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Impact of Silicon and Boron Carbide Reinforcement on AA 2024 Hardness

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***Abstract*- Aluminum matrix composites are emerging as advance engineering materials due to their strength, ductility and toughness. The aluminum matrix can be strengthened by reinforcing with hard ceramics particles like silicon carbide and boron carbide etc. In the present study, an effort is made to enhance the mechanical properties like tensile and hardness of AMCs by reinforcing 2024 Al matrix with boron carbide and silicon carbide particles by stir casting route. It is observed that by adding 5% reinforcement our hardness Brinell hardness as well as Rockwell hardness becomes 119 BHN and 49 HRB & further adding 10% reinforcement our hardness Brinell as well as Rockwell hardness is 185 BHN and 97 HRB respectively.**

***Keywords* – Aluminum matrix, B_4C & SiC**

I. INTRODUCTION

AA 2024 is an aluminium alloy, with copper as the primary alloying element. It is used in application requiring high strength to weight ratio, as well as good fatigue resistance. It is weldable only through friction welding, and has average mach inability. Due to poor corrosion resistance, it is often clad with aluminium. Boron carbide is an extremely hard boron-carbon ceramic, and covalent material used in tank a more, bullet proof vests, engine sabotage powders, as well as numerous industrial applications. With a Vickers hardness of >30GPa, it is one of the hardest known materials, behind cubic boron nitride and diamond. It has density 2.52gm/cm3.It has a melting point of 2763oC.

It has a boiling point of 3500oC.Silicon carbide is used as abrasive material in which molecules are bounded together by sintering to form very hard ceramic that are widely used in applications requiring high endurance, such as car brakes, car clutches and ceramic plate in bullet proof vests.Electronic applications of Silicon carbide such as light emitting diodbes and detectors in early radios were first demonstrated around 1907.Silicon carbide is used in semiconductors electronics devices that operates at high temperature or high voltage or both. It has density 3.16gm\cm3.

It has a melting point 2830oC.Upon reinforcement of boron carbide and silicon carbide on AA2024 its hardness as well as strength will be increased as we had concluding from our research. In the present investigations an attempt has been made on the study of behavior of Aluminum Alloy (AA2024) reinforcing with varying amount of B4C and SiC. The composite is prepared by stir casting process. Several fabrication techniques are available for the production of aluminum metal matrix composites (AMMC). Among the various methods, stir casting route is simple, less expensive, and used for mass production. The experimental study is performed varying weight % of Boron Carbide and Silicon carbide powder. And certain observations are made. The mechanical behaviour of these composites with different wt. % of mixture of Silicon Carbide and Boron Carbide are investigated by Rockwell Hardness Test and Brinell Hardness Test.

II. LITERATURE REVIEW

This chapter present a review of the literature data available on the effect of various reinforcement types, their size and volume fraction, ageing behavior with Al based MMC.

J.R.S. David, D.R.S. Robinson (2013) studied the fabrication of AMCs reinforced with various weight percentages of SiC particulates and a constant weight percentage of fly ash are modify by stir casting route. The amount of wettabiility of SiC and fly ash in the matrix was improved by adding magnesium into the melt. The micro-structure and mechanical properties of the fabricated AMCs were analyzed. The SEM micrographs revealed that the addition pf fly ash helps to prevent the dissolution and the formation.

J. Lakshmipathy, B. Kulendran, (2014) studied the wear behavior of Al/SiC and Al/Al2O3 composites were prepared by stir casting technique to find out the effect of weight percentage of silicon carbide/aluminium oxide the load and the number of stroke on a reciprocating wear testing machine. The tests are carried out with

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different load conditions (25, 50 and 75 N) and different number of stroke (420, 780 and 1605 strokes).

L. Yuan, J. Han, J. Liu, Z. Jiang (2016) studied about aluminium composite matrix reinforced with AlB2 particles have been fabricated using a combination of powder metallurgy and heat treatment solution. The heat treatment parameters on the microstructure and mechanical properties of the composites were investigated by means of SEM and micro hardness test. The friction coefficient, wear behavior and scratch morphology of the AMCs and pure aluminium were also studied using scratch tests.

