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Evaluation of Mechanical Properties and Micro Structural study of AA 7050 Reinforced with SiC Metal Matrix Composite

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ABSTRACT

The present work deals with the fabrication of the Aluminium matrix composites by ultrasonic dispersion of silicon carbide particles in molten Aluminium Alloy. AA7050 has been selected as matrix alloy as it is readily castable. The mechanical properties such as hardness, Young's modulus, tensile strength will be studied and compared with those of the base alloy. The correlation of the properties with respect to the variation of the processing parameters, viz., and weight percentage will be done. The weight percentage of silicon carbide will be varied from 0 to 20%. The proposed values are for chosen based on the literature data. In addition, the analysis of the micro-structural properties of metallurgical structure and grain size will be carried out.

Key words: Metal Matrix Composite, Aluminium Alloy7050, Silicon carbide, Stir casting, ultra-sonic dispersion.

INTRODUCTION

Conventional monolithic materials have limitations in achieving good combination of strength, stiffness, toughness and density. To overcome these shortcomings and to meet the ever increasing demand of modern day technology, composites are most promising materials of recent interest. Metal matrix composites (MMCs) possess significantly improved properties including high specific strength; specific modulus, damping capacity and good wear resistance compared to unreinforced alloys. There has been an increasing interest in composites containing low density and low cost reinforcements.

Metal Matrix Composites (MMCs)

Metal Matrix Composites are composed of a metallic matrix (Al, Mg, Fe, Cu etc.) and a dispersed ceramic (oxide, carbides) or metallic phase (Pb, Mo, W etc.). Ceramic reinforcement may be silicon carbide, boron, alumina, silicon nitride, boron carbide, boron nitride etc. whereas Metallic Reinforcement may be tungsten, beryllium etc. MMCs are used for Space Shuttle, commercial airliners, electronic substrates, bicycles, automobiles, golf clubs and a variety of applications. From a material point of view, when compared to polymer matrix composites, the advantages of MMCs lie in their retention of strength and stiffness at elevated temperature, good abrasion and creep resistance properties. Most MMCs are still in the development stage or the early stages of production and are not so widely established as polymer matrix composites. The biggest disadvantages of MMCs are their high costs of fabrication, which has placed limitations on their actual applications. There are also advantages in some of the phySilicon carbideal attributes of MMCs such as no significant moisture absorption properties, non-in flammability, low electrical and thermal conductivities and resistance to most radiations. MMCs have existed for the past 30 years and a wide range of MMCs have been studied. Due to the poor wettability between the metal matrix and the ceramic particles, the particulates tend to agglomerate in the matrix. External field forces are needed to break up the clusters and help disperse the particles into the metal.

LITERATURE REVIEW

Characterization of silicon carbide reinforced aluminium matrix composites 10th International Conference on Mechanical Engineering, ICME 2013

Md. HabiburRahman, H. M. Mamun Al Rashed[1] This work is to study about the microstructures, mechanical properties and wear characteristics of as cast silicon carbide (Sic) reinforced aluminium matrix composites (AMCs). AMCs of varyingSic content (0, 5, 10 and 20 wt. %) was prepared by stir casting process. Microstructures, Vickers hardness, tensile strength and wear performance of the prepared composites were analysed. The results showed that introducing Sic reinforcements in aluminium (Al) matrix increased hardness and tensile strength and 20 wt. % Sic reinforced AMC showed maximum hardness and tensile strength. Micro structural observation revealed clustering and non-homogeneous distribution of Sic particles in the Al matrix. Porosities were observed in microstructures and increased with increasing wt. % of Sic reinforcements in AMCs. Pin-on-disc wear test indicated that reinforcing Al matrix with Sic particles increased wear resistance.

Initially, the work will look to identify the necessary properties of a material that is to be used in the aerospace industry. The reasons for aluminium's extensive application in the aircraft industry will then be identified and the use of metal matrix composites (MMC) to counter the pure element's (aluminium) shortcomings will be advocated. Once a case for Al-Sic MMC has been made, the work will look to explore and understand the different factors that could have an effect on the fabrication and the final properties of the composite.

FABRICATION OF THE METAL MATRIX COMPOSITE

Although there are several methods for the preparation of the composite, casting evolved as the one of the most effective methods to produce products with the complex shapes. However it is extremely difficult to obtain uniform dispersion of Nano-sized particles in liquid metals due to high viscosity, poor wet ability, and large surface to volume ratio in the metal matrix. So to overcome this problem we use high intensity ultrasonic waves to have uniform dispersion in the liquid phase as they generate the essential non -linear effects required.

