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ANALYSIS OF MECHANICAL PROPERTIES FOR AL6061 ALLOY METAL MATRIX WITH BORON CARBIDE & GRAPHITE

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Abstract - A Composite material is a material made from two or more constituent materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the individual components. A metal matrix composite (MMC) is composite material with at least two constituent parts, one being a metal necessarily, the other material may be a different metal or another material, such as a ceramic or organic compound. When at least three materials are present, it is called a hybrid composite. An MMC is complementary to a cermets. Aluminum 6061 alloy constitutes a very important engineering material widely employed in the aircraft and aerospace industry for the manufacturing of different parts and components. Due to its high strength to density ratio that it a sought after metal matrix composite. Metal matrix has the advantage over polymeric matrix in applications requiring a long-term resistance to severe environments, such as high temperature. Aluminum & B_4C with -Graphite alloys are occupying attention of both researches and industries as a promising material for tribological applications. These are light weight having good malleability, formability, high corrosion resistance and high electrical and thermal conductivity. In this work a composite is developed by adding B_4C with Graphite in Aluminum metal by constant volume based ratio. Composite has to be prepared by crucible casting technique and has to be analyzed various mechanical properties.

Keywords: Aluminum Metal Matrix, B_4C, Graphite, Mechanical Properties, Analysis.

1. INTRODUCTION

Metal matrix composite (MMC) is composite material with at least two constituent parts, one being a metal and the other material may be a different metal or another material, such as a ceramic or organic compound. MMCs are nearly always more expensive than the more conventional materials they are replacing. As a result, they are found where improved properties and performance can justify the added cost. Today these applications are found most often in aircraft components, space systems and high-end or “boutique” sports equipment. The scope of applications will certainly increase as manufacturing costs are reduced. In comparison with conventional polymer matrix composites, MMCs are resistant to fire, can operate in wider range of temperatures, do not absorb moisture, have better electrical and thermal conductivity, are resistant to radiation, and do not display out gassing. On the other hand, MMCs tend to be more expensive, the fiber-reinforced materials may be difficult to fabricate, and the available experience in use is limited.

2. MATERIALS USED

2.1 ALUMINIUM

The name aluminum is derived from the ancient name for alum (potassium aluminum sulphate), which was alumen (Latin, meaning bitter salt). Aluminum was the original name given to the element by Humphry Davy but others called it aluminum and that became the accepted name in Europe. However, in the USA the preferred name was aluminum and when the American Chemical Society debated on the issue, in 1925, it decided to stick with aluminum. Aluminum is a soft and lightweight metal. It has a dull silvery appearance, because of a thin layer of oxidation that forms quickly when it is exposed to air. Aluminum is nontoxic (as the metal) nonmagnetic and non-sparking.
Aluminum has only one naturally occurring isotope, aluminium-27, which is not radioactive.

2.2 BORON CARBIDE

Boron Carbide is one of the hardest materials known, ranking third behind diamond and cubic boron nitride. It is the hardest material produced in tonnage quantities. Originally discovered in mid 19th century as a by-product in the production of metal borides, boron carbide was only studied in detail since 1930.Boron carbide powder (see figure 1) is mainly produced by reacting carbon with B_2O_3 in an electric arc furnace, through carbothermal reduction or by gas phase reactions. For commercial use B_4C powders usually need to be milled and purified to remove metallic impurities. In common with other non-oxide materials boron carbide is difficult to sinter to full density, with hot pressing or sinter HIP being required to achieve greater than 95% of theoretical density. Even using these techniques, in order to achieve sintering at realistic temperatures (e.g. 1900 - 2200°C), small quantities of dopants such as fine carbon, or silicon carbide are usually required. As an alternative, B_4C can be formed as a coating on a suitable substrate by vapour phase reaction techniques e.g. using boron halides or di-borane with methane or another chemical carbon source.

