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Mechanical & Tribological Behaviors of Aluminium Metal Matrix / Hybrid Metal Matrix Composites: A Review

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ABSTRACT

This paper presented the review of past feud years researches work already done in this field. The Aluminium metal Matrix Composite is light weight, high strength to weight ratio, good stiffness to weight ratio etc. Current engineering applications require materials that are stronger, light weight and less expensive. Ceramic particles such as SiC, Al_2O, TiC, MoS_2, TiO_2, TiB_2, and WC prevail as reinforcements, but graphite, graphene and carbon nanotubes are also used. The present work in addition, the overview of mechanical & tribological properties is presented through the equipments used for testing; matrix material, manufacturing process, amount, size & type of reinforcement and test conditions.

KEYWORDS: *Aluminium Metal Matrix Composites (AMMCs), Hybrid Metal Matrix Composites (HMMCs), Reinforcement, Microstructure, Tribological Property, Hardness, Tensile Strength*

I. INTRODUCTION

The aluminium metal matrix composites are advanced materials in recent days; the development of lightweight Aluminium alloys improves the quality of the material preferred as design material. Due to the improved mechanical and tribological properties, aluminium metal matrix composites (AMMC's) got great importance. These composites find various applications in the automobile/vehicle industry, the aerospace industry and in defense and marine engineering because of their being considered as a group of new advanced materials for its light weight, high strength to weight ratio, good stiffness to weight ratio, high corrosion resistance, high specific modulus, low co-efficient of thermal expansion and good wear resistance properties, high stiffness, hardness, wear resistance, high temperature resistance etc., the main fundamental demand from the automobile industry is to find advanced materials, which are capable of reducing fuel utilization and vehicle discharges compared to others. In structural applications, the matrix generally used is lighter metal like aluminium, magnesium, or titanium, and supplied a good support to the reinforcement. At extreme temperature applications, cobalt and cobalt-nickel alloy matrices uses are common. The reinforcement material is implant into the matrix. The reinforcement does not always used to serve as a purely structural task (reinforcing the compound), but it is also used to change physical properties such as wear resistance, friction coefficient, or thermal conductivity; the reinforcement can be either continuous or discontinuous. Discontinuous MMC's can be isotropic, and can be worked with standard metalworking techniques, such as extrusion, forging or rolling. In addition, they may be machined using conventional methods, but most commonly would need the use of polycrystalline diamond tooling (PCD). Continuous reinforcement uses monofilament wires or fibers such as carbon fiber or silicon carbide. Because the fibers are embedded into the matrix in a certain direction, the result is an anisotropic structure in which the alignment of the material affects its strength. One of the first MMC's used boron filament as reinforcement. Discontinuous reinforcement uses whiskers, short fibers, or particles. The most common reinforcing materials in this category are alumina and silicon carbide.

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The aluminium metal matrix composites are advanced materials which consists of two phases i.e. matrix phase and the reinforcement phase for example, SiC, B4C, TiC, Al_2O_3 are hard reinforcements to fabricate composite materials. The reinforcement area can be coated to prevent a chemical reaction with the matrix. For example, carbon fibers are commonly used in aluminium matrix to synthesize composites showing low density and high strength. However, carbon reacts with aluminium and made aluminium brittle and water-soluble compound Al_4C_3 on the surface of the fiber. To forbade this reaction, the carbon fibers are coated with nickel or titanium boride.

Manoj Singla has been develop aluminium based silicon carbide particulate MMCs with an aim to develop a conventional low cost method of producing MMCs and to obtain uniform dispersion of ceramic material. To achieve these objectives two step-mixing method of stir casting technique has been adopted and subsequent property analysis has been made. An increasing trend of hardness and impact strength with increase in weight percentage of SiC has been observed. Md. Habibur Rahaman Investigated that the microstructures, mechanical properties and wear characteristics of as cast SiC reinforced aluminium matrix composites (AMC's). The results depict that introduction of silicon carbide reinforcements in AMC's extend hardness & tensile strength. Microstructural observation revealed clustering & non – homogeneous distribution of SiC particles in the Al Matrix. S. Johny James showed an effect to find the mechanical & machining properties of prepared hybrid aluminium metal matrix composites reinforced by SiC and Titanium diboride (TiB_2). It is observed that density, hardness and tensile strength increases along with machining parameters like cutting speed, feed rate, depth of cut and surface roughness also investigated. S. Sulaiman et al. To fabricated Al – SiC composite 10 wt% SiC & Different % of Sr was added by using vortex method for mixing the particles. The influence of adding different amount of Al – 10Sr wt% on mechanical behaviors showed that UTS increased by adding SiC & Sr. It also showed that the weak interface between particles & matrix decreased the UTS. N.G. Siddesh Kumar to the develop and characterize Al2219 reinforced with B_4C & MoS_2 for Hybrid composites by using stir casting technique. The density & hardness of Al2219 alloy is relatively low as compared to prepared hybrid composites. Tensile strength is lowest for Al2219 + 3% B_4C + 5% MoS_2 and highest for Al2219 alloy. SEM was used to check fracture surface of tensile specimens, it consists of ductile & brittle fracture or mixed mode. The addition of B_4C & MoS_2 reinforcement decreases the wear rate of hybrid composites and increases the wear resistance of the composites. Sean Flanagan et al. the mechanical properties of an aluminium matrix composite with silicon carbide particles (2009 Al / SiC / 15p MMC) was studied. Test specimens were fabricated from a rolled billet and then aged in oil bath or air over a range of temperatures prior to mechanical testing. It was found that averaging led to a decrease in material strength (and hardness). It was also found that the hardness of the material continually decreases as the aging temperature is incrementally increased up to 290^0C. Dinesh M. Pargunde producing Metal Matrix Composites (MMCs) Aluminium (98.41%) and SiC (360-grit) has been chosen as matrix and reinforcement material respectively. Experiments are planned for conducting varying weight fraction of SiC (in the steps of 5%) while keeping all other parameters like furnace temperatures, stirring speed & total mass of material mixture constant. By two stir casting technique are used. N. Rajesh Prabha. Reported the dry sliding performance of the stir casted Al7075 / TiC / MoS_2 hybrid Metal Matrix Composites and optimization using Taguchi method. The parameters selected for this experimental study are applied load, sliding velocity & sliding distance. The experiments were carried out using Taguchi technique with an L27 orthogonal array. Results shows that the increasing wear parameters it also increases the wear. Ms. Kanchan A. More success fully examined the Wear behaviors of hybrid composites of Al7075 alloy reinforced with TiC & MoS_2 hybrid composites prepared by the method of stir casting. Results revealed that reinforcement shows negative influence on weight loss. Weight loss decreases with increasing reinforcement. Hybrid Aluminium Metal Matrix Composites has a series of excellent properties i.e. high hardness, stability and low density. V. Ramakoteswara Rao Aluminium Metal Matrix Composites (AMMCs) reinforced with particulates has important use in many engineering applications because of low wear rate and a good hardness. Al7075 metal matrix composite materials varying in the particle percentage of TiC reinforcement, were prepared by stir casting procedure and optimized volumetric wear at different parameters such as particle percentage of TiC, sliding speed & sliding distance. S. Devaganesh Al7075 tends to have a vast numbers of applications in fields of automobile, aerospace, mechanical and marine industries due to its high strength to density ratio, high tensile strength, high yield strength and high elongation during the time of failure. In most of the fields mentioned above, Al7075 alloy is either used in the form of metal matrix composite. S. Devaganesh focused on fabrication of Al7075 Metal Matrix Composites (MMCs) with silicon carbide ceramic particles & various others solid Lubricants for application in the development of piston. The composites of the casted specimen is 90 wt% Al7075 alloy as well as 5% of SiC, which has to be kept as constant and varying the type of the solid lubricants; graphite, hexagonal boron nitride (hBN), and molybdenum disulfide (MoS_2) with 5 wt% .