Fabrication Barriers of Nano-Composite

EX-SITU methods which include powder metallurgy, stirring techniques, pressure infiltration and spray deposition are usually more cost efficient. However, the particles are easy to agglomerate and hard to be dispersed. Reinforcements created IN-SITU are usually fine and well distributed. However IN-SITU reinforcement has less opportunity than EX-SITU ones for complex reactions involved in the IN-SITU fabrication routes. Fabrication of MMNCs are much more complex compared to fabrication of MMCs. when the particle size scales down from the micro to the Nano level, the major challenges are

1. The reaction process between the bonding interfaces is still unclear. Reaction effect will lead to the failure of the MMNCs.
2. Agglomeration and clustering in bulk materials can still be observed. The dispersion during the processing needs to be optimized.
3. Cost effectiveness is another factor that hinders the fabrication of Nano composites. With the development of Nano technology, the price of the Nano fabrication should be reduced.
4. Currently, low volume and rates are observed. A transition to high volume and high rate fabrication is pivotal to apply the technology to real industry fabrication.
5. Different processes have been applied, however modeling of these processes are needed.

EQUIPMENT AND CONSUMABLES USED

Equipment and Consumables Used

Matrix Alloy	AA7050
Reinforcement	Silicon carbide particles
Wetting agent	Magnesium (Mg)
Crucible	Graphite Material With 1.5 Kg Capacity
Dies	Mild Steel
Inert Gas	Argon.
Ultrasonic Transducer	20Khz, 2000W
Electrical Resistance Furnace	1200°C
Chamber Size	12×12×18

Matrix Alloy

AA7050 has been selected as a matrix material as it is readily cast able from the available group of aluminiumalloys. The alloy designation system of the casing alloys is shown below

- First digit -Principal alloying constituent(s).
- Second and third digits - Specific alloy designation.
- Fourth digit - Casting (0) or ingot (1, 2) designation.

The various classes of the cast alloys available are shown:

- lxx.x - Pure Al (99.00% or greater)
- 2xx.x - Al-Cu Alloys
- 3xx.x - Al-Si + Cu and/or Mg
- 4xx.x - Al-Si
- 5xx.x - Al-Mg
- 7xx.x - Al-Zn
- 8xx.x - Al-Sn
- 9xx.x - Al+Other Elements
- 6xx.x - Unused Series

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- **The temperatures are designated as below:**
  - F - As-fabricated
  - 0 - Annealed
  - H - Strain-hardened (wrought products only)
  - W- Solution heat-treated
  - T - Thermally treated to produce tempers other than F,O,H (usually
  - Solution heat-treated, quenched and precipitation hardened).

Here our matrix alloy belongs to the class 7xx.x.

Composition of AA7050

Component	Wt%
Zn	5.7 - 6.7 %
Cu	2.0 - 2.6 %
Mg	1.9 - 2.6 %
Zr	0.08 -0.15 %
Fe	0.15%
Si	0.12 %
Mn	0.10 %
Ti	0.06 %
Cr	0.04%
Al	Remainder

AA7050

Aluminium alloys of the 7xxx series such as **AA7050** are commonly used in the aerospace industry. They are used for the production of such parts as fuselage of an aircraft. Under carriage components, The **AA7050** alloy is characterized by high mechanical properties and a high ratio of strength to density.

The 7050 series of castings are one of the most widely used because of the High strength provided by the high copper and remaining contents and its contribution to fluidity Plus their response to heat treatment which provides a variety of high-strength options. Further the 7050 series may be cast by a variety of techniques ranging from relatively simple sand or die casting to very intricate permanent mold, lost Foam/lost wax type castings, and the newer thou casting and squeeze casting technologies.

AA7050 block

Silicon carbide

Silicon Carbide is the only chemical compound of carbon and silicon. It was originally produced by a high temperature electro-chemical reaction of sand and carbon. Silicon carbide is an excellent abrasive and has been produced and made into grinding wheels and other abrasive products for over one hundred years. Today the material has been developed into a high quality technical grade ceramic with very good mechanical properties. It is used in abrasives, refractories, ceramics, and numerous high-performance applications. The material can also be made an electrical conductor and has applications in resistance heating, flame ignites and electronic components. Structural and wear applications are constantly developing.

