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Effect of Sic and Graphite Particulates on Properties of Al 2214 Alloy Hybrid Composites

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ABSTRACT: The proposed venture work is to manufacture and think about the mechanical properties, break strength and wear properties of Al2214/SiC-Gr composites are set up by mix projecting technique. The measure of fortification, for example, silicon carbide, is changing on independently from 2-8 wt% in steps of 2 wt%, graphite is changing on independently from 2-8 wt% in steps of 2 wt%, .The blend of silicon carbide is changing on from 2-8 wt% in steps of 2 wt%, and graphite is saved consistent for an enhanced estimation of 4 wt%.

The readied crossbreed composites of Al 2214/SiC-Gr are exposed to number of tests to assess the mechanical properties, for example, hardness, Ultimate Tensile quality, Yield Strength, Compression Strength, and Density, according to the ASTM principles.

Key Words: Aluminum Alloy Al2214, Silicon Carbide, Graphite, Ultimate Tensile Strength, Yield Strength, compression strength, Density.

1. INTRODUCTION

Lately, Al based composites are increasing wide spread significance in a few cutting edge designing applications. Broad exploration have been completed on the mechanical properties of Al based regular composites including a solitary fortification. Utilization of single support in Al grid may some of the time lead to crumbling in its actual properties [1]. In any case, to defeat the downside of single strengthened composites, the idea of utilization of two unique sorts of fortifications is being investigated In Al grid. The two fortifications, typically one of the support will be a hard stage and the other being a delicate greasing up stage. Hard fortifications, for example, SiC, TiO_2, Al_2O_3, and TiB_2 and so on will upgrade the hardness and rough wear obstruction of Al while it negatively affects the machinability and conductivity of Al [2].

To balance these impacts, fortifications like graphite that is a strong ointment and having great conductivity can be scattered in Al alongside hard fortifications. Nevertheless, significant data is accessible as respects the handling and portrayal of these half-and-half Al composites. There are different ways to deal with blend aluminum based metal grid composites viz., dispersion holding, powder metallurgy course, vortex strategy, presses projecting, fluid penetration, Osprey measure, crumbled liquefy affidavit measure, laser composite surfacing, in-situ strategies and so on Different investigates have received the above procedures in creating assortments of metal grid composites.

Aluminum Alloy 2214 material is used in industrial needs and their applications are in automobile sectors like pistons, piston heads, and bearings, where the friction and wear rate is more important role due to having high wt % copper.

The general criteria to choose this series are:

- High mechanical resistance.
- High resistance to fissure propagation.
- Good workability in tool machines.
- Improves its tenacity.
- Poor corrosion resistance.

The Al 2214-based alloys have physical properties:

Tension Strength >=425

Yield Strength >=275

Hardness 125-145

Table 1: Al 2214 Composition

Weight %	Al	SiC	Fe	Cu	Mn	Mg	Cr	Zn	Ti
Al 2214	Balance	1.2	0.3	5.0	1.2	0.8	0.1	0.25	0.15

The Al 2214 material Ingots is a tough aluminum alloy, which is having 1.2 wt% of manganese and other two parameters like silicon and copper as its major alloying elements. Mechanical properties, which enhances the heat treatable alloy as correlated to other Aluminum alloys. It increases high strength, good workability; it improves the good machinability and increases the resistance of corrosion.

Fig. 1.1 Al 2214 Ingots

The SiC are fine dry particles are in form of powder of size 45-50 µm and it is used as reinforcement in this experimental evaluation, and their mechanical properties of SiC are shown in table 2.

Table 2: Silicon Carbide Mechanical properties

Mechanical Properties	Silicon Carbide (SiC)
Density	3.02 gm/cc
Molecular weight	40.20692 g/mol
Melting Point	1380°C
Vickers Hardness	2800
Crystal structure	Hexagonal crystal structure
Thermal Conductivity	120 W/m.K

Fig.1.2. Silicon Carbide and Graphite Particulates

The Silicon Carbide is ceramic material and the individual reinforcement Aluminum matrix may constantly adjust to the physical and mechanical behavior. It is very important to find the path to preserve the effective access to Silicon Carbide while concurrently ministrant when material removing process of Silicon Carbide MMC's.

The metal matrices composite are achieve when adding silicon carbide to aluminum by apprehend the betterment of results.

To achieve required properties of MMC's the reinforcements are used in string, whiskers and chapped. Reinforcement materials are prepared by using liquid metallurgy techniques.

Further, of the few ways to deal with blend aluminum based composites fluid metallurgy course is the most reasonable and prudent method [3]. Graphite particulates are appropriate for this application, as their expansion improves the machinability and wear obstruction of Al–SiC composites. Rajaram et al. (2010) proposed that Al–SiC composites strengthened with graphite particulates are known as Al–SiC–Gr cross breed composites.

The interest in SiC and Graphite (Gr) as fortifications for Aluminum Alloy (Al2214) has been developing extensively. Endeavors have been largely zeroed in on examining their commitment to the improvement of the mechanical and tribological execution of the half-and-half composites.

In this current Project work, the impact of SiC and Graphite (Gr) content on the Physical properties of the mixture composites was explored.

The improvement of physical properties for hybrid composites of Al2214/SiC-Gr will be compared with pure Aluminium Alloy (Al2214). The uniform dispersion of SiC and Graphite (Gr) in the Al2214 matrix will be carried out with proper wettability condition to enhance the properties of composites.

The proposed project work is to fabricate and compare the mechanical properties, fracture toughness and wear properties of Al2214/SiC-Gr composites.

The composites were readied utilizing mix projecting strategy (Liquid Metallurgy course) in which measure of support, for example, Silicon Carbide (SiC), is fluctuated independently from 2-8 wt% in steps of 2 wt%, Graphite is shifted Separately from 2-8 wt% in steps of 2 wt%, and the Combination (Hybrid composites) of Silicon Carbide

(SiC) differed from 2-8 wt% in steps of 2 wt%, and Graphite is saved steady for an upgraded estimation of 4 wt%.

