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Fabrication and Testing of AL7075 with Hard Ceramic Particles and Solid Lubricant Particles (Sic-Gr)using Stir Casting Process

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ABSTRACT

Aluminium 7075 Matrix composites have best research now days in Automobile, Aeronautical, and Marine Applications. Reinforcing various Materials, heat treatment and various manufacturing processes, various process parameters for improving the mechanical, thermal and corrosion related properties. Aluminium 7075 MMC's utilize. The aim of the project is lower weight to strength ratio. Aluminium Metal matrix composites (AMCs) are the competent material in the industrial world due to its excellent mechanical properties. The project involves the Experimental investigation of hybrid the MMC such as the Al7075 Reinforced AL 7075-Sic–Gr composite through stir casting Process. This method involves formation of reinforcements within the matrix by the chemical reaction of two or more Materials which also produces some changes silicon carbide was the reinforcement in the matrix of AA 7075 alloy perform the corrosion, Hardness, wear test, Heat treatment process, Sem. Finally find out the which composition is the best based on the results.

INTRODUCTION

Composites are manmade materials consisting of one or more discontinuous phases having intimate contact with each other, with are cognizable interface between them. These are multifunctional materials systems that provide characteristics not obtainable from individual phases. Further, composites are tailor made to cost effective, property effective and application oriented.

In general, the discontinuous phase is harder and stronger than the continuous phase and is called the 'reinforcement'; whereas continuous phase is termed as the 'matrix'. The matrix holds reinforcement to form the desired shape and bears the major portion of an applied load, while the reinforcement improves overall mechanical properties of the matrix. Reinforcement increases the strength, stiffness, wear resistant and the temperature resistance capacity and lowers the density.

METHODS AND MATERIALS:

Stir casting is a type of casting process in which a mechanical stirrer is introduced to form vortex to mix reinforcement in the matrix material. It is a suitable process for production of metal matrix composites due to its cost effectiveness, applicability to mass production, simplicity, almost shaping and easier control of composite structure. Stir casting setup as shown in consist of a furnace, reinforcement feeder and mechanical stirrer. The furnace is used to heating and melting of the materials.

The bottom poring furnace is more suitable for the stir casting as after stirring of the mixed slurry instant poring is required to avoid the settling of the solid particles in the bottom the crucible. The mechanical stirrer is used to form the vortex which leads the mixing of the reinforcement material which are introduced in the melt. Stirrer consist of the stirring rod and the impeller blade.

The impeller blade may be of, various geometry and various number of blades. Flat blade with three numbers is the preferred as it leads to axial flow pattern in the crucible with less power consumption. This stirrer is connected to the variable speed motors; the rotation speed of the stirrer is controlled by the regulator attached with the motor. Further, the feeder is attached with the furnace and used to feed the reinforcement powder in the melt. A permanent mould, sand mould or a lost-wax mould can be used for pouring the mixed slurry.

Out of various furnaces, bottom pouring furnace is suitable for fabrication of metal matrix composites in stir casting route, this type of furnace consists of automatic bottom pouring technique which provides instant pouring of the melt mix (matrix and reinforcement). Automatic bottom pouring is mainly used in investment casting industry. In this technique, a hole is created in the base of melting crucible to provide bottom pouring and was shielded by a cylinder-shaped shell of metals. In stir casting process, the matrix material is melted and maintained a certain temperature for 2–3 h in this furnace Simultaneously, reinforcements are preheated in a different furnace. After melting of the matrix material, the stirring process has been started to form the vortex.

ALUMINIUM7075: Originally called "Alloy 61S", it was developed in 1935. It has good mechanical properties;exhibitsgoodweld ability,andisverycommonlyextruded(second in popularity only to 6063). It is one of the most common alloys of aluminum for general-purposeuse.Aluminumalloy7075hasadensityof2.70gram/cm^3electricalconductivity of 30% IACS, Young's modulus of 68 GPA across all temperatures, and begins to melted to 500^{o}C

GRAPHITE: Commercial GRAPHITE is produced by abut-grey metallic structure, in an electric arc furnace. GR AND SIC does not melt congruently, thereforethe liquid in contact withthe silicon carbide, does not have the same composition as the solid. This means that the liquid must be solidifiedat aratesothattheliquidandsoliddon't reachto equilibrium. The materialwhichis in a molten state becomes increasingly rich in silicon therefore when the liquid solidifies its composition is one of GRAPHITE and graphite. Hot pressing (including hot isocratic pressing)

SILICONCARBIDE: Silicon carbide (Sic), also known as CARBORUNDUM is a semiconductor containingsiliconandcarbon.Itoccursinnatureastheextremelyraremineral moissanite.SyntheticSicpowderhasbeenmass-producedsince1893foruseasan abrasive.

