A short review on Al MMC with reinforcement effects on their mechanical properties.

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Abstract

This paper deals with the value of composites as engineering materials which is shown by the researchers. The composite is one of the most important and popular material is available in the market. The reinforcement of one or more metals with base material leads to an improvement in its properties of base metal. Many researchers are doing lot many combination for getting the best quality of composite in the form of MMC. In order to overcome the barriers of conventional materials the MMCs plays an important role, in applications like automobile industries, aerospace, defence and thermal management systems.The required properties of material for any special application we can produce or created by the help of Metal Matrix Composite. The use of MMCs in various applications have been increased due to availability of these materials at lower cost. In order to exploit needful physical and mechanical properties Al is reinforcement with different materials. The literature review with respect to current aspect of study in Metal Matrix Composite the base metal is Aluminium 6061 has maximum applications which is reinforced byzircon, Alumina, red mud,silicon carbide,fly ash and boron carbideetc. The reinforcement of material is depend on the needful Mechanical and tribological properties. These properties can be enhanced with the use of reinforced material of suitable size and composition.The detailed discussion of those properties are given in this article.

Keywords:MMCs,reinforcement, Al6061,stir casting, wear

1. Introduction

The industry requires the materials that are stronger, lighter and less expensive. The running industry need to fulfill the requirement of new material is Metal Matrix Composite is available in the market. The metal matrix composites (MMCs), like all other composites consist of at least two chemically and physically distinct phases, suitably distributed to provide properties not obtainable with either of the individual phases. For many researches the term MMCs is often equated with the term light metal matrix composites. Aluminum matrix composites (AMCs) are the competent material in the industrial world. Due to its excellent mechanical properties, it is widely used in aerospace, automobiles, marine etc. The aluminum matrix is getting strengthened when it is reinforced with the hard ceramic particles like SiC, Al2O3, and B4C etc. Aluminium alloys are still the subjects of intense studies, as their low density gives additional advantages in several applications. These alloys have started to replace cast iron and bronze to manufacture

wear resistance parts.[1]In comparison to Al alloy and single reinforced metal matrix composites, it has been found that there are various improvements in various properties of hybrid composite with respect to its hardness, reduced porosity and impact energy. As far as the tensile strength and modulus are concerned hybrid composites (B50A50) shown 40% of tensile strength and 52.12% of modulus more than Al reinforced alloy. As well as there is an improvement of 105.72% in flexural strength with a reduction of 23.88 % in impact energy in hybrid composite (B50A50) as compared to Al alloy. This hybrid MMCs are more suitable and recommended further for use in construction and automobile sectors.[2]By applying the stir casting process developed the Al6061 with SiC, for varying wt%of reinforcement. The results are shown that stir casting is good option for developing the hybrid composite. As per experiment the better results are shown by Microstructure of composite at combination of 6% B4C along with 6% of SiC. The B4C wt% parameter shows the improvement in tensile strength it conclude that B4C plays a vital role in improvement. The material becomes brittle by adding more wt% of B4C. [3] Stir casting is a method which is easy to use for composite production and also lower cost of processing. This process is easier control of matrix structure and also gets proper matrix particle bonding by the stirring action.The researcher reported that by selecting the proper parameters of stirring time, speed, mould preheating temperature, temp. of molten metal and feed rate of the particles reflects on preparation of homogeneous mixture as well as effective output in wetting.[4]Hammar Ilham Akbar,et al.experimented on reinforcement material effect and also in consideration with cost of material. For the experiment uses the natural available materials as well waste as a reinforcement shows better result along with Al MMC. In his experimentation uses Sea sand with the combination of ceramic or oxide compounds. Result shown the higher porosity and density shown by using natural reinforced particle as compared with metals as well as improved mechanical properties.[5]

2. Reinforcements effect on mechanical properties of composites

Most of work is carried on composite reinforcement for the reinforcing the particles uses Alumina, Silicon carbide, AIN, Boron Carbide, fly ash, steel fibers in the base of Al6061. The experiment carried on enhancement in mechanical properties likeductility, hardness and tensile strength. The various types of MMC are to be prepared with the different reinforcements along with the Properties and application of derived materials. As a result, many parts are too manufactured by using the composite materials such as automobiles pistons, airplane body and cylinder liners, etc.