The prepared hybrid composites of Al2214/SiC-Gr were subjected to a series of tests to evaluate the mechanical properties such as hardness, Tensile strength, Compression Strength, Density, as per the ASTM standards.

Hypothesis of the present project work in particularly is to optimize the influence of the reinforcements on the properties and the results obtained will be compared with that of ascast Aluminium Alloy (Al2214).

2. 0BJECTIVES OF THE RESEARCH WORK

The Preparation of Al2214/SiC-Gr Hybrid composites by mix projecting strategy in which measure of support, for example, Silicon Carbide (SiC), is changed independently from 2-8 wt% in steps of 2 wt%, and Graphite is saved steady for a streamlined estimation of 4 wt%, and to assess the thickness of the readied crossover composites and contrasted and that of as cast aluminum amalgam (Al2214).

To characterize developed Al2214/SiC-Gr composites for various mechanical properties such as Ultimate Tensile Strength, Yield Strength, Compression strength by using UTM.

To characterize the hardness of the developed Al2214/ SiC-Gr Composites, and to compare the results of MMCs reinforced with Silicon Carbide (SiC) Varied from 2, 4, 6 and 8 wt% , and Graphite is kept constant to an optimum value as 4 wt% ,with the as cast Al2214 alloy.

3. PREPARATION OF MMC's

Al2214 alloy was used as matrix alloy and SIC, Graphite was used as reinforcements for preparation of composites. SiC of 2- 8 wt. % (interval size 2%) and Graphite of 4% optimum value is reinforced with the Al2214/SiC/Gr composites.

The Graphite crucible containing with the stainless steel impeller was coated with alumina. The charge of about 3kg was melted under pure magnesium of high purity. The Degasser 190 was also used to create inert atmosphere to avoid oxidation and to remove the slag from the Al2214 slurry.

Melting pot consists of impeller and it is made up of stainless steel and done aluminum coating to impeller and rotates at a speed of 400-600 rpm was maintained.

The pure magnesium of 3kg was melted with cleanliness. To avoid oxidation the degasser are used to create inert atmosphere and removes the lava from the Al2214 molten.

During arousing, the preheated SiC was poured in to the molten metal and mixed equally. Once arousing is finished, the ready molten metal is pour into the die.

Table 3: Composition of specimens Reinforced

Specimen	Al2214 (gm)	SiC (gm)	Gr (gm)	Wt.%
A	2000	0	0	0
B	1960	40	40	2
C	1920	80	80	4
D	1880	120	120	6
E	1840	160	160	8
F	1800	200	200	10

3.1 STIRRING PROCEDURE

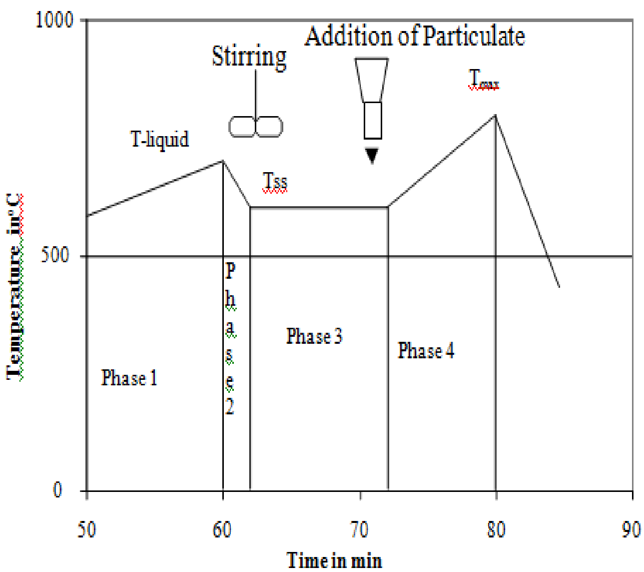

Fig.3.1. Schematic representation of the temperature-time sequence for composite preparation

There are different steps of processing:

Phase 1: Molten metal furnaces are maintained up to 60 minutes in environmental condition.

Phase 2: stirring temperature of the molten metal are brought up to 700°C.

Phase 3: The molten metal in the semi solid phase for five minutes.

Phase 4: MMC's are reheated to form a liquid state up to700-720^0 C for 10 minutes as per temperature time curve.

Phase 5: The ready liquid is cascade and poured to the cast-iron die, cooling for 15 minutes at room temperature.

4. RESLT AND DISCUSSION

4.1 DENSITY MEASUREMENTS

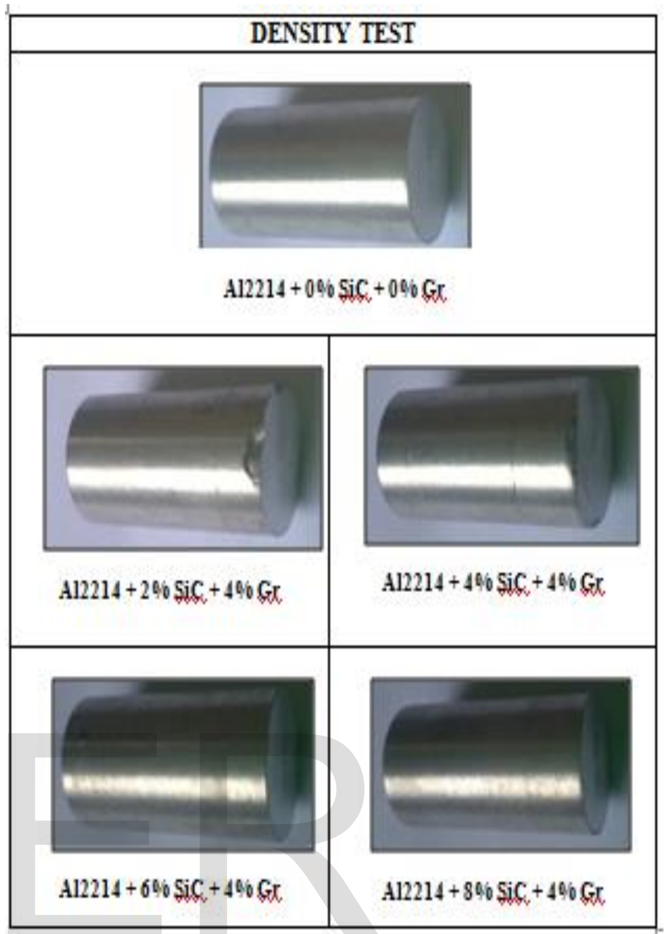

Fig.4.1.1 Density Test Specimens

Table 4: Theoretical and Experimental Density for Al2214 and Al2214/Sic/Gr Hybrid Composites

