Experimental Analysis and Mechanical Charecterisation of Al6061 Matrix with Silicon Carbide and Graphite

Lingeswaran P
AP - MECH

Anthoni Raj B
BE – Mech

Vyshnav MK
BE – Mech

Gnanasiva PC
BE – Mech

Loganathan V
BE - Mech

Shree Venkateshwara Hi-Tech Engineering College, Gobi-638 455 Erode, Tamil Nadu.

ABSTRACT

Composites materials are high stiffness and high strength, low density, high temperature stability, high electrical and thermal conductivity, adjustable coefficient of thermal expansion, corrosion resistance, improved wear resistance etc. Aluminum & Silicon carbide with graphite alloys are occupyingattention 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 Silicon carbide with graphite in Aluminum metal by various volume-based ratio composite has to be prepared by crucible casting technique and has to be analyzed various mechanical properties.

INTRODUCTION

METAL MATRIX COMPOSITES (MMC):

Metal composite materials have found application in many areas of daily lifefor quite some time. Materials like cast iron with graphite or steel with a high carbide content, or tungsten carbides, consisting of carbides and metallic binders are belong to this group of composite materials. For many researchers the term metal matrix composites is often equated with the term light metal matrix composites (MMCs).

In the automotive industry, MMC have been used commercially in fiber reinforced pistons and aluminium crank cases with strengthened cylinder surfacesas well as particle strengthened brake disks.

composites are produced by impregnating the particulates in the surface while keeping the core free from it. Conventional monolithic materials have limitations of achieving the good combination of strength, stiffness, toughness and density.

The tribological properties of thesecomposites can be further improved by adding solid lubricant particles namely graphite, molybdenum disulfide (MoS_2), silicon carbide (SiC), in order to produce hybrid composites. Hybrid metal matrix composites are engineering materials reinforced with combination of two or more different types of reinforcing materialsin order to achieve the advantage of the both.

Pure aluminum obtained from the electrolytic reduction of alumina (Al_2O_3) is a relatively weak material. Therefore for applications requiring greater mechanical strength, it is alloyed with metals such as copper, zinc, magnesium and manganese, usually in combinations of two or more of these elements together with iron and silicon. Wrought aluminum alloys are divided into seven major classes according to their major alloying elements.

LITERATURE SURVEY

Experimental analysis of aluminium alloys for aerospace application**,** Prashant SD, 2019**:**

In this paper they have done that the hardness test, think about of microstructure and mechanical properties such as pliable quality, and surrender quality % prolongation as well as % reduction by using aluminium metal matrix alloy. Then comparison between al 7075 and al 6061 and evaluate the mechanical properties. The result of % elongation as well as % reduction at fracture are performed by experimentally and compared with these result theoretically by using COSMOS works analysis tool. Comparison between al 6061 and al 7075 the almost al 7075 has a more tensile and yield strength of the other alloys.

amalgam fortified with various content of the saffilfibbers, i.e.10%,15%,20%. The basic values of the stretch concentrated calculate of the 44200 aluminium amalgam, come to the taking after levels: 12.201, 12.121, and 11.866 [MPam1/2], separately. Basic esteem of the stretch concentrated figure of the composite was three times littler than that for the 40H steel accomplished. Impact of the Al2O3 saffilfibers substance inside the extend from 10% to 20%, on the basic push concentrated figure was

Fabrication and Testing of Al-6061 Alloy &Silicon Carbide MMCs, Miss. Laxmi, Mr. Sunil kumar, 2017:

They were successfully fabricated the Al 6061-SiC(10%,15%&20%wt) Composite by utilizing mix casting course of action with legitimate dispersion of particles all over the example. They ponder the mechanical properties of hardness and brief investigation of microstructure must be conducted on checking electron magnifying lens (SEM) to verify the scattering of support.