2.1 Hardness

M. Karbalaei Akbari et al. worked on that effective propertiesof composite were hardness and tensile tests is investigated by the effect of various mixed materials in matrix and defined optimized stirring process parameters. M. Karbalaei Akbari et al. concluded that the use of nano particles in Al MMC shown great enhancement in mechanical properties. By increasing the stirring time may get decreases the mechanical properties. As per the microstructural characterization it shows the use of nano particles of a reinforcement materials gives uniform distribution and grain refinement of matrix. The variations in porosity content impacts on the mechanical properties of composite. As per stirring process concerns, process time longer reflects the destructive effect of tensile performance of the composites. [6]M. Kok investigated that by using vortex fabrication method along with incremented applied pressure on the different

sizes and weight fractions of Al2O3 particles up to 30 wt%. Investigation held on theproperties of mechanical, density, porosityand SEM microstructure of the composite and came to conclusion that composite of varying size and varying percentage of particles fabricated successfully and SEM observations shown the particle dispersed more uniformly. The density is increased with increasing weight percentage while porosity increased with decreasing size of particles and increasing weight of particles. It shown that by gradual applied pressure it reflects improvement in wettability and bonding force but decrease in porosity also increased in mechanical properties.[7]Utkarsh Pandey et al. studied that strength of MMC is depends on the reinforcement interfaces. The stronger interfacial bond is expected because the weak interface can fail by applied load whose transfer in matrix and reinforcement. The study found that the ultrasonic stir casting processis improved distribution and wettability of particles as well asthe mechanical properties gets improved as compared to other methods.[8]Ozben et al. stated that to enhance the hardness,tensile strength and density needs to uses the higher reinforcement but due to that he shown the impact toughness gets reduces.[9]Ramanathan Arunachalam et al. has study the experiment on significant attributes of casting processes and suggest for the furnace design, matrix selection and reinforcedparticles/materials, processing parameters and adding additives. As per various experimentation conclude that in the squeezing pressure is most influencing parameter in squeeze casting process which influences the mechanical properties. SiC, Al2O3, and B4C reinforcement particles are the mostly used because of their ability to provide better mechanical properties such as strength and hardness as well Mg is used to enhancingwetting property of the composite. [10]

M. Satheesh et al. prepare the hybrid composite of Al6061 along with Sic and CSA. The Figure01 shows the densities of Al6061 and composites, The density of composite increased due to addition of higher density of SiC particles compared with Al6061. It has been seen that CSA particle density is lower as compared to Al and SiC. The combination of Al6061, SiC and CSA is impacted on the density by varying the percentage of particles such as Al6061–SiC composite density decreases by 1.11%,2.68%,4.39%,5.87% and 6.58% by addition of CSA particle from 2 to 10 wt%, resptly. Figure2 displays the hardness values of Al6061 and it's composite. The hardness increases by the increments in wt% of CSA and SiC. The increment of 2 wt% in Al6061 and SiC in the increasing 2 to 8 wt% of CSA content shows the result in hardness increments by 31.5%, 36%, 39% and 46%, resptly. As per result, output shows that the hardness of hybrid composites is improved by addition of Sic and CSA. [11]