Sl No	Composition	Theoretical Density Kg/m^3	Experimental Density Kg/m^3
1	Al2214 Alloy	2.800	2.73
2	Al2214-2% SiC+4%Gr	2.793	2.69
3	Al2214-4% SiC+4%Gr	2.787	2.67
4	Al2214-6% SiC+4%Gr	2.781	2.65
5	Al2214-8% SiC+4%Gr	2.775	2.64

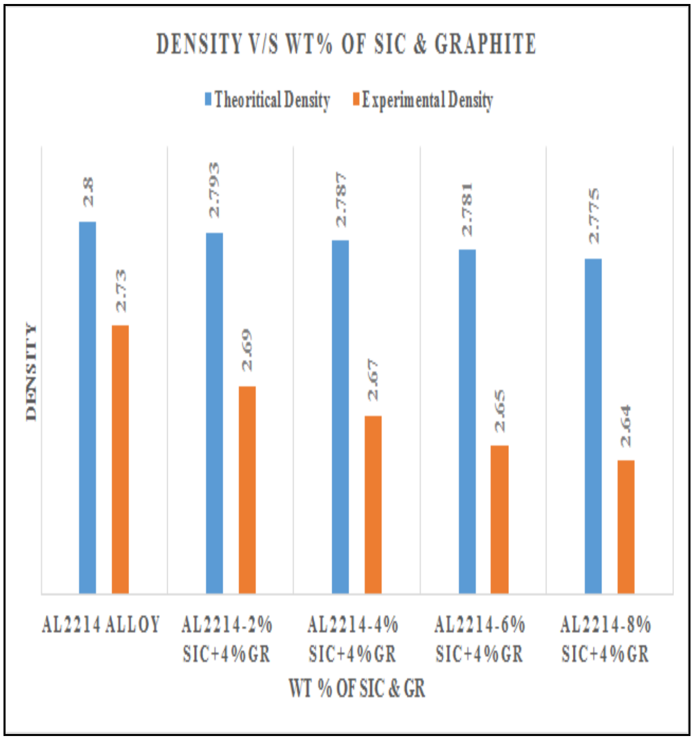

Fig.4.1.2 The effect of Wt% of Sic & Gr on theoretical and experimental density of

Al2214/SiC/Gr half and half composites as appeared in table 4 is given the correlation of hypothetical thickness acquired by rule of blend and test thickness esteems for both the composites considered, further the Figure 4.1.2 shows the test and hypothetical thickness estimations of the both the composites containing different rates of fortifications. From the table 4, it tends to be reasoned that the test and the hypothetical thickness esteems are in accordance with one another and affirms the appropriateness of the fluid metallurgy procedures for the effective composite planning. From fig.4.1.2, it very well may be seen that the densities of composites are lesser than that of their base network, further the thickness lessens with expanded weight level of fortifications substance in the composites. From the fig.4.1.2, it tends to be inferred that Al2214-SiC-Gr composites displays lesser thickness than that of the Al2214.