Processing of Carbon fiber reinforced Aluminium (7075) metal matrix composite, Madhuri dhespande, 2017:

successfully fabricated Pitch based carbon fiber reinforced Al matrix composites Powder Metallurgy (PM) route. Volume % of carbon fibre are (5-50)% uncoated (UnCf) and coated milled pitch based carbon fibers (NiCf) and AA7075 as matrix with different volume contents of carbon fibers. Uncoated and Ni coated carbon fibers were mixed with AA7075 Aluminium alloy powder and subsequently hot pressed and they studied on densification and hardness. A greatest of 11% decreases in thickness is watched for 50vol% Cf composite compared to as cast Al7075. It is observed that the composites developed with uncoated carbon fibre exhibit lower values of hardness as compared with Pure Al7075 hot pressed specimen. Whereas the Ni coated carbon fibre composites show the increase in hardness up to 20Vol% and then it decreases. It is seen from the microstructures that carbon fibres are homogenously distributed in the aluminium matrix for all composites.

Investigation on Mechanical properties of Al-6061 alloy based MMC, Ajit kumar Senapati, 2016:

Their work was on the study of the aluminium alloy 6061 and reinforcement as fly ash (10 and 15%wt). They have considered almost the mechanical behaviour of unreinforced combination and metal network composites. They compared the metal lattice composite arranged with 15% of fly ash debris show wat better mechanical property to unreinforced amalgam as well as MMC.

Fracture Toughness Investigations of Metal Matrix Composites Using Compact Specimens, Tadeusz SZYMCZAK, 2013:

insignificant little. They concluded that the sturdiness of the composites tired isn't all sufficient to be utilizing particularly for the exceptionally mindful components of designing developments.

Development of Aluminium Based Silicon Carbide Particulate Metal Matrix Composite, Manoj singla, 2009:

Revels that his consider on aluminium based composites recommends that with increment in composition of silicon carbide (SiC) comes about within the increment of hardness, affect quality. He inspected that homogeneous dispersion of SiC particles within the Al framework appears an expanding nature within the tests arranged by without applying blending handle, with manual mixing and with 2-step strategy of blend casting separately.

MATERIAL SELECTION AND PROCESS

SELECTION OF BASE MATERIAL

A6061 is selected as the base material due to its excellent welding characteristics and formability along with good corrosion resistance. But it has low wear resistance and low strength, these problems may be overcome by proper selection of reinforcement material. A6061 has excellent cold working characteristics but cannot be hardened by heat treatment. The chemical composition and mechanical properties of base metal A6061 are listed in the Table.

4.1 SELECTION OF REINFORCEMENT MATERIAL

Silicon carbide (SiC) and Graphite (Gr) have been selected as the reinforcement material due to its excellent wear, corrosion resistance and warping at the elevated temperature. These particles frequently acts as a third body abrasives that lead to increase in these mechanical properties. The silicon carbide and graphite particles are shown in Fig.3.1 and 3.2.

COMPOSITION OF SAMPLES

Aluminium 6061 was reinforce in silicon carbide and graphite 5% 10% and 15%table:3.1 show in mixed ratio in %.

MANUFACTURING METHOD:

Metal matrix composite are generally produced either by liquid metallurgy route (LMR) or powder metallurgy technique (PMT). In LMR the particulate phases are mechanically dispersed in the liquid phase before solidification of the melt. Stir casting technique is one of popular LMR method 4and also known as a very promising route for manufacturing near net shape hybrid metal matrixcomposite components at a normal cost.

The executing of stir casting technique yield relatively homogenous and finemicrostructure which improve the addition of reinforcement material in the moltenmetal. In addition, the porosity level composite should be minimized and the chemical reaction between reinforcement and matrix should be avoided . the proper selection of process parameter such as pouring temperature, stirring speed, pre- heat temperature of reinforcement can produce good quality composites.

COMPOSITES PREPARATION BY STIR CASTING METHOD

A stir casting setup (Figure. 4.2), which consisted of a resistance furnace and astirrer assembly, was used to synthesize the composite. The stirrer assembly consisted of a graphite turbine stirrer, which was connected to a variable speedvertical drilling machine (speed 0 to 890 rpm) by means of a steel shaft. The stirrer was made by cutting and shaping a graphite block to desired shape and size manually. The stirrer consisted of three blades at angles of 120° apart. Figure 4.2 show the photograph of the stirrer from two different angles. Clay graphite crucible of 1.5 Kg capacity was placed inside the furnace.