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COMPOSITE

A composite material (composite) is a material made up of two or more constituent Metal / Ceramic which has significantly different physical or chemical properties when combined; produce a composite whose characteristic is different from the individual components. The individual components remain separate and distinct in the finished structure, differentiating composites from mixtures and solid solutions. The aim of composites is to help the new materials to have good strengths from both materials. One is Matrix and other one is hard particle/ceramic (Reinforcements).

Matrix: The matrix is basically a homogeneous and monolithic material in which a fiber system of a composite is implanted. It is toatally continuous. The matrix provides a way for binding and grasping reinforcements together into a solid. The primary functions of the matrix are to transfer stresses between the reinforcing fibers (hold fibers together) and protect the fibers from mechanical and environmental damages. A basic requirement for a matrix material is that its strain at break point must be higher than the fibers it is holding. A composite matrix may be a polymer, ceramic, metal or carbon.

Reinforcement: Reinforcements for the composites may be fibers, fabrics particles or whiskers. Reinforcement is usually done to improve the properties of the base metal like strength, stiffness, conductivity, corrosion resistance, etc. Reinforcing constituents in composites provide the strength. The role of the reinforcement in a composite material is to increase the mechanical and physical properties. Mainly particulate-reinforced composites are best quality for their flammability with a price advantage. Further, they are ingrained with wear and heat resistant properties. For MMCs SiC, Al_2O_3, Gr, B_4C, TiC, MoS_2 etc., is excessively applied particulate reinforcements.

Metal Matrix Composite (MMC)

Metal matrix composite with short or continuous fibrous reinforcements are generally produced by infiltration process, it also defines the final shape of the metal matrix composite and which can also produce fully or partially reinforced components. Recycling of such composites would thus require preservation of the shape of the component. Metal matrix composite materials can be produced by many different techniques. Three processing methods which are primarily used to develop a metal matrix composite are high-pressure diffusion bonding, casting, and powder-metallurgy techniques.

A metal matrix composite (MMC) is a composite material with at least two constituent parts, one being a metal necessarily, and the other material may be a different metal or another material, such as a ceramic or compound. Its properties and structural performance are superior to those of the constituents acting independently. Metals and ceramics, can be embedded with particles or fibers, to improve their properties; combination are known as metal matrix composite (MMC). When at least three materials are present, it is called a hybrid composite. A metal matrix composite consists of two chemically and physically distinct phases, suitably distributed to provide properties that cannot be obtained with either of the individual phases.

Generally, there are two phases either a fibrous or particulate phases in a metallic matrix. Sustainably progress in the development of the light metal matrix composites has been achieved in recent decades, so that they could be introduced into the most important applications specially in the automotive industry, MMCs have been commercially used in fiber reinforced pistons and aluminium crank cases with strengthened cylinder surface as well as particle strengthened brake disk. These innovative materials open up unlimited possibilities for modern material science and development.

Table: 1 LITERATURE SURVEY

Ref. No.	Selection of Materials and Manufacturing Process	Experimental design / Processes and Composition	Finding Parameters	Results

1.	Al7075 – Matrix n Al_2O_3 (20-30nm)- Reinforcement Mg (micro) – Reinforcement & Stir Casting	Tensile - ASTM E8 Hardness – ASTM E92-17 mpact – ASTM E23-12C **& Composition** Al_2O_3 – 1,2,3,4 Wt% Mg- 1% Common	1. Density 2. Hardness 3. Tensile Strength 4. Impact Strength 5. % Elongation 6. SEM Micrograph	1. Increasing the wt% of nano-reinforcement than density decreased. 2. Tensile, Hardness and Toughness gradually increase, increasing wt% of Al_2O_3 3. Morphology revealed that the Al_2O_3 fragments were well dispersed in the Aluminium matrix.
2.	Al7075- Matrix TiC (2µm) – Reinforcement & Stir Casting	Hardness- 1501:2002 ASTM Tensile- ASTM B 557:2006 **& Composition** TiC- 2,4,6,8,10 wt%	1. Hardness test 2. Tensile test 3. Wear test 4.SEM Micrograph 5. % Elongation	1. The mechanical properties for the TiC reinforced composite specimens are better than Al7075 matrix material in both conditions. 2. The high content of TiC particles in AMMCs lead to high wear resistance up to 8 wt.%. 3. Wear rate and coefficient of friction decreases with increase of wt. % of TiC reinforced particle.
3.	Al7075- Matrix TiC (2µm) – Reinforcement & Stir Casting	Taguchi Optimization & ANOVA Technique **& Composition** TiC-2,4,6,8,10 wt%	1. Hardness VHN 2. Density 3. Tensile test 4. % Elongation 5. Volumetric wear rate 6. S/N Ratio 7.SEM Micrograph	1. There is a definite increase in the wear resistance of the Al7075 matrix alloy with the addition of TiC particles. 2. The volumetric wear rate of Al7075 and Al7075 reinforced with TiC increased with increasing sliding distance and decreased with increasing wt. % of reinforcement and sliding velocity.
4.	Al7075- Matrix TiC – Reinforcement MoS_2- Reinforcement & Stir Casting	ASTM G99-95 Taguchi Optimization & ANOVA Technique L_{27} Orthogonal Array **& Composition** TiC – 10 wt% MoS_2 – 10 wt%	1. Volumetric wear rate 2. Wear rate 3.SEM Microstructure	1. Molybdenum disulfide percentage followed by sliding velocity, and applied load exert a significant influence on the specific wear rate of aluminum composites. 2. The sliding velocity is having directly proportional relationship with wear rate and finally the interactions of parameters.
5.	Al7075- Matrix SiC – Reinforcement MoS_2- Reinforcement & Stir Casting	Hybrid composites Size of casting 100mm x 100mm x 10mm **& Composition** SiC – 5,10,15 wt% MoS_2 – 3 % wt Constant	1.SEM Microstructure 2. Tensile Test 3. % Elongation	1. Addition of Silicon Carbide particles further more than 5% did not improve the tensile strength. 2. The maximum % Elongation is obtained for sample 3 i.e., 17.8.
6.	Al7075- Matrix TiC –	ASTM G99 Taguchi Method &	1. Wear loss 2. Coefficient of	1. Wear loss & COF influenced by applied load (45.51%) and percentage of Reinforcement (59.12%) respectively.

