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Study on Mechanical Behavior of Aluminum Alloy 6061 Based Composites a Review

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Abstract: *This paper present the brief review on mechanical behavior of aluminium 6061 based composite. The aluminum alloy 6061 based composite attain different properties with addition of different type of reinforcement. Various researchers done the experiments with adding different types of reinforcement material and attains different property. These composite has high strength and stiffness to weight ratio. The fabricated composite may be used for light weight and high strength applications. Every researchers draw different conclusions. Most of researchers concluded that when the weight % of reinforcement increases in base metal, the mechanical properties of composites like hardness, compressive strength and tensile strength increases. The various researchers observed the surfaces of fabricated sample on Scanning Electron Microscopy.*

Keywords: Al alloy 6061, Reinforcement material, Hardness, Tensile strength, Compressive strength, SEM

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I. Introduction

Aluminium matrix composites are metals reinforced with other metal or organic compound. B_4C, SiC, Al_2O_3 and fly ash are usually used to improve the properties of the base metal like strength, stiffness conductivity etc. fibers are the important reinforcement.BLA, fly ash, RHA are some common reinforcement which used to improves the properties of the matrix composites [1].The various applications of composite material can be seen as automotive parts, Mining equipment, thin and thick cylinder structural component, tool for cutting and the dies which are used for extrusion.[2].Hybrid Aluminium matrix composite consists more than one type of reinforcements. In the hybrid composite we used one ceramic and a natural fibre to reduce the cost of composite. The paper examine the various factor like

(a) Effect of various reinforcement
(b) Mechanical behaviour like tensile strength, hardness, compressive strength
(c) Processing methodology and its effect
(d) Application of AMC with various reinforcements [3].

II. Review Literature

In the automotive industries aluminum alloys are frequently used because of lower density, light in weight. The other properties of aluminum alloys are that these are high in electrical and thermal conductivity and having good corrosion resistance, malleable in nature and formability is also good. The workability and inability of high performance Al alloys are horizontal to porosity due to gases dissolved during melting processes. The engineering application of pure aluminium and its alloys have occurred some problems like low strength, unstable mechanical properties etc. Hence by the modification of microstructure, mechanical properties of alloying, cold working, heat treatment and making composite by the addition of reinforcement can be improved. It will found that the effect of reinforcements on microstructures and mechanical properties of base alloys.

Kandpal and Singh [4] have proposed a method using stir casting technique in which fabricated aluminium alloy 6061 reinforced with different percentages of Al_2O_3 particles at wt. 5%, 10%, 15% and 20% was used.SEM techniques were used to study the microstructure of AMMC. It was found that with addition in wt. % of Al_2O_3, microhardness, tensile and compression strength is also increased.

Alaneme and Olubambi [5] have developed matrix hybrid composite by studying the corrosion and wear behavior of Al-Mg-Si alloy with the use of rice husk ash (RHA) and alumina as reinforcements. Weight

percentage of 2, 3, and 4 of alumina was added in the composite. Further using double stir casting process, the 10 wt. % of reinforcing phase with Al–Mg–Si alloy as matrix were prepared by utilizing the RHA. By making a comparison, it was found that single reinforced Al-Mg-Si with 10 wt. % Alumina was much superior to the hybrid composites in 3.5% NaCl solution and also by increasing the wt. % RHA the corrosion rate were increased.

Kumar and Xaviour [6] synthesized and performed the characterization of Al 6061 matrix by using nanocomposites. In the aluminium matrix, the reinforcement were used was Graphene with various wt. % i.e., 0.25, 0.5, 0.75 and 1 given in percentage. By using the method of ultrasonic liquid processing, the uniform dispersion of Graphene in the mixture is carried out and also powder metallurgy (PM) approach followed by XRD and SEM analysis were used to strengthen the mixtures. Thus the prepared mixture are molded at different temperature and investigation of Graphene weight proportion and sintering hotness was done on mechanical properties like micro hardness, density.

Pramanik [7] has analyzed the wear parameter like sliding distance, pressure, sliding speed of Al 6061/Al2O3 composite. A pin-on-disc wear machine was used for the wear study. A steel made disc was used. Investigated study shows that the composite used in this research work had much higher wear resistance as compared to the corresponding matrix materials.

Khalil et al. [8] reviewed the current developments on bamboo fibre based reinforced composites. The materials are utilized in composite as reinforcement was bamboo fibres. The bamboo fibre, which is stronger than the other fibres were used as raw material in product designing and used for generating high quality sustainable products.