2.3 GRAPHITE

Carbon has two natural crystalline allotropic forms: graphite and diamond. Each has its own distinct crystal structure and properties. Graphite derives its name from the Greek word "graphein", to write. The material is generally greyish-black, opaque and has a lustrous black sheen. It is unique in that it has properties of both a metal and a non-metal. It is flexible but not elastic, has a high thermal and electrical conductivity, and is highly refractory and chemically inert. Graphite has a low adsorption of X-rays and neutrons making it a particularly useful material in nuclear applications.The unusual combination of properties is due its crystal structure. (Figure 1.) The carbon atoms are arranged hexagonally in a planar condensed ring system. The layers are stacked parallel to each other. The atoms within the rings are bonded covalently, whilst the layers are loosely bonded together by van der Waals forces. The high degree of anisotropy in graphite results from the two types of bonding acting in different crystallographic directions. For example, graphite's ability to form a solid film lubricant comes from these two contrasting chemical bonds. The fact that weak Van der Waals forces govern the bonding between individual layers permits the layers to slide over one another making it an ideal lubricant. World production of graphite was estimated to be about 602,000 tons in 2000, with China being the biggest producer followed by India, Brazil, Mexico and then the Czech Republic.

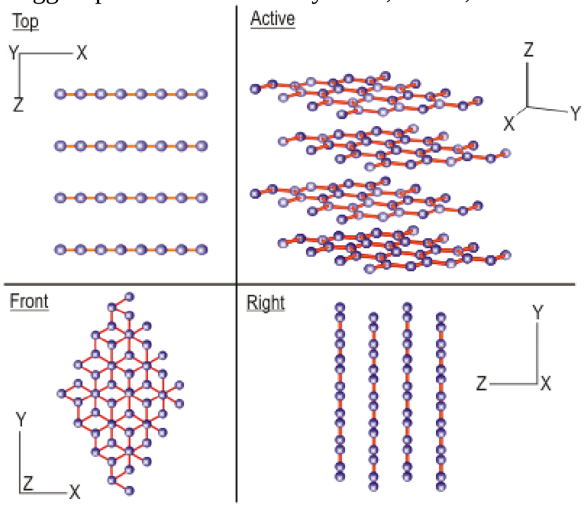

Fig 1: Crystal structure of graphite.

3. EXPERIMENTAL SET UP USED AND CASTING REQUIREMENT

Equipments used to perform the crucible Casting operation is shown in Table 5.1.

Table 1: List of Equipment used for Stir Casting Operation

SL.NO	EQUIPMENT USED
1	Pit Furnace
2	Graphite crucible mould
3	Graphite stirrer
4	Power Hacksaw
5	Stainless steel

3.1 MIXING RATIO

In this project Aluminum and silicon carbide, Graphite mixed below mentioned categories.

Table 2: Mixing Ratio

S.No	Material
1	AL90% B_4C% -5 % Graphite 5%
2	AL92.5% B_4C% -5 % Graphite 2.5%
3	AL90% B_4C - 2.5% Graphite 7.5%

3.2 MATERIAL REQUIREMENT FINDING METHOD

Specimen size-25 mm diameter,Length-320 mm and Volume-3.14/4*25^2*320*percentage of composite*density*percentage of excess of material.

Aluminium alloy materials or simply composites are combinations of materials. They are made up of combining two or more materials in such a way that the resulting materials havecertain design properties on improved properties .The Aluminium alloy composite materialsconsist of high specific strength, high specific stiffness, more thermal stability, morecorrosion and wear resistance, high fatigue life.AlSiC, pronounced 'alsick' is a metal matrix composite consisting of aluminium matrix with silicon carbide particles.

It has high thermal conductivity (180–200 W/m K) and it is chiefly used in microelectronics as substrate for power semiconductor devices and high densitymultichipmodules, where it aids with removal of waste heat. The mechanical properties ofaluminium alloys reinforced with ceramic particulates are known to be influenced by the particle size and the volume fraction.

3.3 CASTNG

In this project we have used sand mold casting for produce the requirement size. Sand casting, also known as sand molded casting, is a metal casting process characterized by using sand as the mold material. It is relatively cheap and sufficiently refractory even for steel foundry use. A suitable bonding agent (usually clay) is mixed or occurs with the sand. The mixture is moistened with water to develop strength and plasticity of the clay and to make the aggregate suitable for molding. The term "sand casting" can also refer to a casting produced via the sand casting process. Sand castings are produced in specialized factories called foundries. Over 70% of all metal castings are produced via a sand casting process. There are six steps in this process.

1. Place a pattern in sand to create a mold.
2. Incorporate the pattern and sand in a gating system.
3. Remove the pattern.
4. Fill the mold cavity with molten metal.
5. Allow the metal to cool.
6. Break away the sand mold and remove the casting.