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	Reinforcement MoS_2-Reinforcement & Stir Casting	ANOVA Technique MINITAB 18 Software L_9 Orthogonal Array **& Composition** TiC – 0,5,10 wt% MoS_2 – 3 wt%	friction 3. S/N Ratio	2. Signal to noise plot gives us optimum condition. The result shows that applied 10N load, 1000c temperature, 10% reinforcement and 400m sliding distance gives optimum condition.
7.	Al7075- Matrix TiC (2µm) – Reinforcement & Stir Casting	ASTM Standard Taguchi Method & ANOVA Technique MINITAB 15 Software L_{27} Orthogonal Array **& Composition** TiC-0,2,4,6,8, wt%	1. Hardness VHN 2. Density 3. Tensile test 4. % Elongation 5. Volumetric wear rate 6. S/N Ratio 7.SEM Micrograph	1. AA7075 matrix material and the increased weight percentage of TiC content increased the density, hardness and wear resistance of the composites. 2. The volumetric wear rate of AA7075 and AA7075 reinforced with TiC composites increased with increasing sliding distance and decreased with increasing of wt. % of reinforcement and sliding velocity.
8.	Al7075-T6 Matrix SiC (150-180 µm) – Reinforcement. MoS_2 (50-80 µm) - Reinforcement. Gr (180-200µm) - Reinforcement. Hexagonal boron nitride “hBN” (90-120 µm) - Reinforcement. & Stir Casting	1. Hardness Test ASTM A730-17 By VHN 2. Tensile Test ASTM E8 By UTM 3. Compression Test ASTM E9 By UTM 4. Wear Test ASTM G99 By Pin-on-disc Machine **& Composition** SiC – 5 % wt Constant. Gr – 5 % wt at B hBN – 5 % wt at C MoS_2- 5 % wt at D	1. Hardness Test VHN 2. Tensile Test 3. Compression Test 4. Wear Test	1. The effect of graphite reinforcement over Al7075 alloy has a significant impact on mechanical properties. 2. Graphite particles tend to increase the bonding between the matrix and reinforcement, while SiC particles increase the ductility of the material. 3. Stir casting method results in even distribution of reinforcements, thus increases the mechanical properties. 4. However, reinforcement of hBN gives higher wear characteristics as compared to other reinforcements such as Gr, SiC and MoS_2.
9.	Al7075- Matrix TiC (2µm) – Reinforcement & Stir Casting	Composites Size of casting (Ø8mm X 30mm) **& Composition** TiC – 0,2,4,6,8,10 wt%	1. Hardness VHN 2. Wear Study 3. Microscopic SEM	1. AA7075 matrix containing 8% (wt.) of TiC particulates exhibited the highest micro-hardness. 2. The wear rate, coefficient of friction and wear factor varying with the sliding distance and the percentages of reinforcement are of same nature. 3. The wear rate of the composites decreased with increasing the weight percentage of Titanium carbide (TiC) particulates than the base alloy.

10.	Al7075- Matrix Chromium "Nano particle" (50nm) – Reinforcement Zinc "Nano particle" (50nm) – Reinforcement **&** Stir Casting	Size of Fabricated Billet Composite 100mm L x 100mm W x 10mm T **& Composition** Cr – 2,3,4,5,6 wt% Zn – 1% Weight Constant	1. Tensile test 2. Hardness test 3. Microstructure Test	1. The tensile properties of developed composites by stir casting method were considerably improved the addition of Zinc nanoparticles which is much higher than the unreinforced aluminium alloy. And also hardness of fabricated composite value improved. 2. Finally composite contain (Al-97%Cr-4%Zn-1%) fabricated composite showed improved properties such tensile and hardness in comparison with other specimens.
11.	Al7075 – Matrix Al_2O_3- Reinforce B_4C – Reinforce **&** Stir Casting	ASTM G99 Standard Taguchi Method & ANOVA Technique MINITAB 16 L_{27} OA **& Composition** Al_2O_3 – 3,6,9,12,15 wt% B_4C – 3% Weight Constant	1. Tensile test 2. Coefficient of friction 3. Volumetric wear rate 4. S/N Ratio 5.SEM Micrograph	1. The wear resistance of the hybrid Al7075- Al_2O_3 – B_4C composites increases with increasing Al_2O_3 weight percentage in the composite. 2. ANOVA results show that load has the highest influence followed by sliding speed and distance, both on wear rate and coefficient of friction.
12.	Al7075 – Matrix N Al_2O_3 (20-30nm)- Reinforcement N SiC (50nm)- Reinforcement Mg (micro) – Reinforcement **&** Stir Casting	Tensile - ASTM E8 Compression – ASTM E9 Hardness – ASTM E92-17 Wear Rate – ASTM G99-95 **& Composition** (Al_2O_3 + SiC) – 1,2,3,4 Wt%	1. Tensile Strength 2. Compression Test 3. Hardness Test 4. Wear Rate 6. Coefficient of Friction 7. Weight loss 5. Microstructural	1. Al composites developed by stir casting process. 2. The compressive strength, ultimate tensile strength (UTS), and hardness values increase by increasing the weight percentage of nano- Al_2O_3 and nano - SiC reinforcement. 3. XRD analysis clearly shows the presence of elemental composition and also the presence of Al, Al_2O_3, and SiC in the composite.
13.	Al6061 – Matrix SiC (20µm) – Reinforcement & Al7075 – Matrix Al_2O_3 (20µm) – Reinforcement **&** Liquid Metallurgy Technique / Stir Casting	As per ASTM Standard **& Composition** SiC – 0,2,4,6 wt% & Al_2O_3 – 0, 2,4,6 wt%	1. Density 2. Microstructure 3. Hardness 4. Tensile Strength 5. Wear Test	1. Liquid metallurgy techniques were successfully adopted in the preparation of Al6061-SiC and Al7075- Al_2O_3 composites containing the filler contents up to 6 wt %'age. 2. Microhardness and tensile strength of the composites found increased with increased filler content and the increase in hardness of Al composites. 3. The wear resistance of the composites are higher, further the SiC contributed significantly in improving the wear resistance of Al6061-SiC composites.

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14.	Al7075 – Matrix SiC (2-3 µm) – Reinforcement Electrode deposited Nickel with SiC **&** Electro codeposition	ASTM standard size : 10mm D and 20mm H **& Composition** 1. SiC without surfactant – (0,5,10,15 & 20g/L) wt% 2. SiC with surfactant(0,5,10,15, 20g/L) wt%	1. Effect of addition of SiC particles 2. Micro Structural Analysis	1. Codeposition of micro SiC of size 2-3 µm in the nickel MMC coatings were successfully performed using electro plating method. 2. The SEM micrographs were reveals the effect of the addition of SiC in the MMC coatings. The increase in concentration of SiC in the bath increases the codeposition in nickel matrix till 15 g/L concentration of SiC in the bath and it reduces beyond the optimum level. The addition of surfactant increases the codeposition and maintains the homogeneity of coating.
15.	Al7075 – Matrix SiC (20 mm average) – Reinforcement **&** Stir Casting	1. Taguchi L27 orthogonal array 2. ASTM B557M 3. Genetic Algorithm (GA) **& Composition** SiC – 10% vol.	1. Hardness (HD) 2. Ultimate Tensile Strength (UTS) 3. Friction welded joints 4. Genetic Algorithm (GA) 5. Microstructure SEM	1. The Genetic Algorithm predicted optimized process parameters of the friction welding on the AMMCs subsequently the Ultimate Tensile Strength and Hardness were experimentally found, and it showed the values with acceptable deviation. 2. Microstructure study also clearly showed that when the hardness preference was given in terms of weights a brittle failure was observed and when the Ultimate Tensile Strength was preferred then a ductile – brittle failure was observed.
16.	Al (98.41% C.P) – Matrix SiC (320 grit) – Reinforcement **&** Stir Casting	ASTM Standard **& Composition** SiC – 5,10,15,20,25 & 30 wt%	1. Hardness 2. Impact Strength 3. Micro structural	1. Study suggests that the increase in composition of SiC, an increase in hardness, impact strength and normalized displacement have been observed. 2. Homogenous dispersion of SiC particles in the Al matrix shows an increasing trend in the samples prepared by without applying stirring process, with manual stirring and with 2-Step method of stir casting technique respectively.
17.	Al– Matrix SiC (74µm below) – Reinforcement Mg (53µm above) – Reinforcement **&** Stir Casting	1. Optical microscope. 2. FV 800 Vickers hardness testing machine. 3. Computerized Instron testing machine. 4. pin-on-disc method. **& Composition** SiC – 0,5,10,20Wt%	1. Microstructures 2. Hardness 3. Tensile Strength 4. Wear Test	1. Clustering and non - homogenous dispersion of SiC particles in Al matrix were observed in the microstructures. Porosities were found in the microstructures. 2. Addition of SiC in Al matrix increased Vickers hardness and tensile strength of composites when compared with unreinforced Al. 3. The results above, SiC reinforced AMCs showed better hardness, tensile strength and wear resistance than unreinforced Al.
18.	Al6061– Matrix SiC (25 microns) – Reinforcement TiB_2 (10 microns) – Reinforcement Mg (2 grams) –	300mm length and 50mm diameter As per ASTM Standard **& Composition** SiC – 10 wt%	1. Microstructures 2. Hardness 3. Tensile Strength 4. Fracture analysis 5. Wear Test	1. Increase in weight percentage of reinforcement (SiC 10% & TiB_2 5%) leads to cluster formation. 2. It has been concluded from hardness measurement that, addition of reinforcements has effect on hardness value, but addition of TiB_2 up to 5% leads to porosity which affects hardness value. 3. Reinforcement of SiC to base metal added 20% strength to the composite but addition of TiB_2