MatrixMaterial

AL 7075 alloy was selected because of its low specific weight and high strength to weight ratio and fatigue and also its excellent machine ability, formability and weld ability. This alloy is widely used in automotive industry, aircraft industry and defense industries. The chemical composition of the used material is given in Table1.

7075Aluminum Alloy Composition by Mass%									
Ai	**Mg**	**Si**	**Fe**	**Cu**	**Cr**	**Zn**	**Ti**	**Mn**	**Remainder**
95.85-98.56	0.8-1.2	0.4-0.8	0-0.7	0.15-0.40	0.04-0.35	0-0.25	0-0.25	0-0.15	0.05each,0.15total

Table1:The chemical composition of the used material

MATERIAL AND MEASUREMENT:

The fabrication process is carried out as two stages one is composite and hybrid composite. The composite measurements are carried as given table for both composites. The AL7075 – GR AND SIC alloy which is used forms metal matrix composition and where the AL7075 is mixed with GR AND SIC in the ratio of (2%,4%,6%,8%) and for the hybrid composite composition mixed with GR AND SIC in the ratio of (96-2-2%,92- 4- 4%,88-6-6% ,84-8-8%,) to form compositions and these alloys are mixed thoroughly in the ball mill for 30 minutes to form the fine mixture (or) mixing in pestle motor thoroughly and the compositions are prepared. In this particular aluminium7075 as matrix and GR AND SIC as reinforcement for composite, increases the mechanical properties of aluminium7075.in the same way for aluminum 2024 ass matrix and both GR AND SIC and graphite as reinforcement for hybrid composite. Many researches were done through powder metallurgy by incorporating ceramic particles as reinforcements on pure aluminium7075 whereas, in this work, a novel idea of reinforcing ceramic particles in aluminium7075 alloy is attempted. Powders of aluminium7075 were generated through ball milling for this work. This paper focuses on further enhancement of the properties of aluminium7075 alloy through powder metallurgy process by incorporation GR AND SIC and as hybrid reinforcement.

EXPERIMENTAL PROCEDURE AND EQUIPMENT:

Aluminium powders of 50µm size are mixed with GR AND SIC and aluminium powder and GR AND SIC mixed in above given table powders are prepared. The mixture was carried out in pestle mortar to ensure uniform distribution of GR AND SIC with Aluminium.

a) Aluminium b) silicon carbide c) Graphite

EXPERIMENTAL STIR CASTIG MACHINE COMPONENTS

1.Furnace 2. Crucible 3. Stirrerrod 4. Stirrerimpeller 5. Mould 6. Feeder 7.Motor

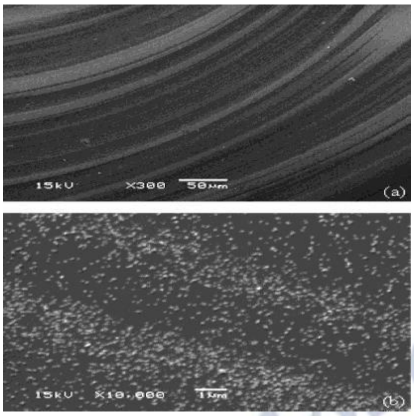
Stir Casting Machine Specifications

Capacity	:	0.7 to 2 kg
Furnace temp (max)	:	950 degree C pre heating of reinforcement (max)
	:	800 degree C
Stirrer Speed	:	100 to 1500 RPM
Die temperature (max)	:	350 degree C
Furnace chamber	:	Organ gas (pure)

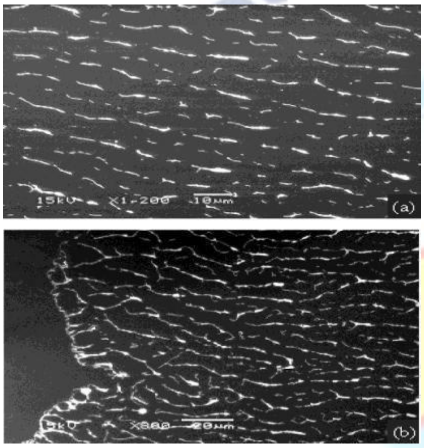
SCANNINGELECTRONMICROSCOPE(SEM)

Initially, the plan of SEM was offered by H. STINTZING in 1927 (a German patent application). His suggested procedure was unable to produce magnified image because the collimated beam with which sample was irradiated was light, X-rays and corpuscles. Then a German electrical engineer named M. Knoll contributed a paradigm of SEM in 1935 where specimen was scanned with electron beam to obtain image. In 1938, VON ARDENNE developed SEM with slight modification by introducing DE magnifying lenses called scanning transmission electron microscope to scan thin samples. For scanning bulk samples Zworykin (in 1942) improved SEM with few other alterations. Eventually SEM was commercialized in 1965 with many alterations being done in the R & D of the OATLEY Lab.

