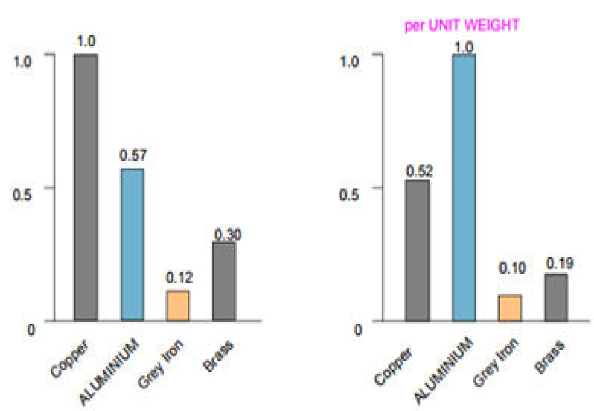


**Fig 2.1 thermal conductivity of Al compared with other metal**

Aluminum is a silvery white and ductile metal that is soft and easily formed. It's the most abundant metal in the Earth's crust and the third most abundant element overall. It makes up about 8% by weight of the Earth's solid surface. Aluminum is commonly used in the foodservice industry in cookware and bakeware and is a great conductor of heat.

Composites are defined as materials with following criteria,

a) Must be a combination of at least two chemically distinct materials with distinct inter phase separating the constituents
b) Must be combined three dimensionally

c) Should be created to obtain properties which would not otherwise be achieved by any of the individual constituent.

Traditionally, aluminium and its alloys are being used for manufacturing various parts (especially aircraft structure) for aerospace application. some of the reasons being low density good castability, high strength, corrosion resistant and good fatigue strength.

However, aluminium based MMCs outsmart aluminum and its alloys in mechanical and thermal properties. Coating that are generally used for aluminum plate are Si and Mg powder which powders coated on the aluminium plate one by one. Primary aim of coating is boosting of mechanical properties like stress and thermal conduction. Methods that are commonly used for fabrication and production of aluminum based MMCs are Powder metallurgy by Plasma Vapour Deposition.

## 1.2 Silicon

The main characterization of silicon has,

- Strength and hardness;
- Decreases ductility and weldability;
- Effects hardenability of steel.

## 1.3 Magnesium

One of the principal deoxidizers used in steel making. In low-carbon steels, silicon is generally detrimental to surface quality.

Properties of Mg can be improved substantially by alloying.

## 1.3(a) Applications,

It includes gearboxes, valve covers, alloy wheels, clutch housings, and brake pedal brackets.

## 1.4 Plasma Vapour Deposition(PVD)

The first evaporated thin films are often attributed to Faraday in 1857, when he exploded metal wires m an inert atmosphere Since then thin film technology has become one of the fastest growing areas of technology. Thin film applications can be found in optical, electronics, chemical, and mechanical areas.

Advantages of using a film on a substrate are either to protect the substrate from external forces or attribute to the substrate properties of a more precious or rare material. The particular area of interest for this project is m materials science.

## 1.4(A) Advantages of using PVD

Low operating temperature

Uniform coating of different shapes

Good step coverage

## 2.1 LITERATURE REVIEW

Literature survey on evaluation of microstructure and properties of composite materials are given in this section. The requirement of microstructure is uniform particle distribution, less porosity and particle matrix interface and mechanical properties depends on the matrix properties, wettability, amount of reinforcement and shape of reinforcing phase and the size of the reinforcing particles.

Kollo et al (2009) [1] studied the effect of High-energy planetary milling in aluminium powders with 1 vol% of silicon carbide (SiC) nano particles. A number of milling parameters were modified for constituting the relationship between the energy input from the balls and the hardness of the bulk nano composite materials. It was shown that mixing characteristics and reaction kinetics with stearic acid as process control agent can be estimated by normalised input energy from the milling bodies. For this, the additional parameter characterizing the vial filling was determined experimentally. Depending on the ball size, a local minimum in filling parameter was found, laying at 25 or 42% filling of the vial volume for the balls with diameter of 10 and 20mm, respectively. These regions should be avoided to achieve the highest milling efficiency. After a hot compaction, difference of hardness for different milling conditions was detected. Therewith the hardness of the Al–1 vol.% nanoSiC composite could be increased from 47HV0.5 of pure aluminium to 163HV0.5 when milling at the highest input energy levels.