Physical properties of Silicon carbide

Parameters	Unit	Data
Density	g/cm^3	3.02
Max service temparature	^0C	1380
Bending strength	Mpa	250 (20^0C) 280 (1200^0C)
Elastic modulus	Gpa	330 (20^0C) 300 (1200^0C)
Thermal conductivity	W/m-k	45 (1200^0C)
Thermal expansion coefficient	K^{-1}	4.5
Acid an alkali resistance	-	Excellent
Grain size	Major fine sand / silt and small per cent of clay size particles	

Properties of H-13 Steel and its Composition

Property	Value		Element	Percent %
Density (g/cc)	7.78		Iron, Fe	90.6
Brinell Hardness (BHN)	180		Carbon, C	0.39
Ultimate Tensile strength (MPa)	1420 - 1810		Manganese, Mn	0.40
Yield Tensile strength (MPa)	1280 - 1520		Silicon, Si	1.00
Modulus of Elasticity (GPa)	210		Chromium, Cr	520
Thermal Conductivity (W/((mm K))	0.0243		Molybdenum, Mo	1.40
Specific Heat (J / kg K)	460			

Fig: Dies

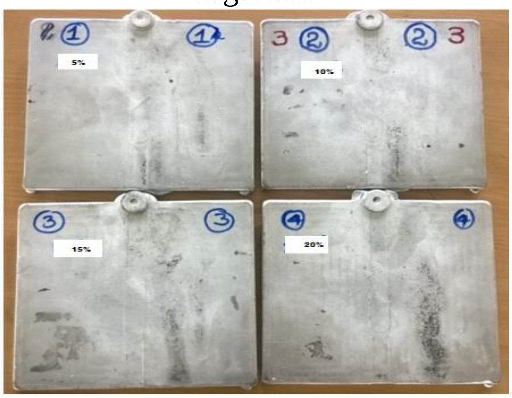

Fig: Samples prepared

Electrical Resistance Furnace

An electric furnace in which heat is generated by conductors that offers resistance to the passage of a current through them. Resistance furnaces are widely used in heat treatment, for heating prior to pressure shaping, and to dry or melt materials. Resistance furnaces are used extensively because of their numerous

Advantages

- Any temperature up to 3000°C can be obtained in the furnace chamber.
- Articles can be uniformly heated either by appropriately locating the heating elements along the walls of the furnace chamber or by means of forced circulation of the furnace atmosphere.
- Automatic control of the power and, consequently, of the temperature conditions in such a furnace is easily implemented.
- Resistance furnaces are readily mechanized and automated, thus alleviating the work of personnel and facilitating the inclusion of such furnaces in automatic transfer lines.
- They are compact. Such furnaces provide a secure environment for various processes.

- A resistance furnace may be well sealed, in which case the heating is carried out in a vacuum, or it may contain either a gaseous medium that prevents oxidation or a special atmosphere for chemical case hardening.

Fig:Electrical Resistance Furnace

Most resistance furnaces are of the indirect type. In indirect-heat resistance furnaces, electric energy is converted into heat when a current flows through the heating elements. The heat is transmitted to the articles to be heated by radiation, convection, or conduction. Such a furnace consists of a working chamber formed by a lining composed of a layer of firebrick that supports both the articles to be heated and the heating elements and that is insulated from a metal casing by a layer of heat insulation (Figure 1). The parts and mechanisms that operate in the chamber, as well as the heating elements, are made of heat-resistant steels, refractory steels, or other refractory materials.

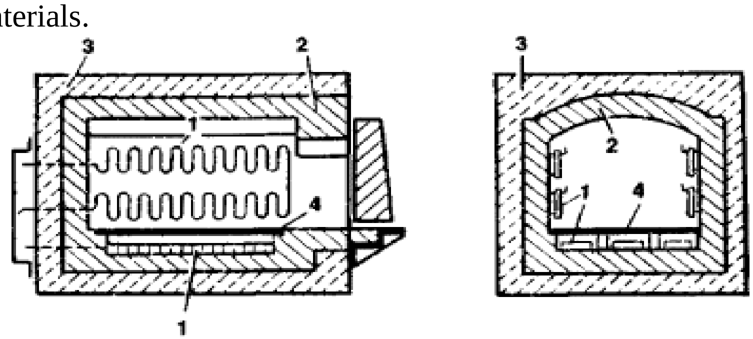

Fig: Indirect Resistance Heat Chamber Furnace

(1) Heating elements
(2) Refractory lining,
(3) Heat insulation,
(4) Refractory hearth plate

Continuous furnaces are used to heat large lots of identical parts. In such furnaces, articles move continuously from one end to the other. As compared with other types of furnaces, the output of continuous furnaces is higher, the heating of articles is more uniform, and the power consumption is lower. As a rule, such furnaces are highly mechanized.