The stirrer assembly consisted of a graphite turbine stirrer fixed to a steelrod. Approximately 1Kg of alloy was then melted at 820°C in the resistance furnace of stir casting setup. Preheating of Silicon Nitride, Aluminium Nitride,and Zirconium Boride mixture at 800°C was done For one hour to remove.

The stirrer was then lowered vertically up to 3 cm from the bottom of the crucible (total height of the melt was 9 cm). The speed of the stirrer was gradually raised to 800 rpm and the preheated Silicon and Iron particle was added with a spoon at the rate of 10- 20g/min into the melt.

RESULT AND DISCUSSION:

MICRO HARDNESS ANALYSIS

The hardness test is conducted at room temperature (30^0C) and themeasurement of hardness is taken at five different places on each samples to obtain an average value of hardness. The results obtained from micro hardness analysis using Micro Vickers hardness tester with a load of 0.5Kg are shown in Figure 5.1 Which indicates the increasing wt 10% of reinforcements, The hardness value also increases due to reduced plastic deformation by the reinforced particles.

TENSILE STRENGTH ANALYSIS:

As per the ASTM standard, the tensile strength is evaluated on the cylindrical rod of reinforced composites. The universal testing machine (UTM-Auto instrument) loaded with 10KN load cell is used to conduct the tensile test.The tensile strength is evaluated at cross head speed of 2.5mm/min.

Aluminium 6061- Silicon Carbide –Graphite the variation of ultimate tensile strength with varying Silicon Carbide - graphite reinforced aluminium 6061 with the tensile strength is increasing in the addition to the reinforcements in variouswt% (5,10,15) improves the mechanical properties. Compared to the matrix material the tensile strength is increased relation to reinforcements. The dispersion of reinforcements are evenly distributed and having continuous locations and having the high strength. The results are shown in improved strength. The results are shown in table wt10%.

PIN-ON-DISC TEST:

In this test, a normal load is applied via a pin onto a rotating disc. The sliding motion may be in one direction or reciprocating. The tests may be conducted in dry or under lubrication. The coefficient of friction, μ, can be obtained from thistest at any point in the test. Typically one

measures the mass before and after thewear test by means of a sensitive microbalance.

. The wear rate is given by The wear test for all specimens was conducted under the normal load (10 N,), slidingdistance (1000 m, 1500 m, 2000 m), and sliding velocity (1.5 m/s, 2.5 m/s and3.5 m/s). The samples were weighed (using electronic microbalance up to an accuracy of ±0.0001 g) before and after each test and weight loss was calculated as the difference between these two data. The wear of the composite was studiedas a function of the sliding distance, applied load and the sliding velocity. The surface of the pin samples rubbed using emery paper of Silicon Carbide (1000 grit size) prior to test in ordered to ensure effective contact of fresh and flat surface with the steel disc.

MICROSTRUCTURE RESULTS:

The micro structure analyses were carried out with various samples 5% 10% 15% taken at optimized condition for the work piece. the main reason for this could be due to the increase in thickness of smeared graphite layer at the sliding surface of the wear sample, which is generated due to the extrusion of brass to the surface of the tested pin during sliding and which acts as a solid lubricant.

Better homogeneity of brass phase spatial distribution leads to lower coefficient of friction of composite or better wear properties. however in conventionally sintered cu-graphite mmc, there is high probability of clustering of brass particles. this may be the only plausible explanation for such high wear depth of brass sample (even with such high brass concentration).