R. Harichandran, N. Selvakumar (2016) studied the fabricated micro and nano Boron carbide particles- reinforced composites were characterized using SEM and X-ray method. Tensile, hardness impact and wear tests were carried out in order to evaluate the mechanical properties of the micro and nano composites. The tensile test results showed that the properties of the samples containing upto 6 %. Nano Boron carbide reinforced composites were better that the micro Boron carbide reinforced composites.

Y. Sahin (2016) studied the Aluminium alloy composites containing various particles size of 10 and 20 wt. % SiC particles. It was observed that there was a reasonably uniform dispersion of particles in the matrix alloy. The density decreased with decreasing particles size but porosity decreased considerably with changing particle size. In addition the tool life gets decreased considerably with increasing cutting speed for all sets.

K. Ravikumar, K. Kiran, V.S. Sreebalaji (2017) studied the investigation on mechanical properties of Aluminuim alloy (AA 6082) composites reinforced with tungsten carbide particles. Stir casting process was employed to fabricate the aluminum composite specimen by changing tungsten carbide in 2, 4, 6, 8 and 10 % by weight. The result is that density and impact strength and the elongation of the composite decreased with increased in tungsten carbide. The tensile strength of the composite changes initially and then tends to decrease

K.K. Alaneme, O.B. Michael, A.A. Adebimpe (2018) studied the mechanical properties of aluminium composites reinforced with ground nut shell (GSA) and SiC was investigated. Ground nut shell and Silicon carbide with various mixing ratio (10:0, 7.5:2.5, 5.0: 5.0, 2.5: 7.5 and 0.10) constituted 6 and 10 wt. % of the reinforcing phase while the matrix material was Al-Mg-Si alloy. The result shows that with increasing of Ground nut shell in the reinforcing phase the grandness and ultimate strength of tensile and specific strength of the composites owing to the amount of the oxides of Al, Si, Ca, K2 and Mg were presenting the composition of GSA.

III. RESEARCH GAPS

- Although a large volume of literature is available on composite materials, the topic is still under development and offers potential opportunity for further research and application.
- Many researchers have conducted the machining study on aluminium based metal matrix composites with SiC, boron carbide, alumina, zirconia, etc., as the reinforcements. But, very few have investigated on hybrid composite.
- Few studies have been reported on composite such as AA-SiC and AA-B4C composite. However, no studies have been carried out in Al-SiC-B4C composite.
- Less research works have been reported on aluminium based (Al2024) MMCs which offer better mach inability and surface finish capabilities, than pure aluminium matrix, so there is plenty of scope to explore the manufacturing of MMCs.

V. OBJECTIVE

The main purpose of this project is to develop the strong light weighted metal matrix Al-SiC+B4C composite material which is useful in the industrial sectors as well as advanced machineries. The most important part of this project is to fabricate Al-SiC+B4Cmetal-matrix of by homogeneous stir-casting to produce High Strength Low Cost Material (HSLCM). We adopt the stir-casting method with high temperature in this project. This types of metal-matrix composite have very high specific strength, temperature resistance, fatigue resistance, abrasion resistance, corrosion resistance and stiffness properties that they are used in Aircraft fittings, gears and shafts, bolts, clock parts, computer parts, couplings, fuse parts, hydraulic valve bodies, missile parts, munitions, nuts, pistons, rectifier parts, worm gears, fast ending devices, veterinary and orthopaedic equipment,
structures. The objective of the project is:

- Development of Al-SiC+B4C composite by varying the reinforcement percentage from 0 to 10% in a step of 5 %.
- To measure the Micro hardness (HRB) of developed composite and its comparison with base metal.
- To measure the Macro hardness (BHN) of developed composite and its comparison with base metal.