In both batch-type and continuous resistance furnaces with a working temperature of up to 700°C, forced circulation of the furnace gases is widely used. The gases are circulated by fans or blowers that either are installed in the furnace or are located, together with the heating elements, outside the furnace in electric heaters.

Laboratory resistance furnaces include small pipe furnaces, muffle furnaces, and chamber furnaces, as well as thermostats (constant-temperature chambers) and drying ovens.

Direct-heat resistance furnace:

(1) Article to be heated,

(2) Step-down transformer,

(3) Contacts;

(4) Power

Ultrasonic Transducer

A transducer is a device which converts a signal in one form of energy into another form of energy.The energy types include electric, magnetic, chemical, acoustic, thermal etc.An ultrasonic horn (also known as acoustic horn, sonotrode, acoustic waveguide, ultrasonic probe) is a tapering metal bar commonly used for augmenting the oscillation displacement amplitude provided by an ultrasonic transducer operating at the low end of the ultrasonic frequency spectrum (commonly between 15 and 100 kHz).

The ultrasonic horn is commonly a solid metal rod with a round transverse cross-section and a variable-shape longitudinal cross-section - the rod horn. Another group includes the block horn, which has a large rectangular transverse cross-section and a variable-shape longitudinal cross-section, and more complex composite horns. Thedevices from this group are used with solid treated media. The length of the device must be such that there is mechanical resonance at the desired ultrasonic frequency of operation – one or multiple half wavelengths of ultrasound in the horn material, with sound speed dependence on the horn's cross-section taken into account. In a common assembly, the ultrasonic horn is rigidly connected to the ultrasonic transducer using a threaded stud.

Ultrasonic horns may be classified by the following main features:

1) Longitudinal cross-section shape – stepped, exponential, conical, catenoidal, etc.

2) Transverse cross-section shape – round, rectangular, etc.

3) Number of elements with different longitudinal cross-section profile – common and composite.

A composite ultrasonic horn has a transitional section with a certain longitudinal cross-section shape (non-cylindrical), positioned between cylindrical sections.In high-power industrial ultrasonic liquid processors, such as commercial sonochemical reactors, ultrasonic homogenizers and ultrasonic milling systems intended for the treatment of large volumes of liquids at high ultrasonic amplitudes (ultrasonic mixing, production of Nano emulsions, solid particle dispersing, ultrasonic Nano-crystallization, etc.), the preferred ultrasonic horn type is the Barbell horn.Barbell horns are able to amplify ultrasonic amplitudes while retaining large output diameters and radiating areas. It is, therefore, possible to directly reproduce laboratory optimization studies in a commercial production environment by switching from Converging to Barbell horns while maintaining high ultrasonic amplitudes. If correctly scaled up, the processes generate the same reproducible results on the plant floor as they do in the laboratory.

Maximum achievable ultrasonic amplitude depends, primarily, on the properties of the material from which an ultrasonic horn is made as well as on the shape of its longitudinal cross-section. Commonly, the horns are made from titanium alloys, such as Ti6Al4V, stainless steel, such as 440C, and, sometimes, aluminium alloys or powdered metals. The most common and simple to make transitional section shapes are conical and catenoidal.

The general **specifications** of the ultrasonic transducer include:

- Frequency =20khz
- Power=2000watts
- Horn diameter =34mm
- Amplitude=25 microns, adjustable to 50% to 100%
- Dry operation possible
- 3m cable transducer to generate interface remote control
- 50 Hz to 60 Hz to disperse Nano particles in the molten metal.