Rhee et al. [9] analyzed the evolution of aluminium metal matrix metallic composites of micro structural were fabricated under the different processing conditions to get the knowledge of their process, structure and property relationship. The composites were the combination of matrix 1050 and 6061 aluminium alloys having a varying wt. %. The mechanical response of the mixture found in this research work were compared to the pre-extruded 1050 and 6061 aluminium alloys. It was found that the yielded strengths of each combination or composite having varying weight percentage were laid between those of matrix and reinforcement alloys.

Qua et al. [10] have proposed a method which forming a composite surface layer on aluminium by using solid state surface engineering technique. In this method hardness, wear resistance were improved without ductility and conductivity of bulk. To form a composite layer of up to 3mm thickness friction stir process utilized for mix and to stir the sub-micro -size alumina, silicon carbide particle into surface of Al6061- $T_6$51 plate. Hard phase concentration was ranges between 20-30 vol. percent. The reduction in substantial friction and wear by 40% and 90% was exhibited by the composite surface formed from FSP as compared to a non processed aluminium surface respectively.

Anil Kumar et al. [11] investigated mechanical properties of combination fly ash and aluminium alloy (Al6061).The stir casting used for processing the samples. The sizes of particle are 4-25, 45-50 and 75-100 μm having three sets of composites were used. The mechanical properties were studied in this research. Also for the same properties, the Unreinforced Al6061 samples were tested. By increasing the size of fly ash particle, decrease in mechanical properties of the aluminium alloy (Al6061) composite were found.

Bharath et al. [12] synthesized metal composite using Al 6061 with ceramic Al2O3 particulates using stir casting technique. To improve wet ability and distribution, reinforcement particles of each composite preheated at a room temperature of 200°C and the vortex of molten were dispersed in steps of three. Micro structural characterization was carried. The tests are conducted before and after the addition of reinforcement.

Kini et al. [13] proposed stir casting technique to fabricated hybrid composite. The Al 6061 matrix with reinforcement materials such as alumina and silicon carbide was used. The alumina weight percent was2 to 4% and the silicon carbide weight fraction is constant at 2%.Hardness and wear tests are performed. Wear resistance increased with the increase in alumina was found in this work.

Gurcan and Baker [14] have proposed a method in which the wear resistance of four AA6061 MMCs together withthe monolithic Al6061 is investigated. In the T_6 Condition all the obtained samples were studied. Pin-on-disc test was done on wear resistance. It was found that hybrid and the AA6061 with 60% silicon carbide had best performance compared to other method.

Kalaiselvan et al. [15] fabricated the aluminium (Al 6061-T_6) matrix composites reinforced with different fraction of B_4C particulates by modified stir casting k_2TiF_6 flux used for improving the wet ability. After the fabrication of AMCs the microstructure and mechanical properties are analyzed. Homogeneous dispersion and reinforcement dispersion are analyzed with the help of SEM and XRD. The mechanical properties have improved with the increase in weight fraction ofB_4C particulates in the aluminium matrix.

Reddy and Zitoun [16] analyzed the various properties of matrix composites. Alumina particulates were used as reinforced in Al 6061, Al 6063 and Al 7072 matrix alloys. Authors had made a comparison in Al 6061, Al 6063 and Al 7072 matrix alloys in decreasing order of their calculated properties such as strength, ultimate strength and ductility of Al/Al_2O_3 metal matrix composites. The Mg content in the matrix alloys was highly reactive with alumina. The fracture mode was mostly ductile in nature.

Shankar et al. [17].discussed the comprise effect of reinforcements on Aluminum Metal Matrix Composites was studied. It was found by reviewing various literatures that, there was improvement in material properties used for different applications and also the liquid metal processing technique found very important in manufacturing if metal matrix composites.

Anil and Kulkarni [18] fabricated Al alloy with fly ash composition of 9%, 12% and 15% weight fraction and Alumina (Al2O3) with 6% weight fraction using vortex casting. Particulate distribution observed by SEM and EDS. It was observed that composite with 6% Al_2O_3 and 15% fly ash has good fatigue life and mechanical properties compared with molithic alloy.

Ramesh et al. [19] developed situ composites by using the technique liquid metallurgy .Al-10% Ti and Al-3% B are used as reinforcements and the fabrication of Al-6061-TiB_2 takes place by the liquid metallurgy where Al 6061 was the base metal .After the fabrication of composite XRD,EDAX analysis metallographic studies , microhardness and mechanical tests are performed. The properties of fabricated composite increases in comparison to base alloy.

Sarada et al. [20] produced hybrid composite of (LM+activated, carban +Mica) by using the stir casting technique. And this hybrid composite compared with the other two composites which are (LM 25 + activated carban) and in the other composite the reinforcement is Mica. Abrasive test wear testing machine was used for the hardness test and wear properties. Wear process and wear loss checked the proper distribution of reinforcement in the composite.