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	Reinforcement & Stir Casting	Constant TiB_2 – 0,2.5,5 wt% Mg - 2 grams	6. S/N ratio 7. Tool wear analysis	reduction in 50 -60% strength is recorded.
19.	Al2014 – Matrix SiC – Reinforcement & Powder Metallurgy	Mathematical Calculation 1. BHN 2. Wear – Grid size 80 of 25cm length. **& Composition** SiC – 10 & 20 wt%	1. Density 2. Porosity 3. Hardness 4. Wear Testing 5. Surface Morphology	1. Wear resistance increases with increasing reinforcement. 2. With decreasing with reinforcement porosity is increases by 7% 3. With increase in BHN overall wear rate is also increases by 48% 4. The hardness value obtain is too lower than the pure aluminium specimen because of less sintering time and compaction pressure.
20.	Al-12Si (LM6) – Matrix SiC – Reinforce Sr – Reinforce & Stir Casting / Vortex method	MITITOYO, ATK-600, Hitachi S-3400 **& Composition** 1. 0.01% Sr 2. 0.02 % Sr 3. 0.5 % Sr 4. 0.02 % Sr + 10% SiC 5. 0.5 % Sr + 10% SiC	1. Hardness 2. Microstructure	1. The microstructure of the Aluminum has been changed dramatically by adding Al -10Sr. 2. The best result is obtained by adding 0.5 wt% Al-10Sr and 10 wt % SiC to Aluminum by vortex method. 3. The UTS for Aluminum increased by adding SiC and Sr.
21.	Al – Matrix SiC – Reinforcement & Stir Casting	1. CATIA and ANSYS 14.0. 2. Specimen approximately 10cm in diameter and 8cm to 10cm in height. **& Composition** SiC – 0,2.5,5,7.5,10 wt%	1. Hardness Test 2. Microstructure Test 3. Design of Spur Gear 4. Design Calculation 5. Modeling and Finite Element Analysis.	1. Hardness of Al-SiC is much better than the aluminum metal. In case of increased silicon carbide content, the hardness, and material toughness are enhanced and highest value is obtained at 10% SiC content. 2. Stir casting is more economical than powder metallurgy. 3. These composites can be used for making power transmitting elements such as gears, which are subjected to continuous loading. 4. Stress distribution obtained in FEA analysis shows highest stress value at tip of the teeth.
22.	Al6061 – Matrix SiC – Reinforcement Multiwall carbon nanotube (MWCNT) – Reinforcement &	ASTM G99-95 200mm L X 20mm D – Rod & 10mm thick X 95mm D – Plate **& Composition** SiC – 15 wt% Constant MWCNT-0,.5,1wt%	1. Hardness 2. Wear Test	1. Aluminium reinforced with SiC and MWCNT exhibits better dry abrasive wear resistance. 2. Hardness of the composites increase as the hybrid ratio increases.

	Stir Casting			
23.	Al6061 – Matrix B_4C – Reinforcement Graphite – Reinforcement **&** Stir Casting	1. 75mm X 10mm X 10mm & notch of 2mm 2. L9 Orthogonal array 3. EDM **& Composition** B_4C – 15 wt% Graphite – 5 wt%	1.Hardness 2. Micro structural Examination	1. Aluminium– B_4C –graphite composites were successfully fabricated by two step stir casting method in an economic way. 2. The distribution of graphite and boron carbide on the matrix was fairly uniform, showing a reduced porosity and a good bonding between the matrix and the reinforcements. 3. Al composites, which was machined by electric discharge machining for various parameters and levels. It is found that current and pulse on time is the most influential parameters in heat treatment.
24.	Al2219 – Matrix B_4C – Reinforcement MoS_2 – Reinforcement **&** Stir Casting	1. X – Ray powder diffraction 2. ASTM G99-95 standards 3. Optical Metallurgical Microscope. 4. ASTM E8M – 04 **& Composition** B_4C – 3 wt% Constant MoS_2 – 3,4 & 5 wt%	1. Density 2. Hardness 3. Tensile Strength 4. % Elongation 5. Wear Test 6. SEM Microstructure	1. Density increases by increasing the percentage of reinforcement material B_4C & MoS_2. 2. It can clearly show that hardness is minimum for Al alloy & maximum for Al2219 + 3%B_4C + 5%MoS_2. When we increases the % of reinforcement than hardness increases of composites. 3. The tensile strength decreases considerably due to the additions of 3%, 4% and 5% by mass of MoS_2. 4. Microstructure consists of fine dendrites of aluminium solid solution for Al2219 + 3% B_4C + 3% MoS_2 & Al2219 + 3% B_4C + 4% MoS_2.
25.	AA1060 – Matrix SiC – Reinforcement 0.3M NaCl – Solution 0.5M H_2SO_4 – Solution **&** Stir Casting	1. ASTM E8/E8M-09 5mm X 10mm X 25mm 2. ASTM E 384 10mm X 10mm X 100mm **& Composition** SiC – 7.5 wt% at Different particle size (0,3,9,29 & 45 µm)	1. Hardness 2. Tensile Test 3. Optical Microscopy Analysis	1. Electrochemical study of the effect of SiC particle size on the corrosion resistance of aluminium silicon carbide matrix composite at 7.5% SiC weight content in sulphate and chloride solutions showed the matrix composite is more corrosion resistant at the lowest and highest SiC particle sizes (3µm and 45µm). 2. Optical images showed the morphological deterioration of the matrix composite in NaCl is more concentrated compared to general surface deterioration on the morphology from H_2SO_4 solution.
26.	Al6063 – Matrix Four types of Reinforcement: 1. Mortar ash (MA) 2. Met coke ash (MCA) 3. Nano fibrillated composite (NFC) 4. Straw ash (SA)	1. ASTM A370 2. ASTM E23 3. TERCO MT 3037 Universal Testing Machine 4. WP400 Pendulum Impact Instrument **& Composition** 1. Al6063	1. Hardness 2. Tensile Stress 3. % Elongation 4. Impact Strength 5. Average chip length	1. The hardness of the MMCs is higher than Al 6063 alloy and the cast of ceramic additives MA composite increasing hardness more than the other types of MMCs due to the high atomic bonding between the atoms. 2. Experimental results show that the impact strength increased by adding MA and SA reinforcements. 3. The machinability of MMCs is different from the traditional materials because of the presence of reinforcement particles, during turning operation the surface roughness is decreased by adding NFC and MCA.