LAYOUT OF THE STIR CASTING

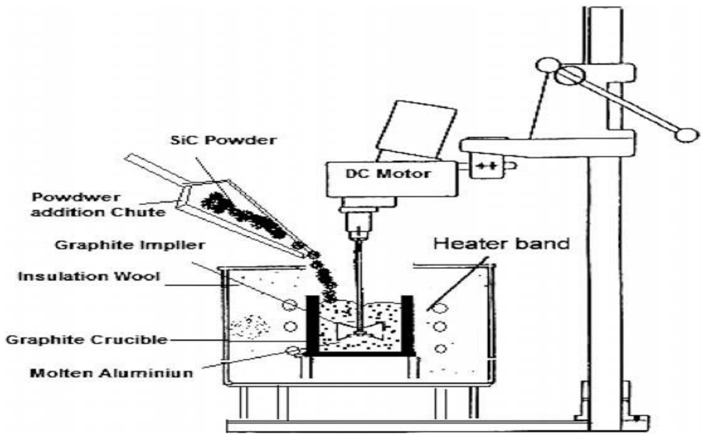

Fig: Layout of the stir casting apparatus

Figure shows layout of the stir casting apparatus. It consist of conical shaped graphite crucible is used for fabrication of Aluminium Metal Matrix Composite, as it withstands high temperature which is much more than required temperature [680°C],along that graphite will not react with aluminium at these temperature. This crucible is placed in muffle which is made up of high ceramic alumina, around which heating element of wound. The coil which acts as heating element is Kanthol-A1. This type of furnace is known as resistance heating furnace. It can work up to 900°C. Aluminium, at liquid stage is very reactive with atmospheric oxygen. Oxide formation occurs when it comes in contact with the open air. Thus all the process of stirring is carried out in closed chamber with nitrogen gas as inert gas in order to avoid oxidation. Closed chamber is formed with help of ceramic sheet. This reduces heat loss and gas transfer as compare open chamber. A K-type (Chromel/constantan) Temperature thermocouple whose working range is -200°C to 1250°C is used to record the current temperature of the liquid. Due to corrosion resistance to atmosphere EN 24 is selected as stirrer shaft material. One end of shaft is connected to 5 HP DC motor with flange coupling. While at the other end blades arc welded. 4 blades are welded to the shaft at 45°C. A constant feeding rate of reinforcement particles is required to avoid coagulation and segregation of the particles. This can be achieving by using hopper. Aluminium alloy matrix will be formed in the crucible by heating aluminium alloy ingots in furnace. A stirring action is started at slow rate of 30 rpm and increases slowly in between 300 to 600 rpm with speed controller. A mixture of reinforcement (Silicon carbide) is to be incorporated in the metal matrix at semisolid level near 640°C. Dispersion time is to be taken as 5 minutes. After that slurry is reheated to a temperature above melting point to make sure slurry is fully liquid and then it is poured in mould.

EXPERIMENTAL SETUP

An electric resistance heating unit was used to melt the AA7050 in the graphite crucible. A titanium waveguide which was coupled with a 20 kHz, 2000w ultrasonic converter was dipped into the melt for ultra-sonic processing.

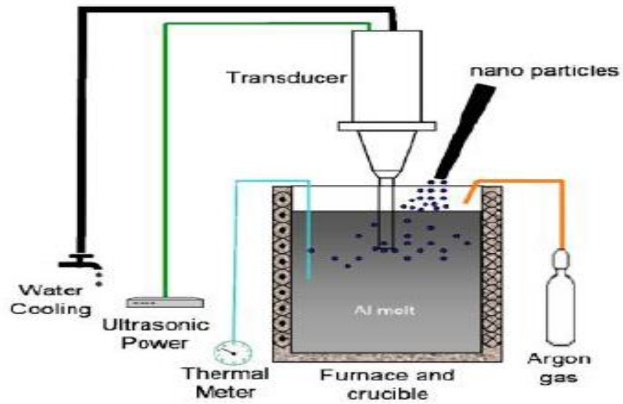

Fig: Schematic diagram of Experimental setup

The Silicon carbide particles were added into melts during the process from the top of the crucible. The aluminium melt pool was well protected by the argon gas. The ultrasonic processing temperature was controlled to 100*c above the alloy melting point (610*c). An ultrasonic power of 1880 watts from the converter was used to generate adequate processing function inside the crucible. Totally four varieties of Nano composites were prepared in which the weight percent of the reinforcement was considered at 5%, 10%, 15% and 20% for the chosen Nano size of 0.5 µm-300 µm silicon carbide particles. As observed during the process the viscosity of the melts significantly increased with the Nano-sized silicon carbide particles in the melts. Thus after efficient ultrasonic processing a higher casting temperature of 760^{0}C was used to ensure the flow ability inside the graphite mould.