Nemati et al (2011) [2] investigated the wear behavior of aluminium alloy matrix composites produced using powder metallurgy technique of ball milled mixing in a high energy attritor and using a blend–press–sinter methodology. Matrix of pre-mechanical alloyed Al–4.5 wt.% Cu was used to which different fractions of nano and micron size TiC reinforcing particles (ranging from 0 to 10 wt.%) were added. The powders were mixed using a planetary ball mill. Consolidation was conducted by uniaxial pressing at 650 MPa. Sintering procedure was done at 400°C for 90 min. The results indicated that as TiC particle size is reduced to nanometre scale and the TiC content is increased up to optimum levels, the hardness and wear resistance of the composite increase significantly, whereas relative density, grain size and distribution homogeneity decrease. Using micron size reinforcing particulates from 5% to 10 wt.%, results in a significant hardness reduction of the composite from 174 to 98 HVN. Microstructural characterization of the aspressed samples revealed reasonably uniform distribution of TiC reinforcing particulates and presence of minimal porosity. The wear test disclosed that the wear resistance of all specimens increases with the addition of nano and micron size TiC particles (up to 5 wt.%).

Krishna et al. [3] evaluated the heat flow distribution characteristics of the metal matrix composite of Al6061 with silicon carbide and graphite using ANSYS software. The results showed the reduction of thermal conductivity due to the inclusion of graphite. Okumus et al. studied thermal expansion and thermal conductivity of matrix Al-11.8 wt.% SiC with silicon carbide and graphite. It was found by generating thermal stress response curve for varying proportions of SiC and graphite that increasing amount of graphite in SiC reinforced base alloy points to higher strain rate but the low coefficient of thermal expansion values. Increasing the graphite content leads to grain refinement for both primary and aluminium dendrites and eutectic silicon. Thus, it results in low thermal expansion. On the other hand, the inclusion of more amount of graphite gives a dimensional stability to the composite because the graphite particles absorb thermal expansion due to their layered structure.

Liu Yao-hui et al. (2004) [4] observed that friction coefficient and wear rate of Al-12Si monolithic alloy and Al-12Si/alumina/carbon composites decreased slightly with increasing temperature up to 100oC. The trend reversed beyond this temperature, finally leading to specimen seizure indicated by a sharp rise in friction coefficient and wear rate.

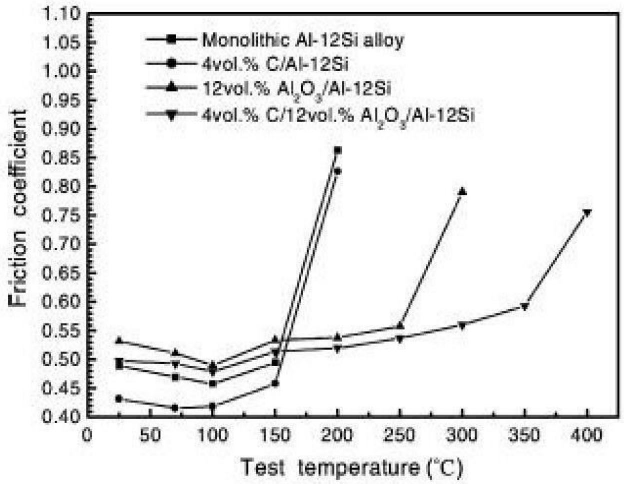


**Fig 2.1(a) Friction coefficient**

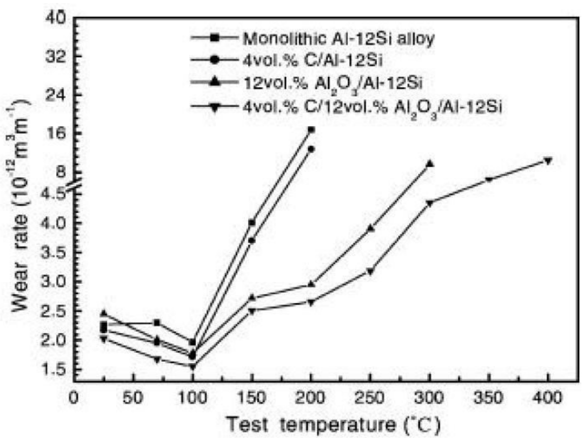


**Fig 2.1(b) wear rate**

**3.1 CHEMICAL PROPERTIES**

## 3.1(a) Aluminium - Silicon Alloys

Silicon can be added to aluminium alloys in quantities sufficient to cause a substantial lowering of the melting point. For this reason this alloy system is used entirely for welding wire and brazing filler alloys, where melting points lower than the parent metal are required. In themselves these alloys are non-heat-treatable but in general they pick up enough of the alloy constituents of the parent metal to respond to a limited degree of heat treatment.