PRINCIPLEOFSEMIMAGEFORMATION-When an electron beam is incident on the sample then many different types of signals are generated which are eventually used to observe or analyze morphology/ topology of thesample.SEM is also used for elemental and state analysis. These signals include: Secondary electrons, Backscattered electrons, Auger electrons,



CATHODOLUMINE SCENCE and X-rays

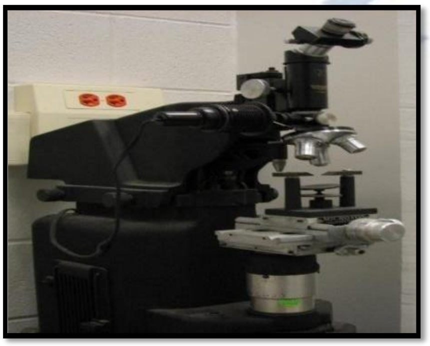


SEM images of silica Nano particles deposited on silicon
SEM images of silica Nano particles deposited on graphite

TESTING

HARDNESS:

Hardnessisameasureofhowmuchamaterialresistschanges inshape.Ability of material to resist wear, tear, scratching, abrasion cutting is calledhardness.Harder materials are more difficult to cut and shape thansofter ones. They are also usually more brittle which means they do not bend much but can shatter.



S.NO	COMPOSITION
1	Al7075
2	Al7075+2%GR+2%Sic
3	Al7075+2%GR+4%Sic
4	Al7075+2%GR+6%Sic
5	Al7075+2%GR+8%Sic

Compositions	D1	D2	VHN
Al7075	90	89	84
Al7075+2%Gr+2%Sic	57	85	88
Al7075+2%Gr+4%Sic	79	97	95
Al7075+2%Gr+6%Sic	67	68	106
Al7075+2%Gr+8%Sic	68	89	110.5

HEAT TREATMENT

Heat treating (or heat treatment) is a group of industrial, thermal and metalworking processes used to alter the physical, and sometimes chemical, properties of a material. The most common application is metallurgical. Heat treatments are also used in the manufacture of many other materials, such as glass. Heat treatment involves the use of heating or chilling, normally to extreme temperatures, to achieve the desired result such as hardening or softening of a material. Heat treatment techniques include annealing, case hardening, precipitation strengthening, tempering, carburizing, normalizing and quenching. Although the term heat treatment applies only to processes where the heating and cooling are done for the specific purpose of altering properties intentionally, heating and cooling often occur incidentally during other manufacturing processes such as hot forming or welding.

Compositions	D1	D2	VHT
Al7075	78	69	89
Al7075+2%Gr+2%Sic	98	98	95
Al7075+2%Gr+4%Sic	68	98	103
Al7075+2%Gr+6%Sic	68	96	110
Al7075+2%Gr+8%Sic	68	95	114

WEAR TEST:

Wear resistance is defined as the ability of stone to resist comprehensive external forces such as abrasion, edge cutting and impact etc. during service. The wear tests were conducted on aluminum (AL7075) alloy and aluminum (AL7075) + nano GR AND SIC M M C s as per ASTM G99-95 standard at room temperature using a computerized pin on disk wear test rig shown in the figure 4.12. The sliding wear test samples were machined of 8 mm nominal diameter and gauge length of 30 mm were shown in the figure 4.11. The sliding wear test was conducted in Pin-on-disc wear testing machine with data acquisition system, which was used to evaluate the wear behaviour of the aluminium's (AL7075) alloy and aluminium (AL7075) + nano GR AND SIC MMCs against the toughened steel disc (En-32) with hardness of 60 HRC and surface roughness (Ra) 0.5 pm. The sliding wear occurs when the test samples were slide over rotating disc. The disc is coupled to a 1000 rpm capacity DC motor and the disc of 120 mm diameter. The load can be applied to test sample adding the dead weight up 200N through steel wire and pulley arrangement.