Thus we obtain 4 Nano composites with different Silicon carbide percentages in each and one raw AA7050 is also prepared to compare and observe the values.

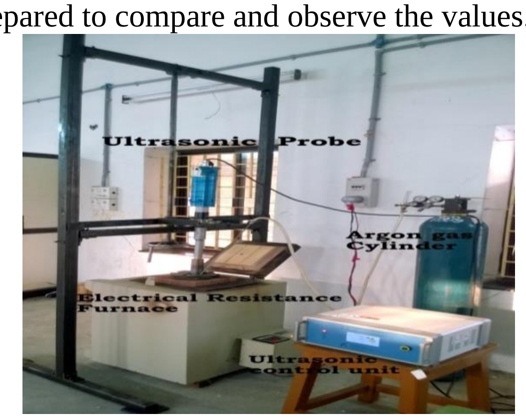

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Fig: Experimental Setup

After obtaining the 5 pieces we go for the micro structural study to know about the dispersion of the Silicon carbide particles in the matrix alloy.

MICROSTRUCTURES

a). The figure below shows the micro structural study for the cast aluminum alloy without Silicon carbide particles and ultrasonic processing. It can be observed clearly that the dendritic grains are clearly revealed.

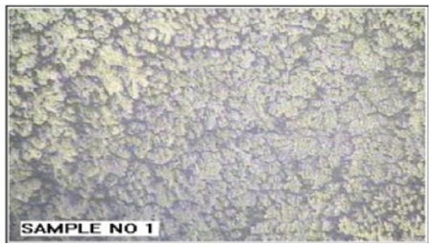

Fig: Microstructure of Raw AA7050

b). The figure below shows the micro structural study for the specimen containing matrix material as AA7050 and the reinforcement material as Silicon carbide for the weight percent of 5%. From the below image we can observe the distribution of the Silicon carbide particles in the AA7050. The grain sizes observed are smaller than that of the cast aluminum alloy without Silicon carbide particles and ultrasonic processing.

Fig: Microstructure of AA7050 with 5% Wt of Silicon carbide

c). The figure below shows the micro structural study for the specimen containing matrix material as AA7050 and the reinforcement material as Silicon carbide for the weight percent of 10 %. From the below image we can observe the distribution of the Silicon carbide particles in the AA7050. The grain sizes observed are smaller than that of the cast aluminum alloy without Silicon carbide particles and ultrasonic processing.

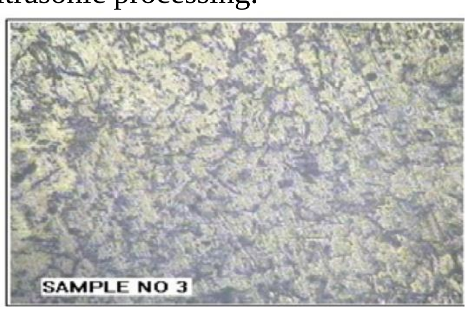

Fig: Microstructure of AA7050 with 10%Wt of Silicon carbide

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d). The figure below shows the micro structural study for the specimen containing matrix material as AA7050 and the reinforcement material as Silicon carbide for the weight percent of 15 %. From the below image we can observe the distribution of the Silicon carbide particles in the AA7050. The grain sizes observed are smaller than that of the cast aluminum alloy without Silicon carbide particles and ultrasonic processing.

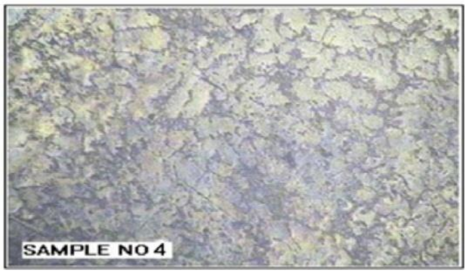

Fig: Microstructure of AA7050 with 15%Wt. of Silicon carbide

e). The figure below shows the micro structural study for the specimen containing matrix material as AA7050 and the reinforcement material as Silicon carbide for the weight percent of 20%. From the below image we can observe the distribution of the Silicon carbide particles in the AA7050. The grain sizes observed are smaller than that of the cast aluminum alloy without Silicon carbide particles and ultrasonic processing.