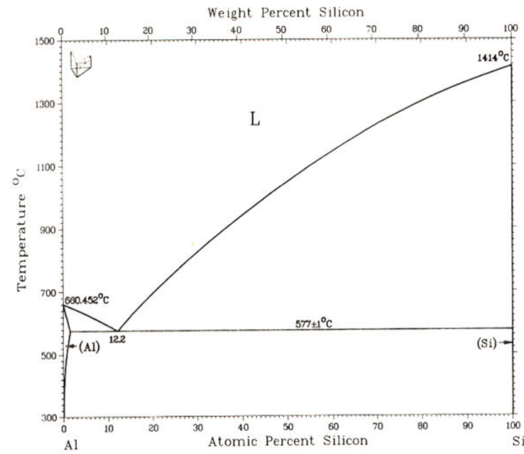


**Fig 3.1(a) phase diagram for Al-Si**

## 3.1(b) Aluminium - Magnesium Alloys

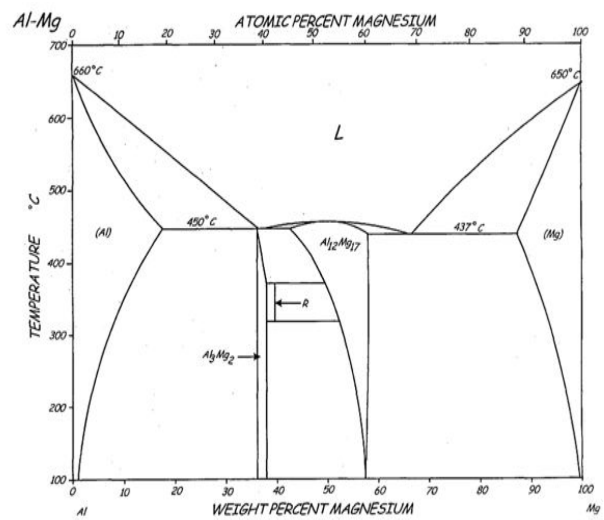


**Fig 3.1(b) phase diagram for Al-Mg alloy**

This series of alloys is non heat-treatable and exhibits the best combination of high strength with resistance to corrosion (as indicated by its frequent use in marine/sea water applications). This series also exhibits good weldability but when the Mg level exceed 3% there is a tendency for stress corrosion resistance to be reduced, dependent on the temper used and temperature of operation. Uses: pressure vessels, bulk road and rail vehicles, ships structures, chemical plant.

### 3.1(c) Aluminium - Magnesium - Silicon Alloys (Al-Mg2Si)

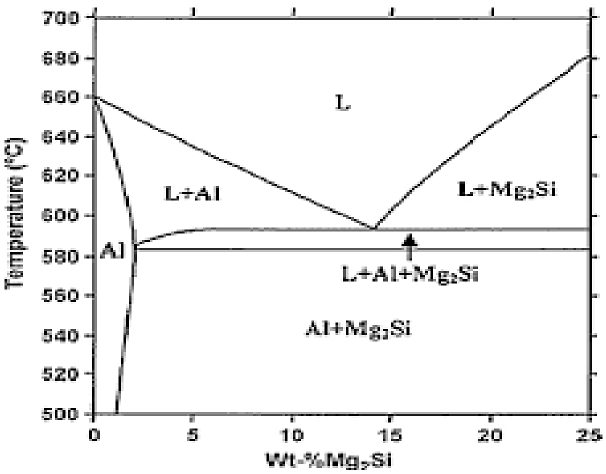


**Fig 3.1(c) phase diagram for Al-Mg2Si**

This group of heat-treatable alloys uses a combination of magnesium and silicon (magnesium Silicide) to render it heat-treatable. These alloys find their greatest strength, combined with good corrosion resistance, ease of formability and excellent ability to be anodized. Typical alloys used for building structure applications, land and sea transport applications.

## 4.1 EXPERIMENTAL PROCEDURE

Aluminium alloys are the most promising lightweight materials used in the automotive industry to achieve weight reduction. High pressure diecasting (HPDC) is a fast and economical near-net shape manufacturing method to produce engineering components. About 80% of cast aluminium alloys are currently manufactured by HPDC.

The increased demands of manufacturing structural components by HPDC process require high strength Al-alloys for the automotive industry. However, the currently available die cast Alloys are unable to fulfil this requirement.

Al-Mg2Si alloy is known as an alloy capable of providing superior high strength and thermal conduction by Mg2Si particles.

Moreover, the Mg-Si alloys are mainly focused on the aluminium plate. The mechanical properties of Al plate is determined by the alloy composition of Mg and Si with this Al plate (by the process of PVD), the powdered Mg and Si has been coated in both surface of the Al plate.

The refined microstructure in Plasma Vapour Deposition of Al-Mg2Si alloys can be obtained to improve the mechanical properties. Therefore, the development of high strength Al-Mg2Si based alloys for the PVD process is significant for manufacturing quality automotive components.

## 5.1 CONCLUSION

The purpose of this literature review is to have a broader perspective about the different grades of aluminium and choosing the best combination of the individual parameters considered.

- Good strength to weight ratio
- Good corrosion and wear resistant
- Good thermal stability

## 6.1 REFERANCE

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