4.2 Tensile Test (Ultimate Tensile Strength and Yield Strength)

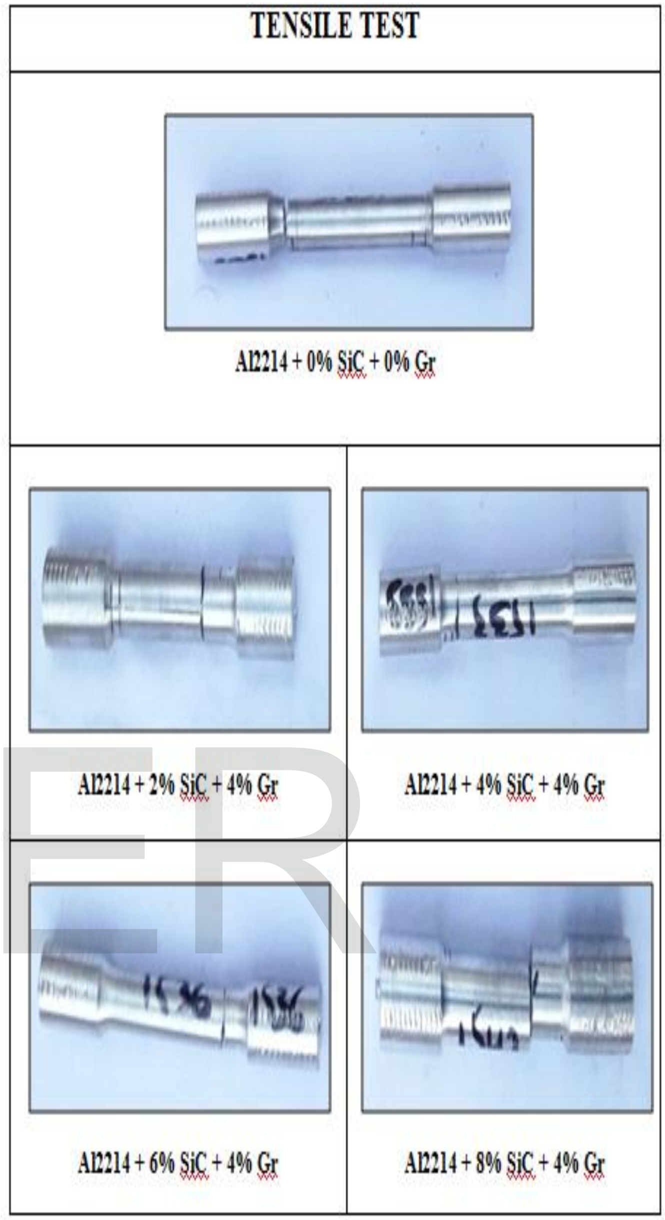

Fig.4.2.1 Tensile Test Specimens

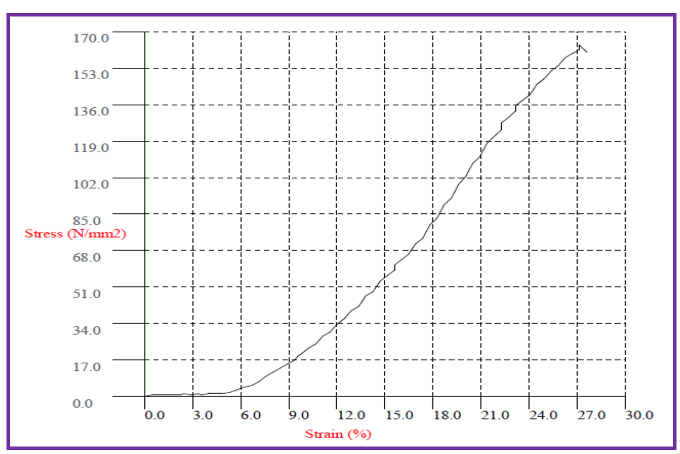

Fig.4.2.2 Typical graph of tensile test for Al2214 alloy

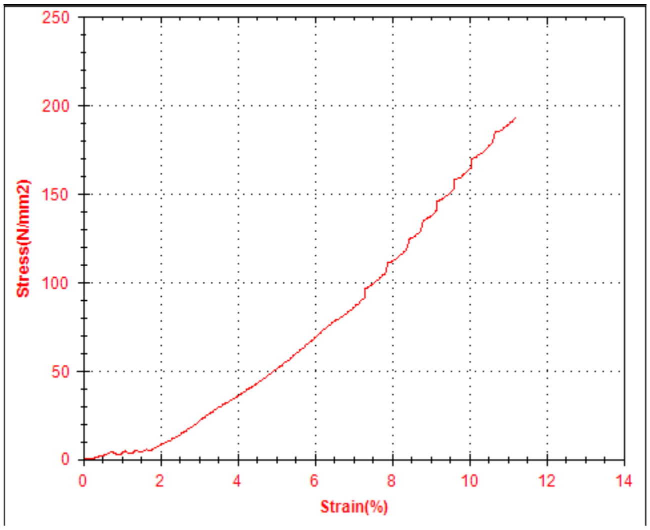

Fig.4.2.3 Typical graph of tensile test for Al2214+2%SiC+4% Gr

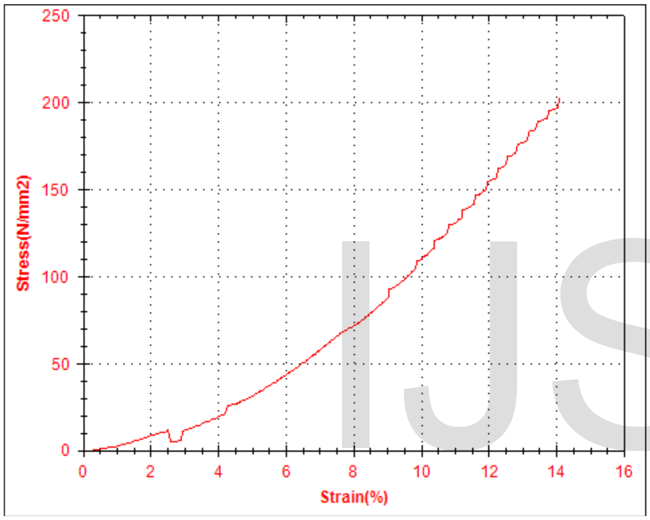

Fig.4.2.4 Typical graph of tensile test for Al2214+4%SiC+4% Gr

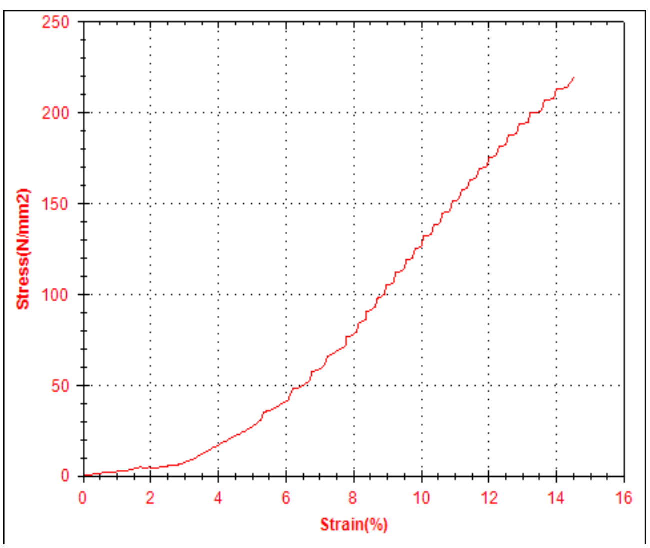

Fig.4.2.5 Typical graph of tensile test for Al2214+6%SiC+4% Gr

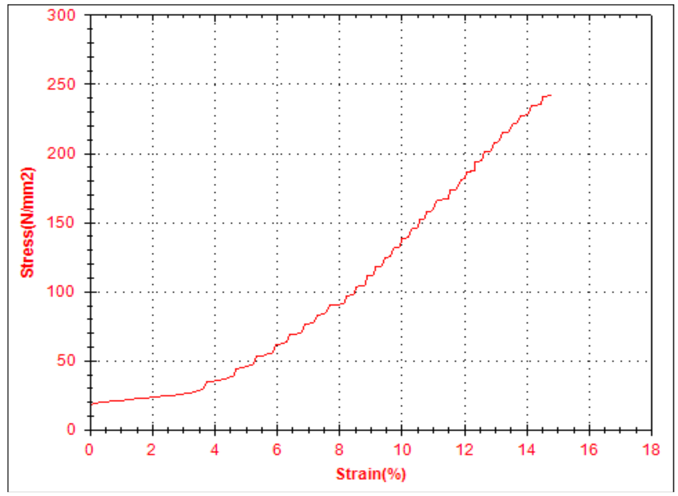

Fig.4.2.6 Typical graph of tensile test for Al2214+8%SiC+4% Gr

Table 5: Ultimate Tensile Strength and Yield Strength for Al2214 and Al2214/Sic/Gr Hybrid Composites