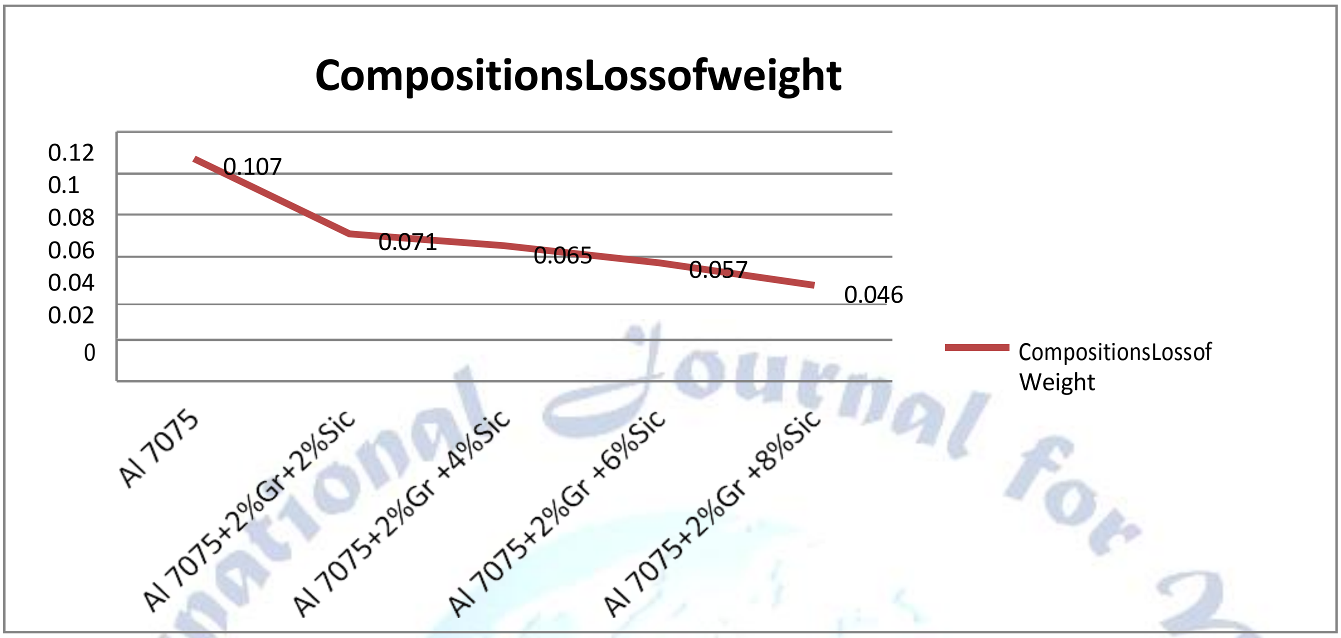
WEAR TEST SPECIMENS

WEAR TEST MACHINE

The test sample was fitted to the collect and placed a t a particular track diameter. The track diameter is to be changed for each sample and test conditions. The machine is having the facility to vary the sliding wear parameter through controller. The particular parameters like sliding velocity, applied and time are selected. The experiment was conducted and after completing the time, the wear in microns and frictional force in Newton's were, recorded. From, the materials the we have done a three load conditions and three distances in machine there are 1.Wear at 1kg load 200mts 2. Wear at 1kg load 400mts 3. Wear at 1kg load 600mts