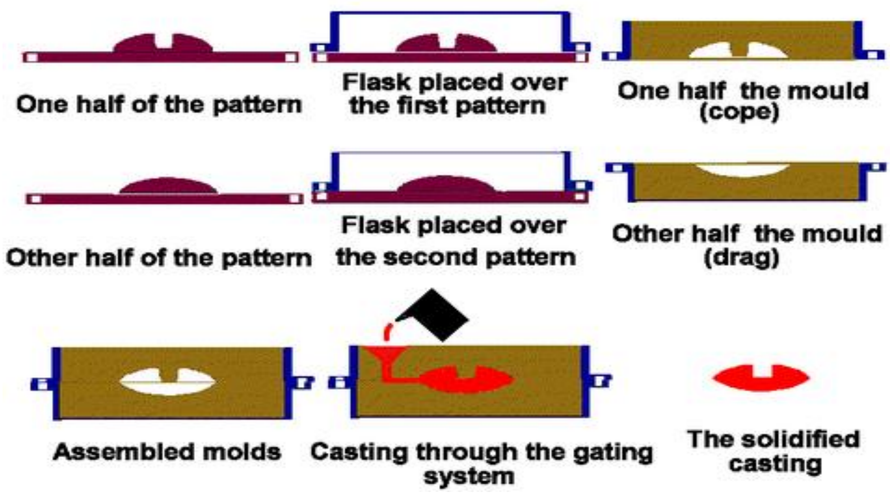

Fig 2: Casting Process

4. EXPERIMENTAL RESULTS

4.1 ROCKWELL HARDNESS TEST

1. Rockwell Hardness systems use a direct readout machine determining the hardness number based upon the depth of penetration of either a diamond point or a steel ball. Deep penetration indicated a material having a low Rockwell Hardness number.
2. However, a low penetration indicates a material having a high Rockwell Hardness number. The Rockwell Hardness number is based upon the difference in the depth to which a penetrator is driven by a definite light or "minor" load and a definite heavy or "Major" load.
3. The ball penetrators are chucks that are made to hold 1/16" or 1/8" diameter hardened steel balls. Also available are ¼" and ½" ball penetrators for the testing of softer materials.
4. There are two types of anvils that are used on the Rockwell hardness testers. The flat faceplate models are used for flat specimens. The "V" type anvils hold round specimens firmly.
5. Test blocks or calibration blocks are flat steel or brass blocks, which have been tested and marked with the scale and Rockwell number. They should be used to check the accuracy and calibration of the tester frequently.

Using the "C" Scale;

a. Use a Diamond indenter
b. Major load: 107.5 Kgf, Minor load: 10 Kg
c. Use for alloy metal.
d. Do not use on hardened steel

HARDNESS VALUE

Table 3: Hardness value

S.No	Material	HRB
1	AL90% B_4C% -5 % Graphite 5%	95
2	AL92.5% B_4C% -5 % Graphite 2.5%	89
3	AL90% B_4C - 2.5% Graphite 7.5%	83

4.2 IMPACT TEST

Izod impact strength testing is an ASTM standard method of determining impact strength. A notched sample is generally used to determine impact strength. Impact is a very important phenomenon in governing the life of a structure. In the case of aircraft, impact can take place by the bird hitting the plane while it is cruising, during take - off and landing there is impact by the debris present on the runway an arm held at a specific height (constant potential energy) is released. The arm hits the sample and breaks it. From the energy absorbed by the sample, its impact strength is determined. The North American standard for Izod Impact testing is ASTM D256. The results are expressed in energy lost per unit of thickness (such as ft-lb/in or J/cm) at the notch. Alternatively, the results may be reported as energy lost per unit cross-sectional area at the notch (J/m² or ft-lb/in²). In Europe, ISO 180 methods are used and results are based only on the cross-sectional area at the notch (J/m²).

The dimensions of a standard specimen for ASTM D256 are 4 x 12.7 x 3.2 mm (2.5" x 0.5" x 1/8"). The most common specimen thickness is 3.2 mm (0.125"), but the width can vary between 3.0 and 12.7 mm (0.118" and 0.500"). The Izod impact test differs from the Charpy impact test in that the sample is held in a cantilevered beam configuration as opposed to a three point bending configuration.