Sl No	Composition	Ultimate Tensile Strength (MPa)	Yield Strength (MPa)
1	Al2214 Alloy	163.60	143.0
2	Al2214-2% SiC+4%Gr	186.629	172.853
3	Al2214-4% SiC+4%Gr	201.884	195.715
4	Al2214-6% SiC+4%Gr	218.862	212.593
5	Al2214-8% SiC+4%Gr	241.660	234.241

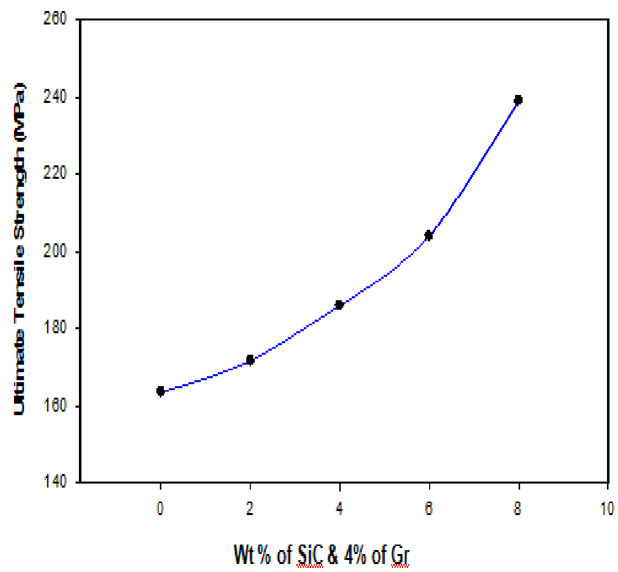

Fig.4.2.7 Effect of Wt% of SiC & 4Wt% of Gr reinforcements on Ultimate Tensile Strength

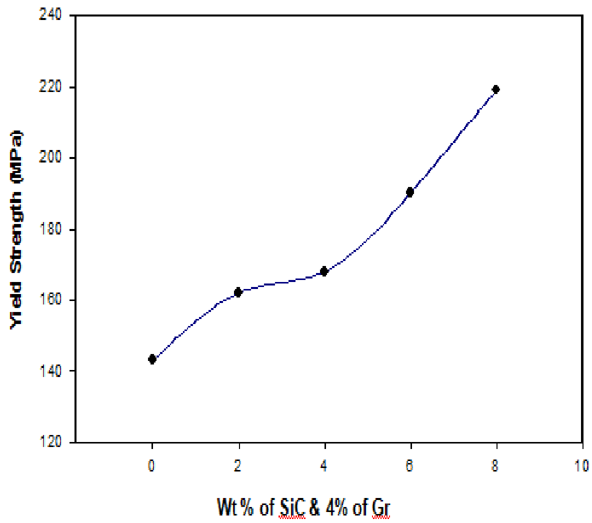

Fig.4.2.8 Effect of Wt% of SiC & 4Wt% of Gr reinforcements on Yield Strength

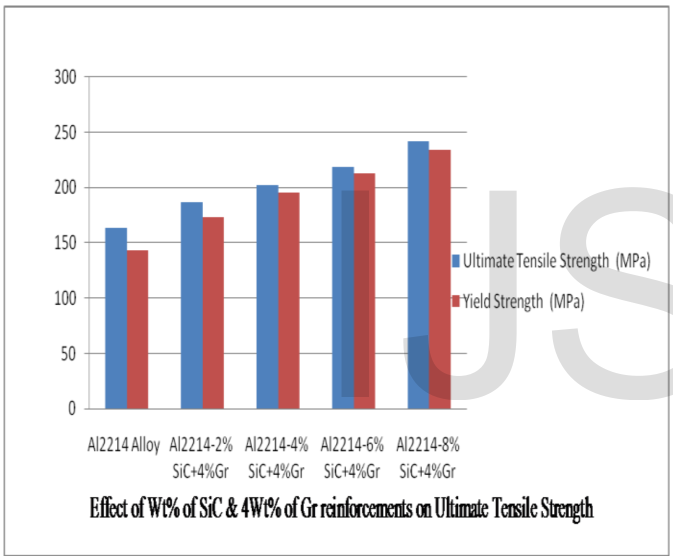

Fig.4.2.9 The effect of Wt% of Sic & Gr reinforcements on ultimate tensile strength and yield tensile strength

Figure 4.2.2 to 4.2.6 shows the typical graphs of tensile test for Al2214 alloy and Al2214+ (2-8 wt% of SiC and 4wt% of Gr) hybrid composites and table 5 represents the average values of ultimate tensile strength and yield strength of alloy and its hybrid composites.

Figure 4.2.8 and 4.2.9 shows the charts for the impact of support content on extreme elasticity (UTS) and Yield quality of the prepared Al2214+(2-8wt%)SiC+4wt % of Gr composites. Each estimation of UTS is a normal of two investigations. From the diagrams is seen that improvement of both elasticity and yield quality was accomplished up to 8 wt % SiC and 4Wt% of Gr. As the SiC content is expanded from 0% to 8%, and Graphite kept to an ideal estimation of 4 wt% the UTS expanded by about 31.54% and Yield quality by 34.70%. The expansion in UTS and YS can be credited to the presence of hard SiC particulates that confer solidarity to the network amalgam, accordingly giving improved protection from elastic burdens.