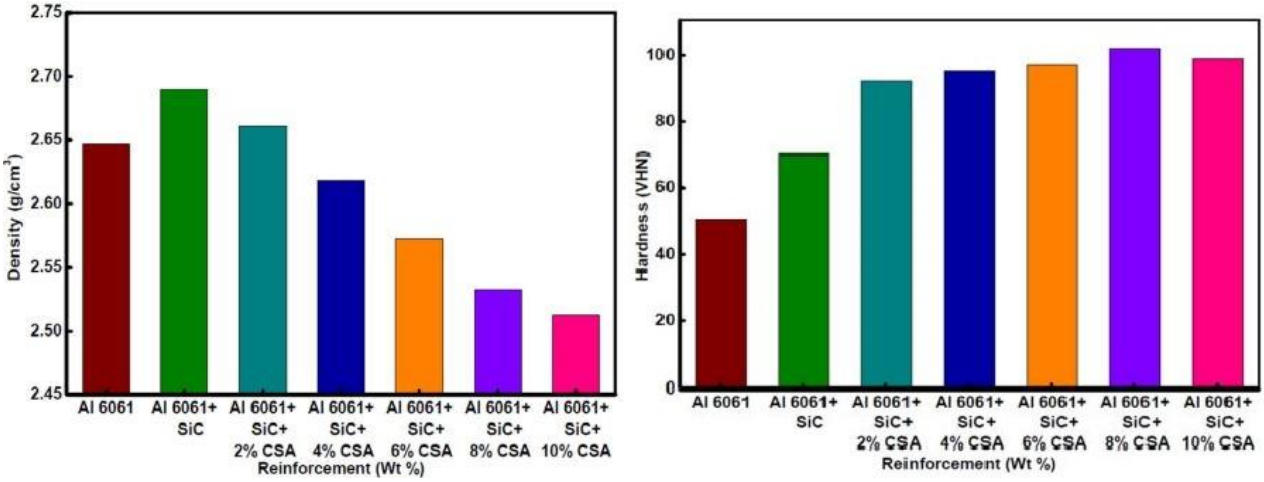

Fig1:Density of Al6061 and its composite[11] Fig2:Hardness of Al6061 and its composite[11]

2.2 Tensile Strength

The tensile properties of any composite is elaborated by its strength, modulus and elongation at its break of the composite. In these study composite isprepared in the combination of Al6061 and the hybrid composite with CSA. P. Lakshmikanthana noted that by gradually adding the weight percentage of CSA it shown the improvement in tensile strength. The number of experimentation shown that it improvementup to 6% and then decreases. [12]The evaluation shows that Al6061 composite of tensile strength. By addition of CSA the tensile strength of hybrid composite is increased. The incremented addition of CSA by2% to 8 wt% compared to that of Al6061-SiC composite the tensile strength is increases by 13.13%, 28.15%, 36.44% and 47.31% respectively. This is due to equallydistributonof CSA particles in the matrix. Satheesh and Pugazhvadivu researched, shown that the more addition of CSA percentage tensile strength goes to decrement as compared with Al6061-SiC–8% CSA composite. Due to decrement in tensile strength the Agglomeration and void are formed. [11] C. R. Raajeshkrishna1 et al. worked on the composite of glass and basalt epoxy prepared by following the method of hand layup (HLC). The result is improvement in tensile strength of basalt epoxy than glass epoxy composites. Also concluded that it has superior mechanical properties as that of glass-epoxy composite.[13]Recep Çalin et al. stated that R –V ratio is helpful for influencing the mechanical properties. [14]S. Gopalakrishnan et al. experiments on the Al MMC with reinforcement of titanium carbide (Al–TiCp) by applying stir casting process. The result shows that Al-TiCp composite with various volume concentration of TiC is an enhanced stir casting method in the atmosphere of an argon. It is observed that the higher the % of TiC the specific strength increases. The various percentage of reinforced material in AMMC impacts on tensile strength and ductility shown in the Figure 03(a), and also reduce the elongation percentage by addition of TiC in the composite shown in the Figure 03(b) [15].

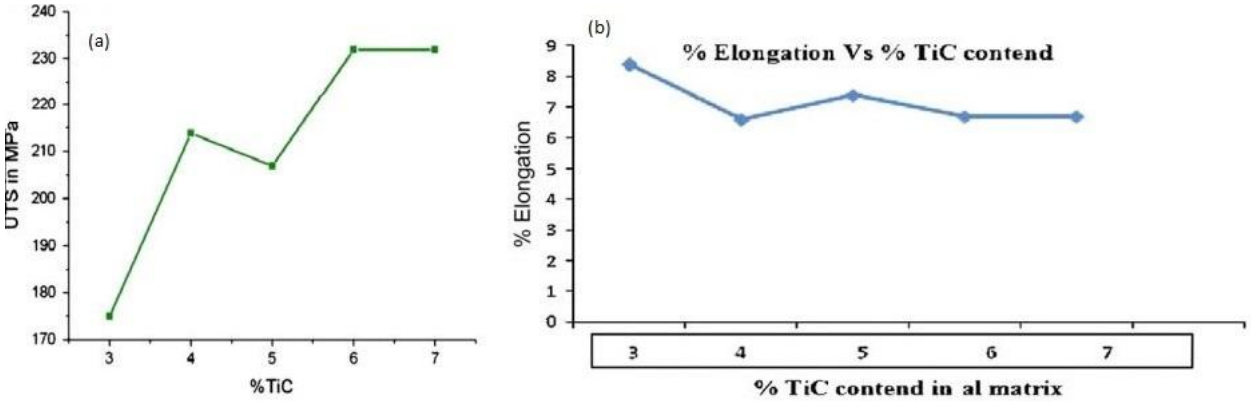

Fig3: TiCreinforcement effect on (a) tensile strength; (b) ductility [15]