VI .EXPERIMENTAL PROCEDURE

A lot of 1000 g of aluminium alloy (AA2024) was measured and put in the crucible and was melted at 7240C using an electric furnace. Proper stirring is required in order to achieve uniform spreading of reinforcement in the aluminium melt. The melt was stirred with the help of a mechanical stirrer to form a fine vortex. To oxidize the surface of ceramic particulates, the SiC+B4Cceramic powder was preheated

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After stirring the molten mixture it was poured in to a preheated permanent mold. Argon gas was supplied until the entire melt was poured into the preheated permanent mold. The manufactured hybrid composite was allowed to solidify in atmospheric air and was taken out from the mold after solidification. The AMCs having different weight percentage (5 and 10) SiC+B4C (5% means equal amount of both reinforcements i.e. 2.5% each, similarly 5% each in case of 10%) ceramic powder were manufactured by the same procedure.

- Mechanical stirring is necessary to help in promoting wett ability.
- Stirring in a fully liquid condition does not help to incorporate particles into the matrix.
- Stirring while the slurry (melt of matrix and reinforcement) is solidifying improves incorporation of the particles into the matrix alloy.

However the slurry must then be re-melted to a fully liquid condition in order to enable pouring into a mold .A decrease in solidifying time during stirring increases the percentage wetting. The particles tend to float to the top of the molten alloy, regardless of the speed of stirring.

The processing temperature is mainly influencing the change in viscosity of Al matrix and it also accelerates the chemical reaction b/w matrix and reinforcement. The change of viscosity influences the particle distribution in the matrix. Effect of holding time helps in hybrid composite mainly two ways: to distribute the particles in the liquid and to create perfect interface bond b/w reinforcement and matrix. The holding time b/w matrix and reinforcement is considered as important factor in the processing of composite.

When the holding time is less the particles are distributed uniformly in the matrix the liquid matrix has sufficient viscosity in the temperature range and velocity of particle flow is small& a vortex created during stirring can suck the air bubbles or gas bubbles in to the liquid metal as the result the particles were attached with air bubbles to form the particles clusters in the matrix. At higher temperature with more holding time more particulates and micro-hardness of manufactured AMCs while Figure shows the relation between weight percentages of SiC+B4Cceramic particulates and macro-hardness of manufactured AMCs. It is revealed that micro and macro-hardness of AMCs are increasing linearly with increase in weight percentage of SiC+B4Cceramic particulates.

This may be attributed because of increase in presence of hard ceramics particles in the alloy and high hardness of reinforcement. Incorporation of reinforcement particles in the aluminium metal matrix increase their surface area and the size of aluminium metal matrix grains are reduced. The presence of these hard surface area of SiC+B4Cceramic particulates offer large resistance to the plastic deformation which results into enhancement of the hardness of manufactured AMCs. Further, the presence of hard and brittle SiC+B4Cceramic particulates in the soft and ductile AA2024 metal matrix reduces the ductility content of manufactured AMCs due to low ductile content of metal matrix in the composite which significantly enhances the hardness value of manufactured AMCs.

Increased content of reinforcement in the matrix alloy leads to increased dislocation density during solidification due to thermal mismatch of the matrix alloy and reinforcement. The mismatch of thermal expansion between matrix and reinforcement due to temperature difference results in large internal stress due to which matrix deforms plastically to accommodate the smaller volume expansion of reinforcement particles. Enhancement in dislocation density at the particle metal interface results in higher resistance to plastic deformation leading to improved hardness.

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VIII. FUTURE SCOPE

Due to cheaper cost and high hardness the reinforced AA 2024 has a bright future for aerospace as well as in automobile industries because it's corrosive and withstand to high temperature property is also very good.

VII. RESULT

The mechanical properties of matrix alloy 2024 are improved upon incorporation of mixture of Silicon Carbide and Boron Carbide. The mechanical properties of matrix alloy 2024 are improved uponSiC+B4Cincorporation. Figure shows the relation between weight percentages of SiC+B4Cceramic

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