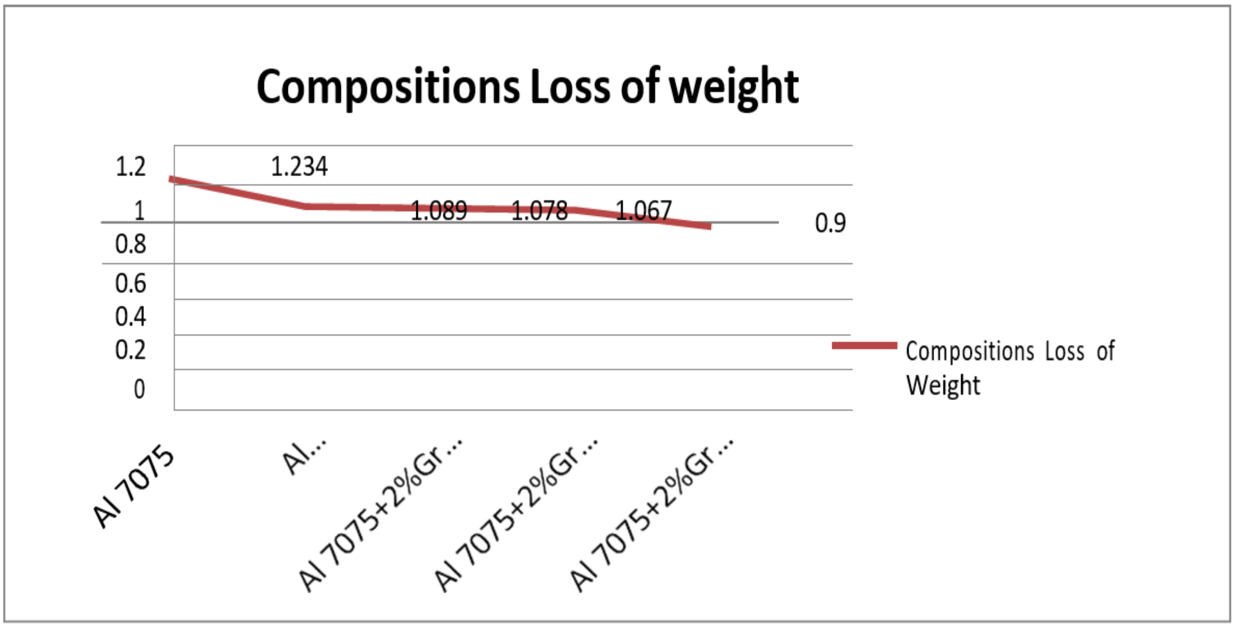
WEARAT1KGLOAD200MTS

S.NO	MATERIALS	INITIAL WEIGHT	FINALWEIGHT	LOSSOF WEIGHT
1	Al7075	14.78	14.673	0.107
2	Al7075+2%Gr+2%Sic	15.674	15.603	0.071
3	Al7075+2%Gr+4%Sic	15.699	15.625	0.065
4	Al7075+2%Gr+6%Sic	14.789	14.732	0.057
5	Al7075+2%Gr+8%Sic	14.345	14.299	0.046



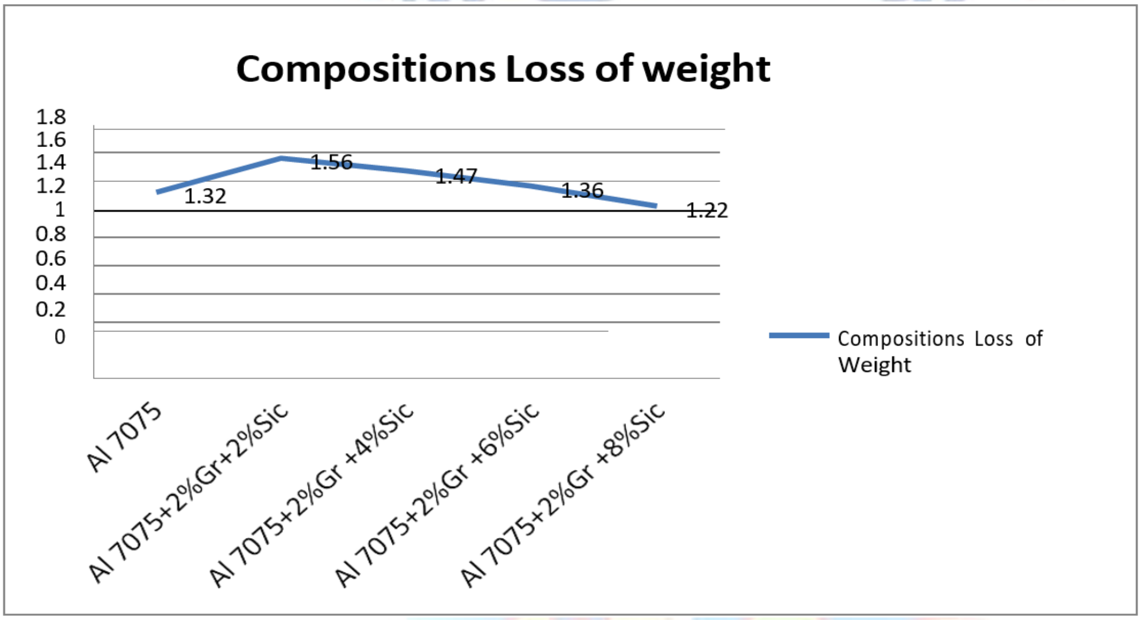
WEARAT1KGLOAD400MTS

S.NO	MATERIALS	INITIAL WEIGHT	FINAL WEIGHT	LOSS OF WEIGHT
1	Al7075	13.78	12.546	1.234
2	Al7075+2%Gr+2%Sic	14.551	13.462	1.089
3	Al7075+2%Gr+4%Sic	14.456	13.378	1.078
4	Al7075+2%Gr+6%Sic	13.444	12.377	1.067
5	Al7075+2%Gr+8%Sic	12.912	11.932	0.98