R. V. Nikhil Santosh et al. fabricated the Al 6063 in the addition of Silicon Carbide 2% by using stir casting to enhancement mechanical properties in that the Graphite percentage is incremented as 1%,2%,and 3%. It seen that with no graphiteacts on tensile strength is improved by 57.5% in compression and addition of 3% graphite the tensile strength is decreased. The adding 2% of graphite the CS increased by 21.4% but tensile reduced at 3% of graphite. Similarly the increases the flexural strength by 125.3% and reduced by 3 wt% of graphite. The graphite percentage vary from 0 to 2% the hardness increases from 42 to 55.9. The graphite percentage increases the strength and hardness decreases so it is noted that more graphite content in not beneficial. [16]Ch.Saikrupa et al. stated that near about 30% hardness increased in MMC. In base aluminium alloy the Tensile strength properties almost improved by double. [17]

2.3 Compressive Strength

The Aluminium with red mud used for mechanical characterizations like hardness and compression strength. Results shows the compression strength and increaseshardness with adding the weight % of red mud. Nano level of aluminium-red mud specially used for improvement in result. Neelima Devi Chinta et al. experiment on red mud powder and aluminium, the size of red mud particles is 100.00, 150.00 and 200.00 at micron level and 42.00 at nano level along with 2%, 4%, and 6% wt fractions and by using sintering processsamples are prepared. The results are examined by applying Deform-2D software technique.[18] Saravanan et al. studied that reinforcement of rice husk with aluminium by the wt % of 9 to 12 the compressive strength is increased. [19]Arvind M. Sankhla et al. experimented on Aluminium MMC with SiC by using the powder metallurgy technique for investigation on hardness and compressive strength. The hardness and compressive strength improved by using barrel mixer. The work hardening effect is greater by small particles as compared to coarse. Due to that finer MMC particles shows high strength shown in Figure 04. Barrel mixer improves the high quality mixing in minimum time also seen that equally dispersion of SiC, in every area and hard particles are bonded by soft matrix. So that it reflects the improvement in compressive strength and hardness of composite. [20]

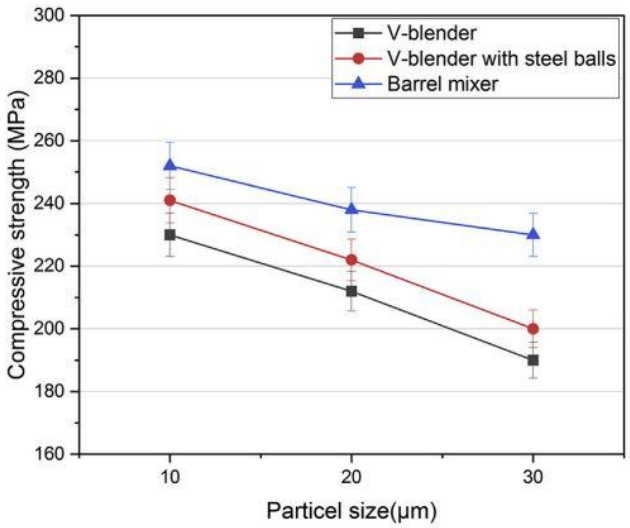

Fig4: Impact of particle size on compressive strength of Al-MMC [20]