IMPACT TEST RESULT

Table 4: Impact Test Result

S.No	Material	Impact Strength Joules
1	AL90% B_4C% -5 % Graphite 5%	11
2	AL92.5% B_4C% -5 % Graphite 2.5%	12
3	AL90% B_4C - 2.5% Graphite 7.5%	15

4.3 TENSILE TEST

Friction processed joints are evaluated for their mechanical characteristics through tensile testing. A tensile test helps determining tensile properties such as tensile strength, yield strength, percentage of elongation, and percentage of reduction in area and modulus of elasticity. The welding parameters were randomly chosen within the range available in the machine. The joints were made with random parameters and evaluate tensile strength and burn off. Then the joints were made and evaluate the mechanical and metallurgical characteristics. The friction welded specimens were prepared as per the ASTM standards. The test was carried out in a universal testing machine (UTM) 40 tones FIE make.The diameter of the rod is16mm.

Table 5: Tensile Test Result

S.No	Material	Tensile Load in KN
	AL90% B_4C% -5 % Graphite 5%	11.24
2	AL92.5% B_4C% -5 % Graphite 2.5%	9.96
3	AL90% B_4C - 2.5% Graphite 7.5%	10.08

5. CONCLUSION

Composite materials especially aluminum and Boron carbide, Graphite composites having good mechanical properties compared with the conventional materials. It is used in various industrial application these materials having light weight along with high hardness .It with stand high load compare with the existing materials are most applicable in the engineering products instead of existing materials. Finally we conclude that the percentage of graphite increases and tensile property were good in this ratio compared than others. Boron carbide content induces the hardness and Toughness properties.

REFERENCES

[1] *P.B.Pawar[1], Abhay A. Utpat [2] Development of Aluminium Based Silicon Carbide Particulate Metal Matrix Composite for Spur Gear Procedia Materials Science 6(2014) 1150 – 1156

[2] Arun L. R, Dr. Suneel Kumar N. Kulkarni, Kuldeep B Characteristic Studies On Aluminium Based Silicon Carbide And Fly AshParticulate Metal Matrix Composite. International Journal of Engineering Research & Technology (IJERT)

[3] Pruthviraj R. D. Wear characteristics of Chilled Zinc-Aluminium Alloy reinforced with Silicon Carbide Particulate composites *Research Journal of Chemical Sciences* Vol. 1 (2) May (2011)

[4] S.B.Chikalthankar1, V.M.Nandedkar2 and D.Sonawane Effect of Silicon Carbide Content on Tribological Properties of Aluminium Zinc Alloy Composite International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-Vol. 3 Issue 10, October- 2014

[5] v.Jeevan,C.S.P Rao,N.Selvaraj Development of a New Aluminium Metal Matrix composite Reinforced with silicon carbide, ISSN (Print): 2321-5747, Volume-1, Issue-2, 2013 Department of Mechanical Engineering, National Institute of Technology Warangal, India

[6] Viney Kumara* Rahul Dev Guptab N K Batrab Comparison of Mechanical Properties and effect of sliding velocity on wear properties of Al 6061, Mg 4%, Fly ash and Al 6061, Mg4%, Graphite 4%, Fly ash Hybrid Metal matrix composite Procedia Materials Science 6 (2014) 1365 – 1375

[7] A Review on Mechanical and Tribological Behaviors of Stir Cast Aluminum Matrix Composites 3rd International Conference on Materials Processing and Characterization (ICMPC 2014) Procedia Materials Science 6 (2014) 1951 – 1960

[8] W. Lia*, H. Liang a,J. Chen a, S. Q. Zhu b, Y. L. Chen Effect of SiC particles on fatigue crack growth behavior of SiC particulate-reinforced Al-Si alloy composites produced by spray forming Procedia Materials Science 3 (2014) 1694 – 1699

[9] H.M. Zakaria * Microstructural and corrosion behavior of Al/SiCmetal matrix composites Ain Shams Engineering Journal (2014) 5, 831–838

[10] Iftekhar Ahmad and Prakash A. Mahanwar Mechanical Properties of Fly Ash Filled High Density Polyethylene Journal of Minerals & Materials Characterization & Engineering, Vol. 9, No.3, pp.183-198, 2010jmmce.org

[11] PSG Design Data Book, PSG College of Technology Coimbatore, 1966,pp 8.1-8.64