	& Stir Casting	2. + 5wt% MA 3. + 5wt% MCA 4. + 5wt% NFC 5. + 5wt% SA 6. + 5wt% MA + 5wt% MCA + 5wt% NFC + 5wt% SA		4. The advent of the importance of new agricultural waste SA in particulate form as a reinforcement for MMCs is not just of added advantage to our manufacturing industries because of its availability and low cost.
27.	Al2009 – Matrix SiC – Reinforcement **&** Wire Electric Discharge Machining	ASTM E21-09 ASTM E8-16a ASTM E23 **& Composition** SiC – 15 vol%	1.Tensile Testing 2. Impact Testing 3. Hardness 4. Micrographs	1. The effects of aging in oil and air appeared to be nearly identical. The primary deleterious effect of the observed aging was a decrease in the material's strength and hardness, whereas the elastic modulus and impact toughness of the material were unaffected. 2.It was found that an increase in aging temperature led to further decreases in hardness up to an aging temperature of approximately 290^0C
28.	Al – Matrix Groundnut shell ash (GSA- 50 µm below) – Reinforcement SiC (28 µm) – Reinforcement **&** Stir Casting	1. ASTM E 92-82 2. ASTM E8M-91 3. Emco TEST DURASCAN microhardness testing machine **& Composition** GSA and SiC with different mix ratios (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.	1. Hardness Test 2. Ultimate Tensile Strength 3. Specific Strength 4. % Elongation 5. Microstructure	1. Hardness and tensile strength increased with increasing weight percent of the reinforcing phase but the strength and hardness dropped slightly with an increase in GSA content in the reinforcing phase. 2. Percentage elongation improved marginally with increasing GSA content. The improvement did not follow a consistent trend with increasing SiC–GSA weight ratios. 3. Fracture toughness (K1C) improved with an increase in GSA content. 4. The use of GSA as complementing reinforcement is viable for the production of low-cost high performance aluminium matrix composites.
29.	Al (98.41%) – Matrix SiC (360 grit) – Reinforcement **&** Stir Casting	ASTM 262-A **& Composition** SiC – 5,10,15,20,25 & 30 wt%	1. Density 2. Hardness 3. Impact Strength 4. Corrosion Test 5. Microstructure	1. Hardness (BHN) and Density (gm/cc) increases with increasing reinforcement. 2. Impact Strength (NM) decreases with the increase in reinforced and increases with the increase in weight fraction of SiC particles. 3. Corrosion rate of Metal Matrix Composites is 4.88822 mm/month and 2307.23 miles/year. 4. Optical micrographs showed uniform distribution of SiC_p.
30.	Al6061 – Matrix Red-mud – Reinforcement **&**	L25 orthogonal array. **& Composition** Red-mud – 4,4,12,16 & 20 wt%	1.SEM 2. EDS	1. Heat treatment of the castings has been show improvement in surface properties of the heat treated samples. 2. SEM images shows that the fairly uniform

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	Stir Casting			distribution of red-mud particles in Al6061.
31.	Al6061 – Matrix Al_2O_3 (37µm) - Reinforcement Bagasse ash (37µm, 53 µm, 75µm) – Reinforcement & Stir Casting	ASTM E92 ASTM E-8 ASTM E23 **& Composition** Al_2O_3 – 5% Constant Bagasse ash – 8% wt. Constant in diff. Size (37µm, 53 µm, 75µm) respectably.	1. Hardness 2. Tensile Test 3. Impact Test 4. Optical Microscopy Analysis	1. Hybrid composites gave better mechanical properties than the base metal through the use of smaller particle sized reinforcements. 2. The microstructural images illustrated uniform distribution of the reinforcements in aluminium.
32.	Al7075 – Matrix TiC – Reinforcement MoS_2 – Reinforcement & Stir Casting	Rockwell Hardness (HRB) **& Composition** TiC – 0,2 & 4 wt% MoS_2 – 0 & 2 wt%	1. Hardness 2. Density 3. Flank wear 4. Surface roughness 5. Chip morphology 6. Microstructure	1. The hardness increased with increasing amount of TiC, since TiC is a hard ceramic material. With the addition of MoS_2 in the above AMCs, the hardness values had been reduced, which is due to the soft phase MoS_2. 2. The measured densities of TiC ceramic and MoS_2 nanoparticles are found to be more than that of base alloy. 3. Using stir casting process, the synthesized AMCs microstructures show that the TiC and MoS_2 micro particles are randomly scattered in the AA7075 matrix. 4. The AMCs have improved machinability compared with the base AA7075. 5. The surface roughness of AMCs is higher than that of the base AA7075, which is caused by the hard TiC content.
33.	AA 6351 – Matrix SiC (50 µm) – Reinforcement & Electrodischarge Machine	1.Analysis the Matlab software 2. SEM photographs **& Composition** SiC – 15% wt	1. Electrodischarge Milling (3D-EDM) 2. SEM photographs	1. The experiment involves the impact of machining parameters such as current amplitude, discharge voltage and pulse time on the machining speed and accuracy, tool wear and surface roughness. 2. Due to the application of deionized water as electrolyte, electrochemical dissolution plays an important role in material removal. **USES:** pistons, pushrods, brake rotors and components.
34.	AA2024 – Matrix SiC (2 µm) – Reinforcement & Friction Stir	1. FEA software DEFORM-3D 2. Numerical simulation **& Composition**	1. Mechanical resistance 2. Microstructure	1. The introduction of SiC powders allows the production of MMC using FSE process; 2. Excessive amount of reinforce (p>1%) causes the formation of big inter-granular conglomerate. 3. A helical material flow was found through

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	Extrusion process	SiC - 0.5, 0.75, 1, 3, 5 and 15 wt%		numerical simulation reflecting the spiral shape of the conglomerates of specimens' cross sections.
35.	Al365 – Matrix SiC – Reinforcement Graphite (Gr) – Reinforcement **&** Stir Casting	ASTM Standard SEM **& Composition** SiC – 3,6 & 9 wt% Gr – 3 wt% Constant	1. Sliding Speed on Wear Rate 2. Analysis of worm surface 3. EDS Analysis 4. Microstructure	1. SEM microscopy analysis, the wear rate of Al356-9SiC-3Gr T6 – 9hrs was found to be optimal for low sliding rate. Wear rate decreases with decrease of normal load and increase of sliding speed 2. The increase of SiC in composite material acts as load graphite particles acts as solid lubricant, combined it improves the tribological properties of the composites its use in automotive disc brakes.
36.	Al2219 – Matrix n-B_4C (30-60nm) – Reinforcement MoS_2 (600-900nm) – Reinforcement **&** Stir Casting	ASTM G99 95 Standard **& Composition** 1. Al2219 2. Al2219 + 2% n-B_4C 3. Al2219 + 2%n-B_4C + 2% MoS_2	1. Specific Wear Rate 2. Microstructure SEM	1. The specific wear rate of Al2219 is higher and for nano composites is lesser, the wear rate of Al2219+2% n- B_4C and Al2219+ 2% n- B_4C +2% MoS_2 nano composites decreases gradually by means of increasing temperature (500C to 1000C) as compared to Al2219 matrix. 2. The wear resistance of Al2219 +2% n- B_4C +2% MoS_2 is higher than Al2219+2% n-B_4C and Al2219 matrix. 3. FESEM wear debris of Al2219 shows larger wear scares, where wear debris of Al2219+2% n-B_4C shows mono-layered with lighter edges and fine particles with powder.
37.	Al7075 – Matrix B_4C (10 μm) – Reinforcement MoS_2 (2 μm) – Reinforcement **&** Stir Casting	ASTM E – 8 ASTM E9 ASTM G99 XRDA analysis **& Composition** B_4C – 4,8 & 12 wt% MoS_2 – 3 wt% Constant	1. Compressive Strength 2. Hardness 3. Tensile Strength 4. Wear resistance 5. Coefficient of friction 6. Microstructure	1. Increasing the higher percentage of multi reinforcement increases the hardness, ultimate strength and yield tensile strength of the hybrid composites. 2. B_4C increases friction coefficient. 3. The dominant wear mechanism for all specimens is abrasive of the composites. 4. The total depth of deformation of aluminum hybrid composites is smaller than the unreinforced aluminum alloy specimens.
38.	Al7075 – Matrix SiC – Reinforcement MoS_2 – Reinforcement **&** Stir Casting	ASTM Standard UTM and Rockwell Hardness testing machine **& Composition** SiC – 3, 6 & 9 wt% MoS_2 – 1% wt.	1.Tensile Test 2. Hardness	1. The Tensile test of Al7075 + 9%SiC + 1% MoS_2 has the highest strength than that of all other specimens. 2. The hardness value is also increased with increase the weight percentage of SiC. 3. The main advantage of the reinforcement is that the strain rate decreases.