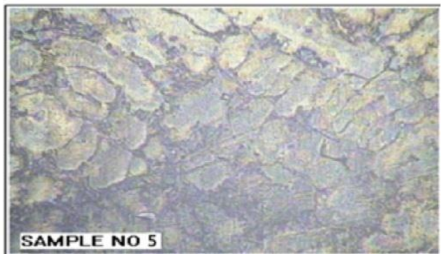

Fig: Microstructure of AA7050 with 20% Wt of Silicon carbide

From the above micro structural images the distribution of the Silicon carbide particles in the matrix alloy is observed and the difference in the distribution of the particles is clearly observed. In the raw cast aluminum alloy, Fig 5.5 the size of the dendritic grains is large and no ultrasonic processing is carried out and no Silicon carbide particles are present. Sample No.5 shows the microstructure of the cast aluminium alloy sample with 20 wt.% Silicon carbide particles with ultrasonic processing. The grain sizes from the samples with Silicon carbide particles and ultrasonic processing are much smaller.

From the above images it is observed that the Silicon carbide particles are distributed and now SEM graphs are taken.

SEM IMAGES

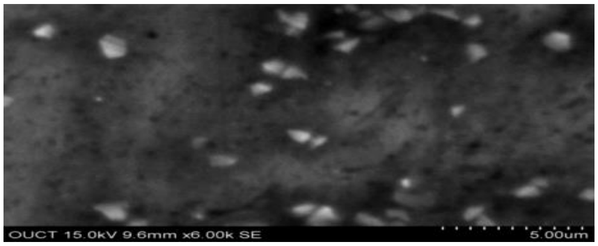

Fig: SEM Image OF AA7050 with 5% Wt. of Silicon carbide

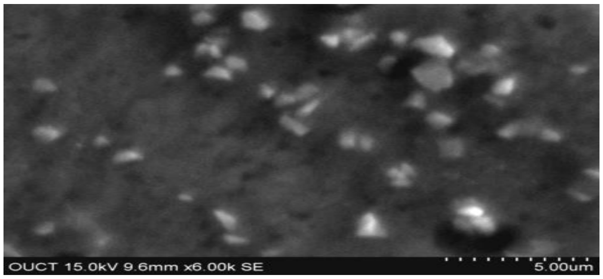

Fig: SEM Image of AA7050 with 10% Wt. of Silicon carbide

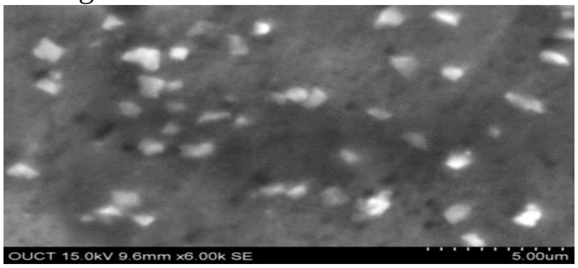

Fig:.SEM Image of AA7050 with 15% Wt. of Silicon carbide

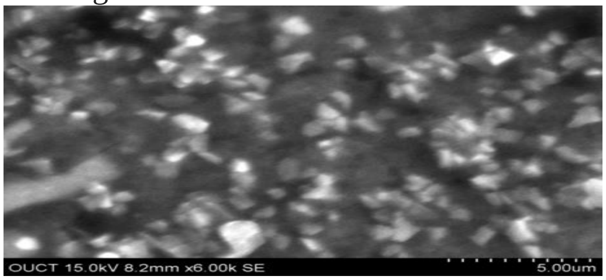

Fig: SEM Image of AA7050 with 20% Wt. of Silicon carbide

The above images show the dispersion of the Silicon carbide particles in the AA7050 matrix alloy. From the images it is clear that the Silicon carbide particles (from 5 to 20 wt. % of size 5µm) were well dispersed in the AA7050 matrix, as shown. Tiny scratches/cracks due to polishing are displayed. High intensity ultrasonic waves have generated strong cavitations and acoustic streaming effects during mixing. Transient cavitations have produced an impulsive impact strong enough to break up the clustered particles and disperse them more uniformly in the liquid.

QUALITATIVE ANALYSIS

1. Line identification

The object of qualitative analysis is to find what elements are present in an 'unknown' specimen by identifying the lines in the X-ray spectrum using tables of energies or wavelengths. Ambiguities are rare and can invariably be resolved by taking into account additional lines as well as the main one.

2. Qualitative ED analysis

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The ED spectrometer is especially useful for qualitative analysis because a complete Spectrum can be obtained very quickly. Aids to identification are provided, such as facilities for superimposing the positions of the lines of a given element for comparison with the recorded spectrum.