4.3 Compression Test (Compression strength)

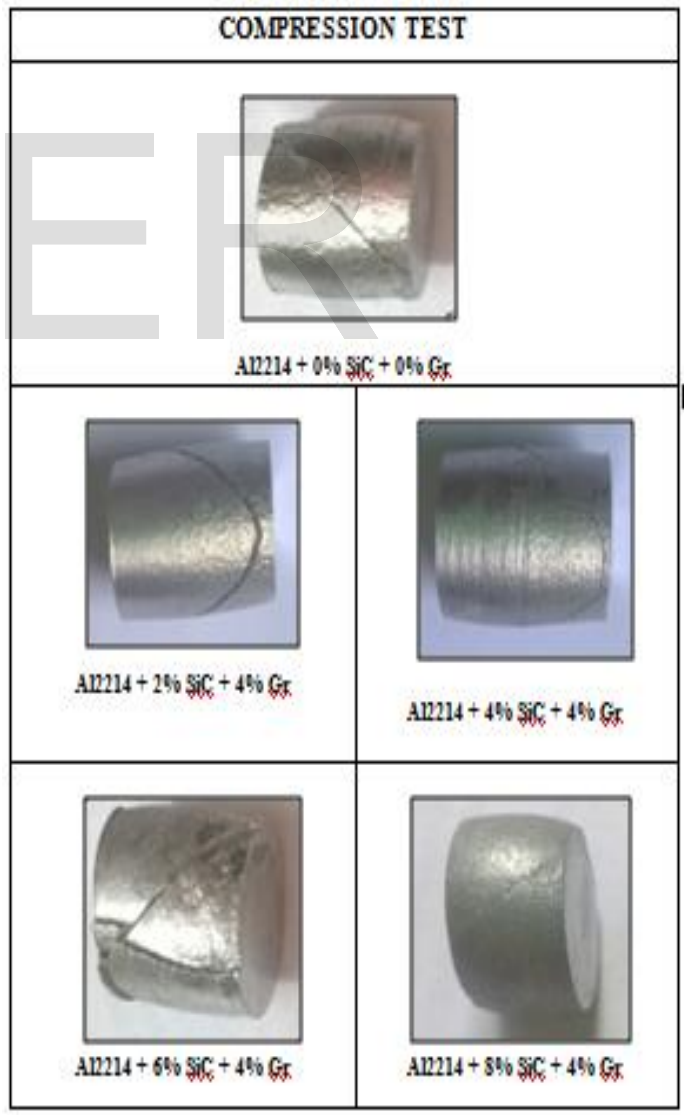

Fig.4.3.1 Compression Test Specimens

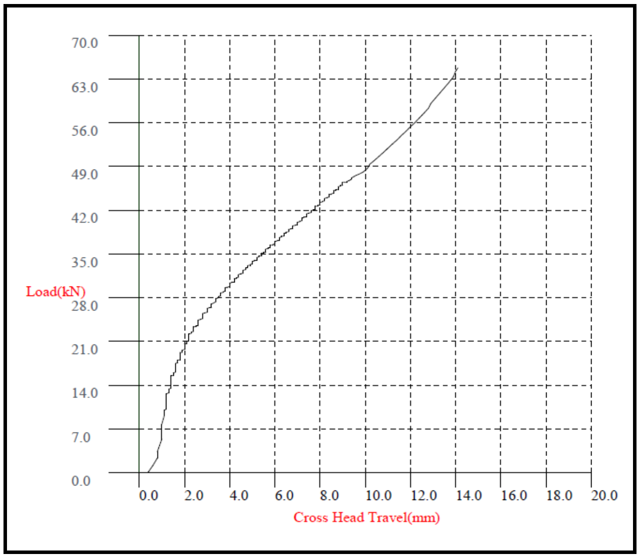

Fig.4.3.2 Typical graph of Compression test for Al2214 alloy

Fig.4.3.3 Typical graph of Compression test for Al2214+2%SiC+4% Gr

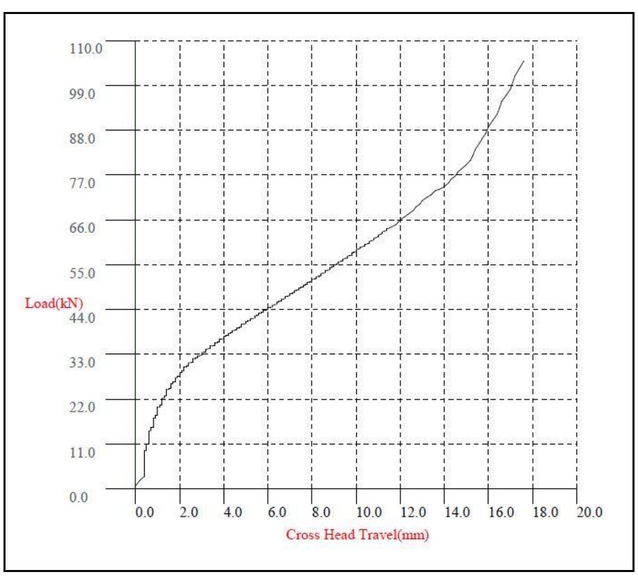

Fig.4.3.4 Typical graph of Compression test for Al2214+4%SiC+4% Gr

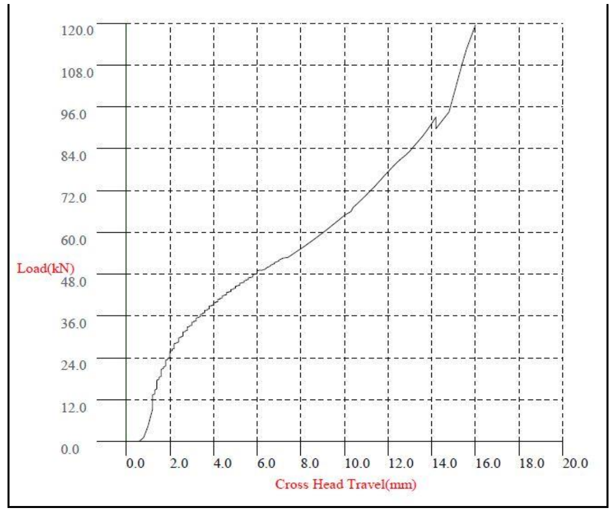

Fig.4.3.5 Typical graph of Compression test for Al2214+6%SiC+4% Gr

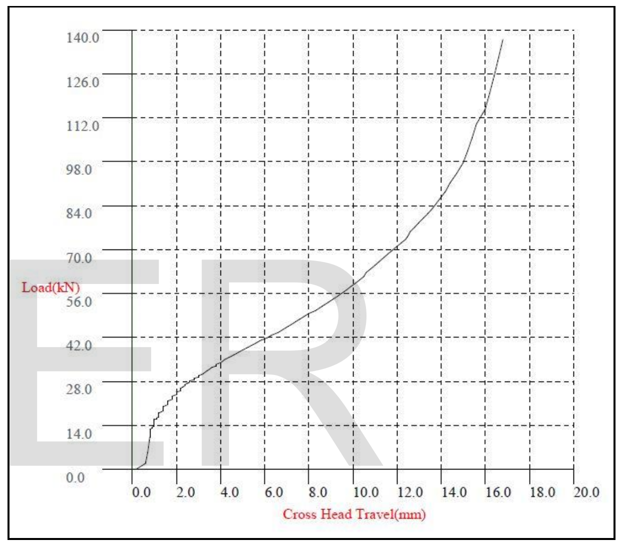

Fig.4.3.6 Typical graph of Compression test for Al2214+8%SiC+4% Gr

Table 6: Compression Strength for Al2214 and Al2214/Sic/Gr Hybrid Composites

Sl No	Composition	Compression Strength (MPa)
1	Al2214 Alloy	572
2	Al2214-2% SiC+4%Gr	652.80
3	Al2214-4% SiC+4%Gr	927
4	Al2214-6% SiC+4%Gr	1056
5	Al2214-8% SiC+4%Gr	1210

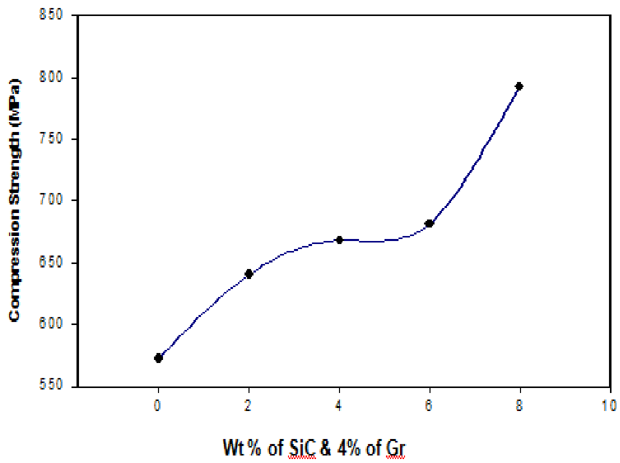

Fig.4.3.7 Effect of Wt% of SiC & 4Wt% of Gr reinforcements on Compression Strength

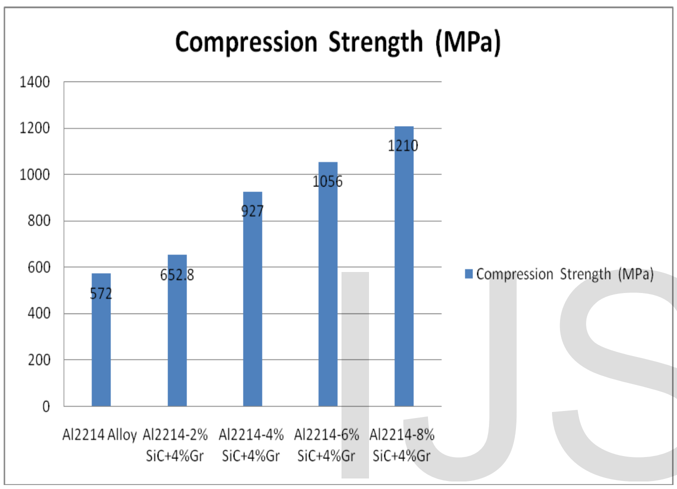

Fig.4.3.8 The effect of Wt% of Sic & Gr on compression strength

Figure 4.3.2 to 4.3.6 shows the typical graphs of Compression Tests for Al2214 alloy and Al2214+ (2-8 wt% of SiC and 4wt% of Gr) hybrid composites and table 6 represents the average values of compression strength of alloy and its hybrid composites.

From the Fig.4.3.7 and Fig 4.3.8 shows that the compressive quality of the composites is higher than that of the base Al2214 compound because of the presence of hard SiC and Gr particles. The SiC+Gr particles have higher compressive quality than the network. Subsequently an expansion in compressive quality is seen with expanding wt% of SiC and an ideal estimation of 4wt% of Graphite fortifications. From the diagram it is seen that there is an unexpected expansion in compressive quality at 8 % of SiC fortification and 4% of Gr, which is supposed to be expanded by 14%. Anyway as the SiC content is expanded from 0% to 8% and Gr held steady to an ideal estimation of 4% the pressure quality is expanded by about 52.72%. Since SiC is a lot harder than the lattice. The hard earthenware SiC particles oppose distortion stress while expanding pressure quality of the composite. All things considered, the expansion of hard fired particulates has caused the MMCs to carry on as weak as opposed to pliable materials, as is obvious from the above outcomes.