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39.	Al7075 – Matrix Graphene – Reinforcement Beryl – Reinforcement & Stir Casting	Taguchi analysis and ANOVA using MINITAB software, L27 orthogonal array ASTM G99 standard **& Composition** Graphene – 0,0.5 & 1 wt%,Beryl 6 wt% Constant	1. Wear behavior 2. Signal to noise (S/N) ratio 3. Microstructure SEM	1. The ANOVA results show that the weight percentage of reinforcement is most significant parameter having the highest influence (94.50%) on the weight loss of the composites followed by load, sliding distance and sliding speed. 2. The wear of the composite decreases as the weight percentage of the reinforcement increases. 3. From S/N ratio study shows the weight percentage of reinforcement is the most influential and significant parameter in the study of wear.
40.	Al6061 – Matrix B_4C – Reinforcement & Stir Casting	1. Current 2. Pulse on time 3. pulse off time 4. X-ray Diffraction test MINITAB 16' software. **& Composition** B_4C – 10 wt%	1.MRR 2. Surface roughness 3. XRD Analysis 4. Microstructure	1. The variance analysis indicates that current and pulse on time was highly influencing parameter among other parameters in predicting the machining rate and SR. 2. Among the above three parameters with respect to MRR and surface roughness, the optimum parameters are current 240 A, Pulse on time 100 µs, Pulse off time 40 µs, and material removal rate is 0.0407 g/min and the surface finish was found out to be 2.99 mm.
41.	Al7075 – Matrix Al_2O_3 (5-10µm) - Reinforcement Hexagonal boron nitride "hBN" (5-10µm) - Reinforcement & Stir Casting	1.Automated KALPAK's UTM aided by KALPAK software. ASTM E9 ASTM G99. ASTM G65 **& Composition** Al_2O_3 – 2.5 & 5 wt% Different Composites hBN – 2.5 & 5 wt% Different Composites	1. Density 2. Hardness 3. Compressive Strength 4. Wear resistance 5. Coefficient of friction 6. Microstructure	1. With increasing the wt. % of reinforcements, the density of the composites increases. 2. For hBN composites as the reinforcement wt. % increases the density decreases, decrease in density by 2%. 3. The hardness of the composite is the highest with value of 95 BHN. It is because of the existence of hard Al_2O_3 particles. 4. SEM indicates that the failure mechanisms were network of micro-cracks, particles pull-out, and breakage of micro particles. 5. The dry sliding wear test confirms that by increasing wt. % of reinforcements, the SWR is reduced by 10% (in both filled composites).
42.	Al7050 – Matrix Graphene – Reinforcement & Stir Casting And Squeeze Casting	Taguchi analysis and ANOVA software, L27 orthogonal array Electric Discharge Machine (EDM) ASTM E8 **& Composition**	1. Hardness 2. Yield Strength 3. Tensile Strength 4. Microstructure	1. The AA7050-graphene composite was successfully produced by stir and squeeze cast techniques. Mechanical properties were increased due to the addition of graphene which act as effective reinforcement in aluminum matrix for both the processes. 2. Maximum mechanical properties are obtained with the 0.3 wt% graphene content through squeeze cast processes which also eliminated casting defects such as blow holes and porosity. 2. The analysis of squeeze cast specimen, it was noted that melting temperature is the most influencing

		Graphene – 0.3,0.5 & 0.7 wt%		parameter on tensile strength and hardness of AA7050-graphene composite.
43.	Al-LM6 – Matrix B_4C – Reinforcement Ti – Reinforcement & Stir Casting	ASTM E8M04 standards **& Composition** B_4C – 0.0,0.2,0.4 & 0.6 wt% Ti – 0.0,0.2,0.4 & 0.6 wt%	1. Micro Hardness 2. Tensile Strength 3. Wear Resistance 4. % Elongation 5. Microstructure	1. The tensile strength, hardness and wear resistance whereas percentage of elongation and wear rate were declining due to the varying load conditions. 2. In the SEM analysis it is found that the B4C and Ti particles are uniformly distributed in all weight percentages. These composites can be used in automobile, aerospace and medical applications.
44.	Al – Matrix Al_2O_3 – Reinforc MoS_2 – Reinforc & Powder Metallurgy	SEM & ASTM Standard **& Composition** 1. Al + 5% Al_2O_3 2. Al + 5% Al_2O_3 + 5% MoS_2 3. Al + 5% Al_2O_3 + 10% MoS_2	1. Wear Loss 2. Coefficient of Friction 3. Microstructure	1. The combination of Al + 5% Al_2O_3 + 5% MoS_2 has minimum wear and coefficient of friction at constant sliding speed of 0.5 m/s and constant sliding distance of 1000 m. 2. The study reveals that further addition of 10% MoS_2 in the hybrid composite does not help to improve the tribological property.
45.	Al6061 – Matrix SiC – Reinforcement Al_2O_3 – Reinforcement & Stir Casting	ASTM E-8 FIEUNT40 model UTM **& Composition** SiC – 0,5 & 10 wt% Al_2O_3 – 0,5 & 10 wt%	1. Density 2. Hardness 3. Tensile Strength 4. Yield Strength 5. Microstructure	1. The microstructure analysis, it is found that the hard ceramic particles were uniformly distributed in the metal matrix. 2. Hardness and tensile strength of the composite increases with respect to the wt% of reinforcement particle increases. Ductility of the composite reduces marginally as the reinforced increases.
46.	AA5052 – Matrix WC – Reinforcement SiC – Reinforcement Graphite (Gr) – Reinforcement & Stir Casting	ASTM A370 Standard ASTM E- 384-11 Standard **& Composition** WC – 5 & 10 wt% SiC – 5 & 10 wt% Gr – 4 wt% Constant	1. Densities 2. Micro Hardness 3. Charpy Impact Strength 4. Tensile Strength 5. Peak Elongation 6. SEM Micrograph	1. For the Al/WC/graphite hybrid composites, there was a notable increase in microhardness and Charpy impact strength as compared to Al / SiC / graphite composites. 2. It was also found from the investigations that 10% by weight of WC and 4% by weight of graphite particles could be considered as the best composition in achieving improvement in the density, microhardness, impact strength, tensile strength and peak elongation of the AA 5052 hybrid composites.
47.	Al356 – Matrix Granite (53µm) – Reinforcement Graphite (53µm) – Reinforcement	Taguchi approach ANOVA techniques “MINITAB 18” software	1. Wear Test 2. S/N Ratio 3. Coefficient of Friction	1. The coefficient of friction of Graphite and granite dust reinforced 356 aluminium alloy hybrid composite decrease with increasing the reinforcement of particles and increasing the sliding time and increases with increase in sliding time. 2. The results of S/N ratio indicate that sliding time is