In order to verify the composition of the Nano-composite, EDS analysis was used. The typical result is shown in Fig below.

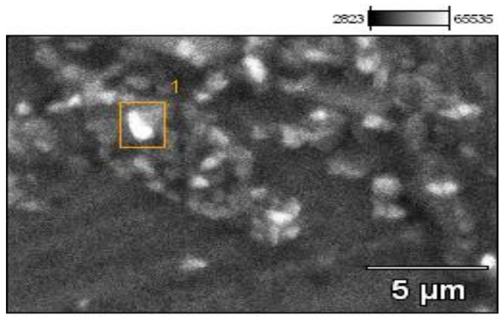

Fig: Electron Dispersion Microscope Image

It seems that the composite was protected well during fabrication since the oxidation level is quite low. Since the average size of the Silicon carbide particle is 5µm, it is very difficult to use EDS spot analysis due to the limitation of the e-beam resolution in the instrument. Therefore, mapping scanning was employed. Shows the distribution of the elements aluminum (Al), Silicon carbide, respectively,the results show that C is distributed uniformly, which indicates a good dispersion of Silicon carbide particles in matrixfrom the mapping of Si element, there are some concentrations from the eutectic Si of the alloy.

The bulk Al cast alloy was cut according to the above standerds in Wire Edm process.

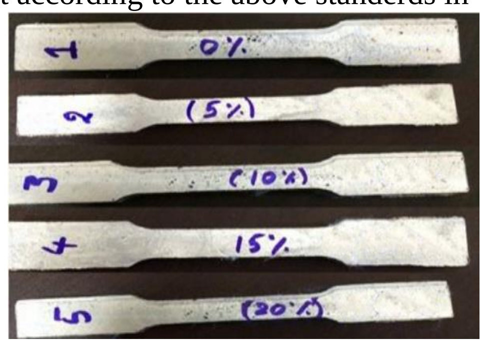

Fig: Al Cast Alloy According To ASTME8 Standards


Fig:Tensile Testing Pieces

CONCLUSIONS

The significant conclusions of the experiment on Al7050-SiC metal matrix composite were as follows. Stircasting method was successfully adopted in the preparation of Al7050-SiC composite containing the reinforcement up to 20%wt. The mechanical properties of the composites are found improved than their base matrix. The microstructural studies revealed the uniform distribution of the particles in the matrix system. Micro-hardness of thecomposites found increases in hardness it will showed that there is a lower %wt of reinforcement. The tensile strength properties of the composite was found higher than that of base matrix that is 474 MPa and Al7050-SiC composites superior tensile strength properties than that the other aluminium7000 series alloy MMCs.

From the studies in overall it can be concluded that Al7050-SiC exhibits superior mechanical andtribological properties. The process parameters affecting the stir casting technique was considered whilemanufacturing of composites.

- It can be observed from the SEM images and EDS analysis that the particles are well distributed in the base alloy and agglomeration of the particles are greatly reduced, and the melt pool is well protected from the atmospheric conditions.
- In the mechanical characterization the following improvements were observed:
- The ultimate tensile strength of the base alloy is observed to be 434MPa.
- On addition of the Silicon carbide for weight per cent of5% the UTS value increased to 462MPa.
- On addition of the Silicon carbide for weight per cent of 10% the UTS value increased to 474MPa.
- On addition of the Silicon carbide for weight per cent of15% the UTS value increased to 430MPa.
- On addition of the Silicon carbide for weight per cent of20% the UTS value increased to 407MPa.
- 390MPa is the value where the yielding starts for the base alloy.
- On addition of the Silicon carbide for weight percent 5% the yield strength increased to 414MPa.
- On addition of the Silicon carbide for weight percent 10% the yield strength value increased to 431MPa.
- On addition of the Silicon carbide for weight percent 15% the yield strength value increased to 378MPa.
- On addition of the Silicon carbide for weight percent 20% the yield strength value increased to 356MPa.
- Ductility value on addition of the Silicon carbide for weight per cent 5% is 8.1%.
- Ductility value on addition of the Silicon carbide for to weight per cent 10% is 7.4%.
- Ductility value on addition of the Silicon carbide for weight per cent 15% is 7.2%.
- Ductility value on addition of the Silicon carbide for weight per cent 20% is 6.4%.
- With up to 10% addition of Silicon carbide Mechanical properties are enhanced and with further addition of Silicon carbide the properties starts decreasing.

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