CONCLUSION:

Silicon Carbide -graphite reinforced aluminium 6061 particulate composite wassuccessfully synthesized by the Stir casting method.This may be attributed to the fact that Cu particles greatly interact with eachother leading to clustering of particles and consequently settling down.The micro structural behavior of Silicon Carbide -graphite reinforced aluminium6061has been studied by varying mass fractions of 5%, 10%, 15%, and15%. Micro structural observations show that the Silicon Carbide -graphite reinforced aluminium 6061 particulates are uniformly distributed in the AL matrix.In all microstructures consist of coarse grains of AL 6061 solid solution with brass inter metallic particles in the grain boundaries are observed and this can influence the fracture behavior.It is observed from results that the hardness of AL6061 reinforced Silicon Carbide -graphite MMC increases with increasing wt% of AL 6061 particulate upto 10 wt% and then decreases with increasing wt% of brass particles.

The tensile strength and impact strength (by using Charpy test) of the composite increased with increase in wt% of brass particulates up to 15%.

REFERENCES:

1) Prashant S D, Sushil dange, “experimental analysis of aluminium alloys for aerospace application” IRJET, e-ISSN: 2395-0056, p-ISSN: 2395-0072 Vol: 06 issue:03 Mar 2019.

2) Miss. Laxmi, Mr. Sunil kumar, “Fabrication and Testing of Al-6061 Alloy &Silicon Carbide MMCs”, International Research Journal of Engineering And Technology[IRJET],Vol:04,Issue:06, June-2017, p-ISSN:2395- 0072.

3) Ajit kumar senapati, Abishek kumar, Anurag kumar, “Investigation on Mechanical properties of Al-6061 alloy based MMC”, IOP Conf,series: Material science and Engineering,Jan2016.

4) Tadeusz SZYMCZAK, Zbigniew L. KOWALEWSKI “Fracture Toughness Investigations of Metal Matrix Composites Using Compact Specimens” Polish Academy of Sciences, ENGINEERING TRANSACTIONS, 61, 3, 219–229, 2013.

5) Manoj Singla, D.Deepak Dwivedi, Lakhvir Singh, Vikas Chawla, “Development of Aluminium Based Silicon Carbide Particulate Metal Matrix Composite”, Journal of Minerals and Materials Characterization and Engineering [JMMCE], Vol 8, Issue 6, 2009, pp 455 – 467.

6) A.WłodarczykFligier, L.A.Dobrzanski, M.Kremzer, M.Adamiak, “Manufacturing of aluminium matrix composite materials reinforced by Alumina particles”, Journal of Achievements in Materials and Manufacturing Engineering [JAMME], Vol 27, Issue 1, March 2008, pp 99-102.

7) B.Babu, S.Meinathan, P.Manikandan, P.Lingeswaran, S.Nanthakumar, A.Yasminebegum and R.Girimurugan, “Investigation on the characterization of hot extruded AA7075 based metal matrix composites developed by powder metallurgy”, 2603 (2023).

8) P.Thangavel, K.M.Arunraja, S.Prakasam, P.Lingeswaran, “Investigation of AA7075 MMC Reinforced by Al0.5cocragnic Heap Through Stir casting and Cryorolling.

9) Lingeswaran P, Nagaraj J, “Design & Fabrication of Electro Magnetic Clutch System for Four-Wheeler”, ISSN No: 2583 0368, Special Issue, March-April 2023, Vol 3 (02), 81-82.

10) P.Lingeswaran, “A study on Electro chemical discharging drilling of soda-lime-silicon-glass with aid of modified setup”, ISSN: 2582-3930, Volume 05, Issue 05, May 2021.

11) Mathew Joseph P. Lingeswaran, “New Product Development of Advanced Tube Conveyor Shrink Tunnel for Packaging Industry”, Vol. 4, Issue 05, 2016 | ISSN (online): 2321-0613.

12) J. Yasin, S. Selvakumar, P.M. Kumar, R. Sundaresan, and K.M. Arunraja, Experimental Study of TiN, TiAlN and TiSiN Coated High Speed Steel Tool, Mater. Today Proc., 2022, 64, p 1707–1710. https://doi.org/10.1016/j.matpr.2022.05.468

13) Mathivanan, S., K. M. Arunraja, and M. Viswanath. "Experimental Investigation on Aluminum Metal Matrix Composite." International Journal of Engineering Research & Technology, ISSN (2018): 2278- 0181.

APPENDIX