Kumar et al. [21] fabricated Al6061 with silicon carbide and alumina composites using the liquid metallurgy technique. The variation in wt% was 2-6%.Castings of the composite materials was carefully maintained to prepare the test specimen for several tests. The reinforcement improving the hardness .The microphotograph shows the proper distribution of the particle in the matrix system. Tensile strength of the composites also increases due to addition of SiC and Al_2O_3.

Alaneme et al. [22] investigated Al matrix with silicon carbide and bamboo leaf ash. Two step stir casting method was used.10 wt % phase with aluminum –mg- silicon alloy and 0,2 3 and 4 wt fraction of bamboo leaf ash were utilized. It was observed that the mechanical properties of hybrid composites decreased with increase in bamboo leaf ash. Corrosion resistance of 2 and 3 wt% of bamboo leaf have higher values than the single reinforced aluminium. And this was reverse in 0.3 M hydrogen sulphide solution.

Baradeswaran and Perumal [23] investigated Al alloy 7075–graphite composites forits tribological and mechanical behavior under the condition of dry sliding. Conventional liquid technique was used for the manufacturing of composite which was subjected to T_6 heat treatment. In dry sliding condition reinforcement content was taken as 5, 10, 15 and 20 wt.% of graphite to identify the potential for self-lubricating property. With the addition of graphite content wear rate decreases and reaches at 5 wt. % graphite.

Deaquino et al. [24] wear method at a 0.367 m/s sliding velocity. The applied load was 20 N and 40N.SEM was used to determine the worn surface. By the addition of 1.5% graphite and 10 hr of milling the hardness and wear resistance of AMC improved. The distribution of reinforcement was found homogeneous in the composite material.

Mindivan et al. [25] studied the tribological behavior of Al alloy of the grade 2618, 6082, 7012,and 7075) all

these alloys are squeezed cast. And reinforced with SiC particle (50 vol%). The 10mm diameter Al_2O_3 ball rubbing for the wear test. This was observed that at low test load the tribological performance of the composites was not influenced by the properties aluminium base alloy.

Khorasani1 et al. [26] predicted the tool life during milling process of Al alloys. The optimization was based on three main parameters composed of cutting speed, feed rate and depth of cut. The aim of this study was to discover the role of parameters in tool life prediction in milling operations by using artificial neural networks and Taguchi design of experiment.

Kumar and Chauhan [27] investigated the effect on cutting parameter of roughness in turning Alluminium alloy7075 of hard ceramic composite 10 wt.% Silicon Carbide, where Al Alloy 7075 hybrid composite 7 wt.% Silicon carbide and 3 wt.% by graphite using diamond tool of polycrystalline. Dry turning were determine trend of roughness using roughness tester of both composite cutting speed at 80–170 m/min, 0.05–0.2 mm/rev feed rate, approach angle 45–90°. This was found the surface roughness of hybrid composite (7 wt. % Silicon Carbide and 3 wt. % of graphite) lower than the hard ceramic composite (10 wt. % Silicon Carbide) for all combination of experiment.

Verma et al. [28] fabricated Al7075-B4C-RHA hybrid composite. SEM was used to study the surfaces of fabricated composite. It was found that the hardness increases with increase in wt.% of B4C as well as RHA. The results of SEM were revealed that there was uniform distribution of reinforcement in aluminum matrix alloy.

Verma et al. [29] reviewed the effect of addition of various reinforcement in Al 6061 and Al7075 matrix alloys. It was found that stir casting is best technique for fabrication of metal matrix composite.

Verma and Vettivel [30] used two levels factorial design to fabricate Al7075-B4C-RHA hybrid composite. They also study the fractograhy of fractured samples.

III. Conclusions and Future Scope

The following inferences are drawn by reviewing the above mentioned literature:-.

1. Stir casting method is best for adding reinforcement in order to avoid porosity, agglomerations and does not damage the reinforcement.
2. The method of stir casting was successfully use to manufacture the Al 6061composite with proper allocationof particle in the Al matrix composite.
3. The mechanical properties of composite material like compressive strength, hardness, tensile strength enhances because of adding various reinforcement like B_4C, SiC, Al_2O_3, Bamboo leaf and Rice Husk Ash etc. The properties of composite increases by using more than one reinforcement. That type of composite are called as hybrid composite.
4. Weight percentage of reinforcement is considered as primary parameter to control the mechanical properties.
5. In this paper we reviewed the superior properties of composites by adding more than one reinforcement. Those composites are called hybrid composites.
6. Variousreinforcement effect on AA 6061 composite can be studied.
7. The percentage of reinforcement can be optimized by different optimization technique like RSM, Taguchi and ANN etc.
8. The cryogenic treatment can be performed on composite and mechanical behaviour can be studied.

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