WEAR AT 1KG LOAD 600MTS

S.NO	MATERIALS	INITIAL WEIGHT	FINAL WEIGHT	LOSSOF WEIGHT
1	Al7075	11.046	9.726	1.32
2	Al7075+2%Gr+2%Sic	12.206	10.646	1.56
3	Al7075+2%Gr+4%Sic	11.999	10529	1.47
4	Al7075+2%Gr+6%Sic	10.765	90405	1.36
5	Al7075+2%Gr+8%Sic	10.036	8.816	1.22



CORROSIONTEST

Effect of corrosive media concentration on time (10% H C l)

IMMERSION HOURS	WEIGHTLOSS(GRAMS)				
MATERIALS	AL7075	AL 7075+2% Gr+2%Sic	AL 7075+2% Gr+4%Sic	AL 7075+2% Gr+6%Sic	AL 7075+2% Gr+8%Sic
2	0.063	0.18	0.17	0.121	0.11
4	0.074	0.032	0.027	0.026	0.024
6	0.190	0.0017	0.014	0.009	0.007
8	0.087	0.02	0.018	0.01	0.008
10	0.876	0.034	0.03	0.026	0.024

Effect of corrosive media concentration on time (20% H C l)

IMMERSION HOURS	WEIGHTLOSS(GRAMS)				
MATERIALS	Al7075	AL 7075+2% Gr+2%Sic	AL7075+2% Gr+4%Sic	AL 7075+2% Gr+6%Sic	AL 7075+2% Gr+8%Sic

2	0.019	0.182	0.161	0.118	0.107
4	0.067	0.024	0.022	0.021	0.02
6	0.064	0.007	0.004	0.005	0.004
8	0.072	0.02	0.017	0.009	0.008
10	0.097	0.028	0.023	0.017	0.016

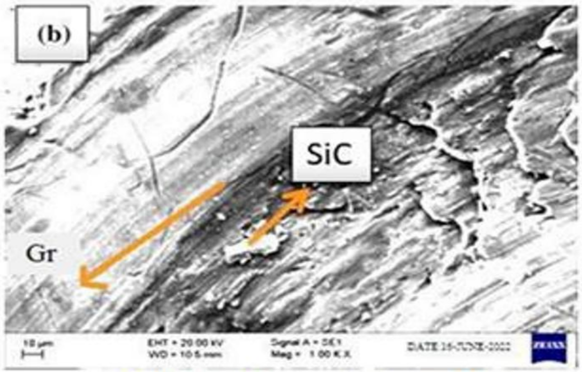
Effect of corrosive media concentration on time (30% H C l)

IMMERSION HOURS	WEIGHTLOSS(GRAMS)				
MATERIALS	AL 7075	AL 7075+2% Gr+2%Sic	AL 7075+2% Gr+4%Sic	AL 7075+2% Gr+6%Sic	AL 7075+2% Gr+8%Sic
2	0.017	0.193	0.14	0.143	0.132
4	0.023	0.071	0.065	0.049	0.0436
6	0.029	0.012	0.01	0.008	0.009
8	0.098	0.023	0.02	0.019	0.013
10	0.109	0.091	0.079	0.068	0.053

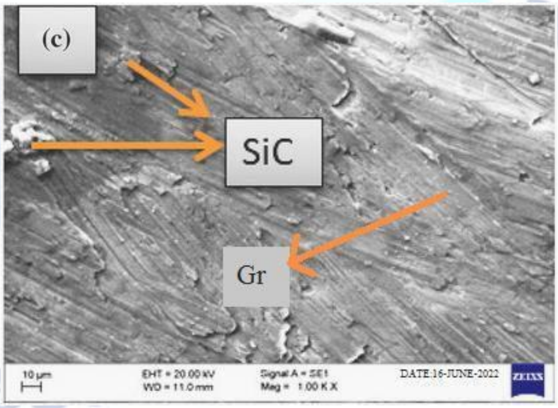
MICROSTRUCTUREANALYSIS:

Microstructure Analysis the Scanning electron microscope (SEM) is used to analyze the distribution of Silicon Carbide particles in the matrix material Aluminum 7075.SEM produces images of a sample by scanning with a focused beam of electrons. The electrons interact with atoms in the sample to produce various signals that contain information aboutthe sample surface composition. The electron beam is generally scanned in a raster scan patternand the beam'sposition iscombined withthe detected signalto produce an image. The uniform and non-uniform distribution of reinforcement particles are verified by using SEM analysis.