4.4 Hardness Test

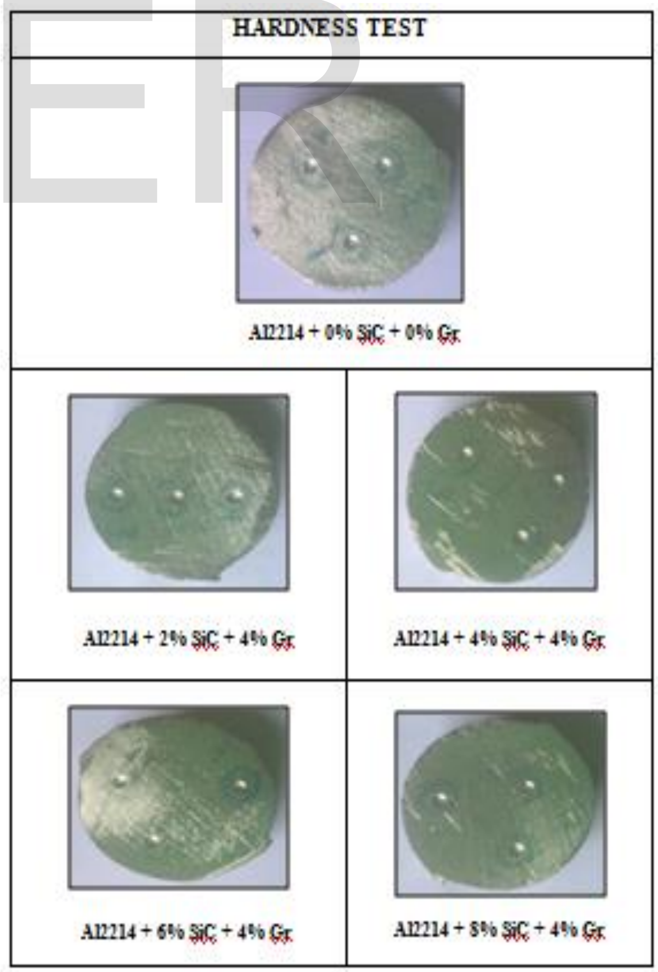

Fig.4.4.1 Hardness Test Specimens

Table 7: Brinell hardness Test for Al2214 and Al2214/Sic/Gr Hybrid Composites

Sl No	Composition	Brinell Hardness BHN
1	Al2214 Alloy	61.7
2	Al2214-2% SiC+4%Gr	73.4
3	Al2214-4% SiC+4%Gr	82.3
4	Al2214-6% SiC+4%Gr	88.7
5	Al2214-8% SiC+4%Gr	99.3

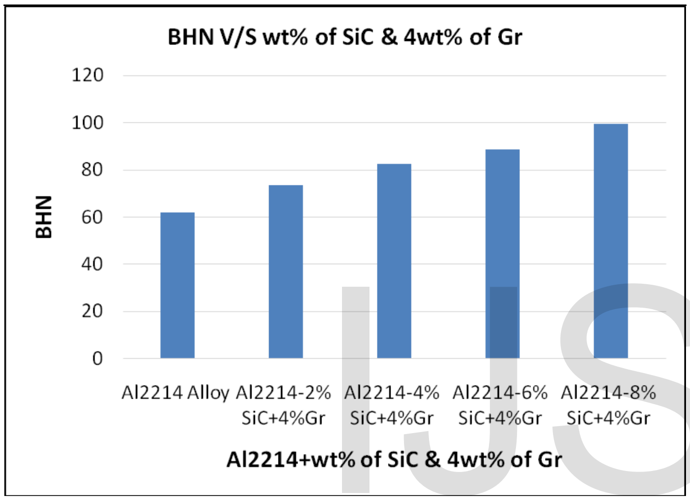

Fig.4.4.2 Effect of Wt% of SiC & 4Wt% of Gr reinforcements on Hardness

Table 7 represents the average of hardness (BHN) reading values of alloy and its hybrid composites. Figure 4.4.2 shows the graphs for the effect of reinforcement content on brinell hardness number of the processed Al2214+(2-8wt%)SiC+4wt% of Gr composites. Each value of hardness is an average of 3 readings (experiments). From the graphs is noticed that improvement in hardness was achieved up to 8 wt % SiC and optimum of 4Wt% Gr. As the SiC content is increased from 0% to 8%, and Graphite kept to an optimum value of 4 wt% the hardness increased by about 37.86 %. The increase in hardness can be attributed to the presence of hard SiC particulates that impart strength to the matrix alloy, thereby providing enhanced resistance to indentation or scratch.

5. CONCLUSIONS

The significant conclusions of the studies on Al2214+SiC+ 4wt% of Gr Hybrid metal matrix composites are as follows.

- Al2214+SiC+ 4wt% of Gr composite was arranged effectively utilizing fluid metallurgy methods by fusing the strengthening particulates.
- They got projecting was uniform with no blowholes or any imperfections in the projecting by visual review and it additionally uncovers great holding among lattice and fortification particles, which yields better burden move from network to support material
- The specimens for Density, Tensile test, Compression test, Hardness were machined as per ASTM Standards.
- It was found that increasing the SiC and 4 wt% of Gr content within the aluminum matrix results in significant increase in the Ultimate Tensile Strength by 31.54% and Yield strength by 34.70% compared to that of Al2214 alloy.
- It was found that increasing the SiC and 4wt% of Gr content within the matrix material, resulted in increase in compressive strength by 52.72% compared to that of Al2214 alloy.
- As the SiC content is expanded from 0% to 8%, and Graphite kept to an ideal estimation

of 4 wt% the hardness expanded by about 37.86 %. The expansion in hardness can be credited to the presence of hard SiC particulates that give solidarity to the grid composite, in this manner giving upgraded protection from space or scratch.

- It was found that increasing the SiC and 4 wt% of Gr content within the matrix material, resulted in significant improvement in mechanical properties like, Ultimate tensile strength, Yield strength, compressive strength and Hardness at the cost of reduced ductility.
- Highest values of mechanical properties like, Ultimate tensile strength, Yield strength and compressive strength and Hardness were found at 8 wt% SiC and 4wt% of Gr.

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