3. Tribological Studies of Al MMC.

As per the Tribological studies it contains wear, friction and lubrication. In the metal matrix the Aluminium is uses as base metal and is reinforced by various materials are as Alumina, Silicon Carbide, TiC, and Boron Carbide. Aluminium has an excellent Tribological qualities so that it mostly uses in high friction environments. D. Suja experimented on Aluminium and the reinforcement with SiC and Al2O3 so result shows that Al + SiC have less wear rate as compared with Al+Al2O3. [21] S. Gopalakrishnan worked on Al matrix reinforced with TiC, improvementin various characteristics like strength,wear and high temperature. Also analyzed dry sliding wear behavior by using pin on disc wear also used friction monitor. The result shows better enhancement in the specific strength as well in wear resistance. The effect of TiC reinforcement the composite made byusing melt reaction method and it displays that wear rate decreases as compared to previous one.[15] G.B. Veeresh Kumar et al. experiments on Al6061-SiC composite for mechanical and Tribological properties. Using liquid metallurgy method prepare the composite of Al6061 with the combination of 2-6 wt% SiC. The result shows that addition of SiC improve the Density, hardness, ultimate tensile strength and reduces the composite ductility. Finally is has been concluded that mechanical as well as Tribological properties has been shown superior in Al6061 – 6 wt% SiC composite and shows less wear loss. Figure 5 shows the condition on applied load 60N and sliding distance 6km of the worn-out surface of cast Al6061 alloy and filled SiC composite. In the wear test images shows the available of wear form particle withabrasive and adhesive wear along with plastic shearing of the asperities. The load goes on increasing the degree of grooves are formed and composite impose lesser volume fractions of SiC paricles are sizeable and improve the plastic deformation which leads to high wear. [22]Shoufa Liu et al. analyzed the composite properties, micro structural analysis and Tribological behavior of Al 7075 by adding B4C and MoS2 hybrid composite by using stir casting method. In this MoS2 is used as a lubricant under different percentages 4%, 8% and 12%. As per the investigation it shown that the particles are distributed uniformly. Adding the harder reinforcement SiC and MoS2 in higher wt% increases the hardness,yield tensile strengthandultimate strength of composite compared to monolithic alloy. By following the pin-on-disc wear test at room temperature, initial wear is increasesin the absence of roughness projections on reinforcement particles. Further increasing the applied stress, matrix material roughness is deformed and particles touches the counter face and pin face due to that particles was crushed and protecting layer is formed this reduces the wear rate. For various acting load of 10,20 and 30 N respectively friction coefficients of B4C reinforcement are maintained withinrange of 0.48-0.49. While applied load the friction coefficient of the reinforced composite is higher than unreinforced Al7075 alloy. SEM micrographs are presented for the applied of 10N load on Aluminium hybrid composite in Figure 5 and un-reinforcement shows deep grooving.[23]

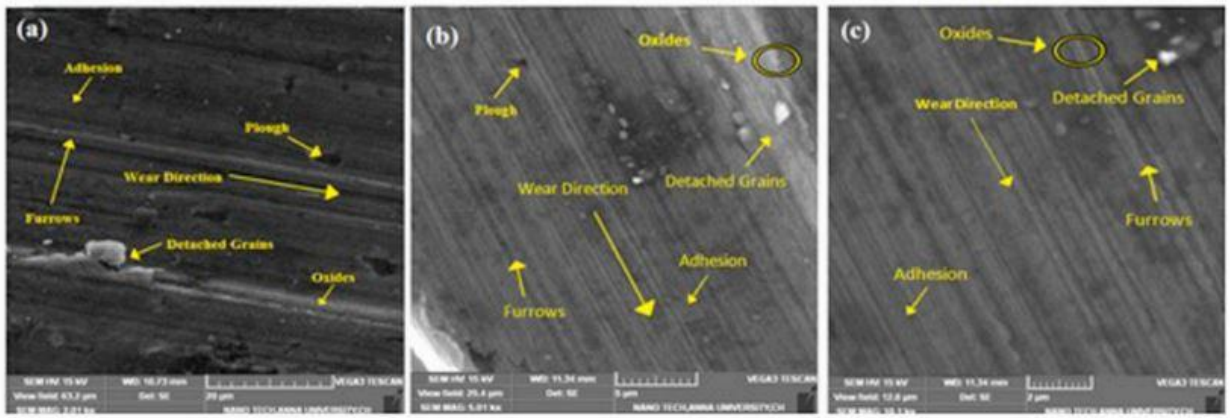

Fig 05: Wear surface of Al7075 + 12% B4C + 3% MoS2 in SEM [23]

As per the literature review on Aluminium Metal Matrix composite it has been observed that many researchers are experiments on enhance the mechanical as well as Tribological properties. The researcher works on hybrid composite by using the combinations for obtain the enhance properties. The stir casting method is suggested for composite preparation.The mostly preferable reinforcement materials are Alumina, Silicon carbide, TiC, B4C, zircon as well as many research also worked on natural fibers, red Mud, fly ash, industrial and agriculture waste in AMMCs.

4. Conclusion

The goal of this literature is to understand the depth of works on effect of mechanical and Tribological property behavior of Aluminium MMC along with various reinforcement. It gives an overview of AMMC, shown as follows.

1. The enhancement of mechanical properties of AMMC fully depends on reinforcement of materials as well as the size of reinforced particles.
2. In AMMC agriculture waste and industrial waste use as a reinforcement particlealso improves Mechanical and Tribological properties in low cost.
3. Enhancement of mechanical properties like tensile strength, hardness and ductility depends on the distribution of reinforcement into the matrix.
4. Stir casting method plays a significant role while preparation of composite preparation.
5. By addition the hard reinforcements such as Sic, TiC the wear resistance is improved and Hybrid composites also improves the wear resistance.

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