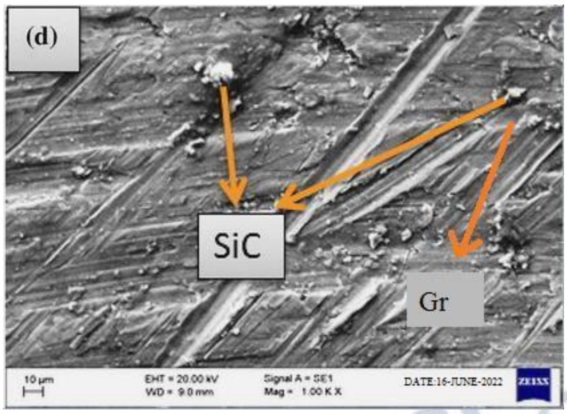
Al7075 MATERIAL



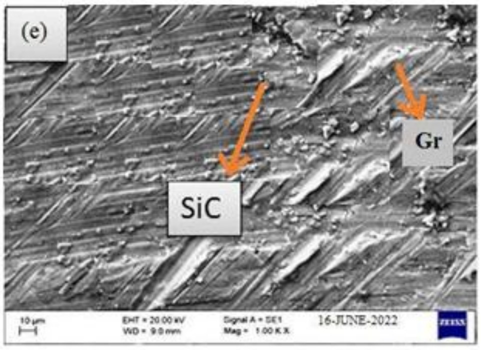
AL 7075+2% Gr+2%Sic



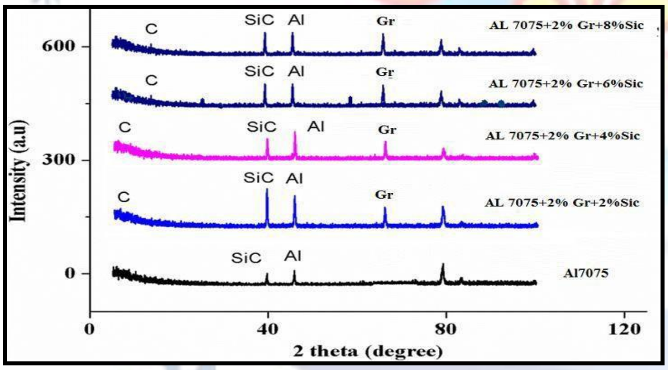
AL7075+2%Gr+4%Sic



AL 7075+2% Gr+6%Sic



AL7075+2%Gr+8%Sic



XRD DIFFR ACTION ANLAYSIS OF VARIOUSHYBRID

GRAPH BETWEEN THE INTENSITY AND 2Ø:

The X-ray diffraction (XRD) results for the prepared Al7075 with Sic and Gr as shown below Graph. These results Indicate the presence of aluminum (in the largest peaks), and the presence of silicon carbide particles and Gr is indicated by minor peaks. A clearly visible Gr peak can be observed in the hybrid composites. A gradual marginal shift ofthe Al peaks to higher angles with an increase in the weight% of the graphite content is also evident. Below figure shows that there is no oxygen reaction in the samples during the process. The phases identified by XRD analysis were similar for all hybrid composites. These patterns show that reinforcement particles are well distributed in the aluminum matrix. The XRD pattern confirmed the presence of aluminum, Gr (C) and Sic particles.

CONCLUSION

- The nano GR AND SIC particulates are evenly dispersed in the matrix alloy. The micro hardness of AL7075-GR AND SIC nano metal matrix composite material is superior than the matrix material. The micro hardness increases by 12.2% by the addition of 2 wt.% of GR AND SIC nano particulates in aluminum (AL7075) matrix alloy.
- The inclusion of GR AND SIC nano particulates in AL7075 matrix alloy significantly enhanced the ultimate tensile strength and yield strength of the AL7075-GR AND SIC 2 nano metal matrix composite materials. The 8 wt.% of GR AND SIC reinforced aluminum (AL7075)- GR AND SIC nano composite shows 54.11% increase in the ultimate tensile strength as compared to ultimate tensile strength of LM 13alloy.
- The ductility of AL7075-GR AND SIC nano metal matrix composite material decreases as compared to matrix alloy. The ductility decreases by Fracture toughness increases as the reinforcement substance amplifies in the matrix material. The fracture toughness increases by 130% by the addition of 2 wt. % of GR AND SIC nano particulates in AL7075 matrix alloy.
- The wear resistance increases as the wt. O/o of reinforcement substance amplifies in the matrix material. The wear resistance of aluminum (AL7075) +6 wt.% nano GR AND SIC MMC shows 40.76 0/o increases in the wear resistance as compared to wear resistance of aluminum (AL7075) alloy. The wear resistance of 6 hrs heat treated aluminum (AL7075) alloy increases by 21.57% and increase 14.28%in the wear resistance of extruded aluminum (AL7075) alloy with that of as-cast aluminum (AL7075) alloy.
- The wear resistance decreases as the applied load boosts. The wear rate of aluminum (AL7075)+6% wt nano GR AND Sic MMC increases by 2.99 % as load increases to 40N and