	& Stir Casting	L27 orthogonal array. **& Composition** Granite – 2 & 4 wt% Graphite – 2 wt% Constant	4. Microstructure	a significant parameter on the coefficient of friction followed by load and Reinforcement. 3. SEM images explain Wear in terms of abrasive Mechanism.
48.	Al – Matrix Al_2O_3 – Reinforcement & Powder Metallurgy	Sample size is 55×8.5mm Specimen size is 14.45×8.5mm **& Composition** Al_2O_3 – 10,15,20 & 25 wt%	1. Hardness 2. Compression Strength 3. Wear Test 4. Coefficient of Friction	1. Compression strength on composites has done successfully of all the composites. 2. Hardness of material with goes on increasing with percentage of Al_2O_3. 3. Wear test of composites have done successfully by using pin on disc wear test apparatus (TR 201).

II. CONCLUSION

In this present paper investigation are Mechanical and Tribological properties obtained from different researcher in different process, reinforcement, partials size, concentration & condition ect.

- The strength of metal matrix like tensile strength increased as addition of reinforced particles but at particular percentage.
- Mostly Aluminium composite is successfully fabricated by stir casting technique, Stir casting is low cost processing technique.
- Most composite material are increased in reinforcements then increased in mechanical properties & decreased in tribological properties.

III. REFERENCES

1. S. Suresh, G. Harinath Gowd and M.L.S. Deva Kumar, “Experimental investigation on mechanical properties of Al7075/Al_2O_3/Mg NMMC’s by stir casting method” Sadhana 44:51, (2019)
2. Veeravalli Ramakoteswara Raoa, Nallu Ramanaiah, Mohammed Moulana Mohiuddin Sarcar, “Mechanical and tribological properties of AA7075–TiC metal matrix composites under heat treated (T6) and cast conditions” Jmr&t; 5(4):377–383, (2016)
3. V. Ramakoteswara Rao, N. Ramanaiah, M. Srinivasa Rao, M.M.M. Sarcar and G. Kartheek, “Optimisation of process parameters for minimum volumetric wear rate on AA7075-TiC metal matrix composite” (IJAME) Volume 13, Issue 3 pp. 3669 - 3680, December 2016
4. N.Rajesh Prabha, Dr. Edwin Raja Dhas and Visakh S, “Investigation on Optimization of Wear Properties on Aluminium Hybrid Metal Matrix using Taguchi Method” IJIET – Volume 6 Issue 3 February (2016)
5. P. Saritha, Dr. P. Ravikanth Raju, Dr .R. Venkat Reddy and S. Snehalatha, “Mechanical Behavior of Hybrid Composites” (IJMET) - Volume 9, Issue 9, pp. 71–76, September 2018
6. Ms. Kanchan A. More, Prof. Suyash Y. Pawar, “Tribological Investigation of Al7075/TiC/MoS_2 Hybrid Composite Material” (IRJET) e-ISSN: 2395-0056, Volume: 05 Issue July (2018)
7. V.Ramakoteswara Rao, N.Ramanaiah, M.M.M.Sarcar, “Optimization of Volumetric Wear Rate of AA7075-TiC Metal Matrix Composite by Using Taguchi Technique” Volume 10 Number 3, September. 2016
8. S. Devaganesh, P.K. Dinesh Kumar, N. Venkatesh, R. Balaji, “Study on the mechanical and tribological performances of hybrid SiC-Al7075 metal matrix composites” JMRTEC-1367; No. of Pages 8, (2020).

9. V. Ramakoteswara Rao, N. Ramanaiah and M. M. M. Sarcar, "Tribological properties of Aluminium Metal Matrix Composites AA7075 Reinforced with Titanium Carbide (TiC) Particles" International Journal of Advanced Science and Technology- Vol.88 pp.13-26 (2016).
10. M. Dinesh, R. Ravindran, "Tensile And Hardness Behavior of Aluminium 7075 And Zinc And Chromium Metal Matrix Composite By Stir-Casting Route" Int. Arch. App. Sci. Technol; Vol 7 [2] 39-46 June (2016).
11. S. Dhanalakshmi, N. Mohanasundararaju, P. G. Venkatakrishnan and V. Karthik, "Optimization of friction and wear behaviour of Al7075-Al_2O_3-B_4C metal matrix composites using Taguchi method" International Conference on Advances in Metallurgy, Materials and Manufacturing- 314 (2018).
12. S. Suresh, G. Harinath Gowd & M. L. S. Deva Kumar, "Mechanical and wear behavior of Al 7075/Al_2O_3/SiC/mg metal matrix nanocomposite by liquid state process" Advanced Composites and Hybrid Materials 2:530–539 (2019).
13. G. B. Veeresh Kumar, C. S. P. Rao, N. Selvaraj, M. S. Bhagyashekar, "Studies on Al6061-SiC and Al7075-Al_2O_3 Metal Matrix Composites" Journal of Materials & Materials Characterization & Enginineering Vol. 9, No.1, pp.43-55, (2010).
14. S. Pradeep Devaneyan, T.Senthilvelan, "Electro Co-deposition and Characterization of SiC in Nickel Metal Matrix Composite Coatings on Aluminium 7075" Procedia Engineering 97, 1496 – 1505 (2014)
15. K.S. Sreenivasan, S. Satish Kumar and Jeeva Katiravan, "Genetic algorithm based optimization of friction welding process parameters on AA7075-SiC composite" Engineering Science and Technology, an International Journal.
16. Manoj Singla, D. Deepak Dwivedi, Lakhvir Singh & Vikas Chawla, "Development of Aluminium Based Silicon Carbide Particulate Metal Matrix Composite" Journal of Materials & Materials Characterization & Enginineering- Vol. 8, No. 6, pp 455-467, (2009).
17. Md. Habibur Rahman, H. M. Mamun Al Rashedb, "Characterization of silicon carbide reinforced aluminum matrix Composites" ICME 2013, 103 – 109, (2014).
18. S. Johny James, K. Venkatesan, P. Kuppan, & R. Ramanujam, "Hybrid Aluminium Metal Matrix Composite Reinforced With SiC and TiB2" Procedia Engineering 97, 1018 – 1026 (2014).
19. Abhik Rathod, V. Umasankar, M. Anthony Xavior, "Evaluation of Properties for Al-SiC Reinforced Metal Matrix Composite for Brake Pads" Procedia Engineering 97, 941 – 950, (2014).
20. S. Sulaiman, Z. Marjom, M.I.S. Ismail, M.K.A. Ariffin and N. Ashrafi, "Effect of Modifier on Mechanical Properties of Aluminium Silicon Carbide (Al-SiC) Composites" Procedia Engineering 184, 773 – 777, (2017).
21. P. B. Pawar, Abhay A. Utpat, "Development of Aluminium Based Silicon Carbide Particulate Metal Matrix Composite for Spur Gear" Procedia Materials Science 6, 1150 – 1156, (2014).
22. K.R.Padmavathi, Dr. R.Ramakrishnan, "Tribological behavior of Aluminium Hybrid Metal Matrix Composite" GCMM 2014, 97, 660 – 667, (2014)
23. K. Rajkumar, S. Santosh, S. Javed Syed Ibrahim, A. Gnanavelbabu, "Effect of Electrical discharge machining parameters on microwave heat treated Aluminium-Boron carbide-Graphite composites" Procedia Engineering 97; 1543 – 1550 (2014)
24. N.G. Siddesh Kumar, V.M. Ravindranath, G.S. Shiva Shankar, "Mechanical and wear behavior of aluminium metal matrix hybrid composites" Procedia Materials Science 5, 908-917 (2014)
25. Roland Tolulope Loto, Phillip Babalola, "Electrochemical analysis of SiC composite additions at 7.5% weight content on the corrosion resistance of monolithic aluminium alloy in sulphate–chloride solution" jmr&t ; 8(3): 2517-2527 (2019)
26. Fakhir Aziz Rasul Rozhbiany, Shawnim Rashied Jalal, "Reinforcement and processing on the machinability and mechanical properties of aluminum matrix composites" jmr&t; 8(5), 4766-4777 (2019)