when load increase to 80N, the wear rate of aluminum (AL7075) +6 wt.% nano GR AND SICMMC increases by 29.68% with that of 20N loaded aluminum (AL7075) +6% wt. nano GR AND SIC MMC.

The wear rate in both the AL7075 / nano GR AND SIC metal matrix composites and the matrix material enhances as the sliding distance increases.

- The wear rate in both the AL7075 / nano GR AND SIC metal matrix composites and the matrix material decreases as the sliding velocity enlarges. The wear rate of aluminum (AL7075) +6% wt. nano GR AND SICMMC decreases by 13.29% as sliding velocity increases to 1.728.
- 32.72% with the inducing of 2 wt. % of GR AND SIC nano particulates in aluminum (AL7075) matrix alloy.
- The compression strength increases as the fraction of reinforcement enhances in the matrix material. The 8 wt.% of GR AND SIC reinforced as-cast aluminum (AL7075)-GR AND SIC nano composite Shows40.32%increase in the compression strength as compared to compression strength of aluminum (AL7075) alloy.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

REFERENCES

[1] RAVICHANDRAN, M. AND DINESHKUMAR, S: Synthesis of AlTiO2 Composites through Liquid Powder Metallurgy Route,

[2] IZADIA, H and NOLTINGB, A. et.al: Friction Stir processing of Al/Sic composites fabricated by powder metallurgy, Journal of Materials Processing Technology, 1900– 1907, 2013

[3] KESHAVAMURTHY, R., SADANANDA MAGERI, et.al: Microstructure and Mechanical Properties of Al7075–TiB2 in–situ composite, Research Journal of Material Sciences, Vol. 1(10), (6-10), 2013.

[4] [4 UVARAJA, C. AND NATARAJAN, N: Comparison on Al6061 and Al7075 with Sicand B4C reinforcement hybrid metal matrix composites, IJART, Vol.2, pp,1–12, 2012.

[5] ANANDKUMAR,MANASMOHANMAHAPATRA,PRADEEPKUMARJHA:Fabrication and Characterizations of Mechanical Properties of Al-4.5%Cu/10TiC Composite by In–Situ Method, Journal of Minerals and Materials Characterization and Engineering, Vol. 1075–1080, 2012.

[6] HARTAJ SINGH, SARABJIT, NRIP JIT et.al: An overview of metal matrix composite processing and Sic based mechanical properties, Journal of Engineering Research andStudies,Vol.II,(72–78),2011.

[7] Dr. Mahesh Mallampati Energy Performance of a Compression Refrigeration Cycle Using Environment-Friendly Refrigerants MaterialsToday: Proceedings Elsevier https://doi.org/10.1016/j.matpr.2022.07.178.

[8] Dr. Mahesh Mallampati Surface Modification of Strenx 900 Steel Using Electrical Discharge Alloying Process with Cu-10Ni- CrxPowder Metallurgy Sintered Electrode https://doi.org/10.1590/1980-5373-MR-2021-0390 .

[9] Dr. Mahesh Mallampati Analysis of responses on zirconium carbide based titanium using laser beam machining processMaterials Today: ProceedingsElsevier 26/02/2022 https://doi.org/10.1016/j.matpr.2020.12.967

[10] Dr. Mahesh Mallampati Design Process to Reduce Production Cycle Time in Product Development IAES International Journal of Artificial Intelligence ISSN: 2252-8938, DOI: 10.11591/ijai.v7.i3.pp125-129.

[11] Dr. Mahesh Mallampati Design and Analysis of Micro-Cantilever Beam Attached with Piezoelectric Material for Vibration Control International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET) e-ISSN: 2319-8753, p-ISSN: 2320-6710.

[12] Dr. Mahesh Mallampati Evaluation of Mechanical Properties of Rice Straw Fibre Polypropylene Composites SSRG International Journal of Mechanical Engineering (SSRG - IJME) ICETST Nov 2018. ISSN: 2348 – 8360.

[13] Dr. Mahesh Mallampati Investigation of Mechanical Properties of Slag Reinforced Polymer CompositesIOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X PP. 72-76.