27. Sean Flanagan, Jeremy Main, Paul Lynch, Conner Vanderwiel, John T. Roth, "A Mechanical Evaluation of an Overaged Aluminium Metal-Matrix-Composite (2009Al/SiC/15pMMC)" Procedia Manufacturing 34, 58-64 (2019)
28. Kenneth Kanayo Alaneme, Michael Oluwatosin Bodunrin, Adebimpe A. Awe, "Microstructure, mechanical and fracture properties of groundnut shell ash and silicon carbide dispersion strengthened aluminium matrix composites" Journal of King Saud University – Engineering Sciences 30, 96-103 (2018)
29. M. Dinesh Pargunde, Prof. N. Gajanan Thokal, Prof. P. Dhanraj Tambuskar, Mr. S. Swapnil Kulkarni, "Development of Aluminium Based Metal Matrix Composite (AlSiC)" Int. J. Adv. Engg. Res. Studies/III/I/Oct.-Dec., pp: 22-25, (2013).
30. Narender Panwar, Amit Chauhan, Harveer Singh Pali, Mukund Dutt Sharma, "Fabrication of Aluminum 6061 Red-mud Composite using Stir Casting and Micro Structure Observation" Materials Today: Proceedings 21, 2014–2023 (2020)
31. Yashpal, C.S. Jawalkar, Suman Kant, Narender Panwar, Mukund Dutt Sharma, Harveer Singh Pali, "Effect of Particle Size Variation of Bagasse Ash on Mechanical Properties of Aluminium Hybrid Metal Matrix Composites" Materials Today: Proceedings 21, 2024–2029 (2020)
32. Anvesh Dhulipalla, Budireddy Uday Kumar, Varupula Akhil, Jian Zhang, Zhe Lu, Hye-Yeong Park, Yeon-Gil Jung, Jing Zhang, "Synthesis and machining characteristics of novel TiC ceramic and MoS_2 soft particulate reinforced aluminium alloy 7075 matrix composites" Society of Manufacturing Engineers (SME), (2020)
33. Sebastian Skoczypiec, Wojciech Bizon, Anna Podolak-Lejtas, "Selected Aspects of Electro - discharge Milling of Aluminum Alloy-Based Metal Matrix Composite with SiC Reinforcement" Procedia Manufacturing 47, 795–798 (2020)
34. Dario Baffari, Gianluca Buffa, Davide Campanella, Livan Fratini, "Al-SiC Metal Matrix Composite production through Friction Stir Extrusion of aluminum chips" Procedia Engineering 207, 419–424 (2017)
35. H.S. Balasubramanya, J. Sharana Basavaraja, S. Srinivas, V. Ravi Kumar, "Wear rate behavior of As-cast and heat treated hybrid Aluminium Metal Matrix Composites" Procedia Materials Science 5, 1049-1055 (2014)
36. N.G. Siddesh Kumar, R. Suresh, G.S. Shiva Shankar, "High Temperature Wear Behavior of Al2219 / n-B_4C / MoS_2 Hybrid Metal Matrix Composites" Elsevier (2020)
37. Shoufa Liu, Yinwei Wang, T. Muthuramalingam, G. Anbuchezhiyan, "Effect of B_4C and MoS_2 reinforcement on micro structure and wear properties of aluminum hybrid composite for automotive applications" Composite Part B 176, 107329 (2019)
38. K. Maruthi Varun, R. Raman Goud, "Investigation of mechanical properties of Al 7075 / SiC / MoS_2 hybrid composite" Materials Today: Proceedings (2019)
39. Shanawaz Patil, Mohamed Haneef, Seenappa, "A statistical analysis of optimization of wear behavior of Al7075-Beryl-Graphene hybrid composites using Taguchi technique" Materials Today: Proceedings (2019)
40. K. Raju, M. Balakrishnan, "Experimental study and analysis of operating parameters in wire EDM process of aluminium metal matrix composites" Materials Today: Proceedings (2019)
41. S. Rakshath, B. Suresha, R. Sasi Kumar, I. Saravanan, "Dry sliding and abrasive wear behavior of Al-7075 reinforced with alumina and boron nitride particulates" Materials Today: Proceedings (2019)
42. S. Venkatesan, M. Anthony Xavior, "Characterization on Aluminium Alloy 7075 Metal Matrix Composite Reinforcement with Graphene Nanoparticles" Procedia Manufacturing 30, 120–127 (2019)
43. Prabhu Rubesh George, I. Kantharaj, S. Mohanasundaram, G. Babu Rao, "Experimental Investigation on the Mechanical Properties of LM6 Aluminium Alloy Reinforced with Boron Carbide And Titanium Hybrid Composites" (IJMET) Volume 10, pp. 1584–1593, Issue 02, February (2019)
44. K. Kanthavel, K.R. Sumesh, P. Saravanakumar, "Study of tribological properties on Al/Al2O3/MoS2 hybrid composite processed by powder metallurgy" Alexandria Engineering Journal (2016)
45. M. Satheesh, M. Pugazhvadivu, "Comparative Study on Mechanical Properties of SiC and Al_2O_3 Reinforced in Al6061 Matrix by Stir casting" International Journal of Scientific Research in Physics and Applied Sciences; Vol.6, Issue.5, pp.01-06, October (2018)
46. D.S. Ebenezer Jacob Dhas, C. Velmurugan, K. Leo Dev Wins, K.P. BoopathiRaja, "Effect of tungsten carbide, silicon carbide and graphite particulates on the mechanical and microstructural characteristics of AA 5052 hybrid composites" Ceramics International 45, 614-621 (2019)

ISSN- 2394-5125 VOL 7, ISSUE 15, 2020

47. Tirlangi Satyanarayana, Putti Srinivasa Rao, M. Gopi Krishna, "Influence of wear parameters on friction performance of A356 aluminum – graphite/ granite particles reinforced metal matrix hybrid composites" Heliyon 5; e01770 (2019)
48. A. Sabiha khathun, P.N.S.Srinivas, Dr. P. Ravindra Babu, "Experimental Investigation of Mechanical and Tribological properties of Aluminum Metal Matrix Composite (MMC) Reinforced with Alumina (Al2O3) using powder metallurgical Process" IJARSET; vol. 5, Issue 5, May (2018)