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Assessment of influence of reinforcement on hardness in Al MMC- A review

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Abstract

A composite material is produced using heterogeneous materials with unique chemical and physical properties that, when consolidated, prepare material with qualities of previous component Material researchers and specialists have been satisfying the interest of the different areas for decades in incorporating materials to achieve the requested properties to improve effectiveness and reduction in cost in a variety of areas. The main objective of paper is to review the literature on the fabrication of Aluminium metal matrix composite material with addition of different reinforcement. Fly-ash, Al2O3, SiC, B4C, Gr, TiO2, etc in the composite and the effect of addition of reinforcements on different mechanical properties mainly hardness along with tensile strength, strain, hardness, wear and fatigue of aluminium matrix composite.

Keywords: Composite materials, aluminium matrix composite, reinforcement, mechanical properties;

1. Introduction

Modern materials have provided a wide range of options for the material manufacturer to a variety of specifications to choose the products for different applications. In line with the emerging technological developments, material properties are constantly being developed to meet environmental and operational expectations. AMC are the materials that have high firmness and moderate-quality with imperative properties.

Metal Matrix Composites materials are used in the aviation fields, automobile sectors, Defense, Electrical components, and space equipment. When there is addition of reinforcement into the metallic matrix improves properties like wear resistance stiffness, specific strength, , fatigue and creep. AMCs are composites in which aluminum was used as a matrix and many reinforced material are mixed into the matrix during the past decade, AMCs with variety of reinforcements, such as fibers, particles, and sheets, whiskers, have been produced to allow such composite alloys to be used in many practical applications.

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Aluminium matrix gives good result as compare to (Aluminium) alloys. These include improved, strength-to-weight ratios, dimensional stability, good stiffness-to-weight and and better high temperature performance.

The most usually utilized reinforcement are Silicon Carbide (SiC), Boron carbide (B4C), Aluminum oxide (Al_2O_3), Fly-ash.Aluminum oxide (Al2O3) has moderate to extremely high mechanical strength and high hardness. Silicon Carbide (SiC) has a low density and has excellent chemical resistance. Boron carbide (B4C) is one of the hardest materials and has high impact resistance. Fly-ash has good toughness and compressive strength.

Fly-ash, Al2O3, SiC, B4C, Gr, TiO2, etc are added as reinforcement in the composite. Metal matrix composites are manufactured by different casting process most of the time stir casting is preferred because Stir casting has improved fatigue , high strength to weight ratio and better creep strength. The aim of this review paper is to present a detailed study on the effect of addition of reinforcements in the metal matrix composites on hardness of material.

Ajay Singh Verma, et. al.[1] prepared the MMC of Al 6063 with the fly ash by stir casting method. By keeping the Al 6063 constant vary the percentage of fly ash (3, 6, 9) with different pouring temp. And different steering speed. Due to increasing t fly ash percentage it increases the hardness and decrease the fatigue life. It was found that the percentage of fly ash is the main parameter to increase the hardness. The 9 % of fly ash give the maximum hardness of 42.9 but lagging in fatigue life at 720^0 C with 400 rpm steering speed.

Prakash Rao, et.al.[2] manufactured the Al6061 reinforced with fly ash (0, 5, 10, 15) % by stir casting. After increasing the fly-ash content, it enhanced the hardness but decrease in density of material. It was discovered that feed and cutting speed were the important factors that affected on surface roughness value. From the experimentation, it was found that 10% of fly-ash gives the best surface roughness value. For 15% fly ash the maximum hardness value is 80.79.

Kumaravel S.[3] Investigated that mixing of 2.5%, 5 %, 7.5% of basalt ash with 7.5 %, 5%, 2.5% of fly-ash increases the hardness value of the material by manufacturing Al6061 composite by stir casting. Author has conducted tensile, hardness and impact tests for his experimentations. As the % of fly-ash reinforcement increases, and increase in impact value. In microscopic results, the combination of Fly-ash and basalt ash show homogeneous dispersion.

Rajan Verma, et al.[4] The author used Al356 as the base metal, 10% Alumina and 10% Silicon carbide as the reinforcement material. For fabrication Stir casting is used, with the addition of reinforcement, the mechanical properties get enhanced. Different tests were conducted like Tensile Strength Test, Hardness Test, Toughness Test, shear test. The conclusion we came to from these tests that in terms of tensile strength, shear strength Al356/Sic is more superior to Al356/Al2O3 and in other tests vice-versa.The average hardness is maximum 99.3 when 10% Al_2O_3 is added.

A Baradeswaran, Et al.[5] The author studied mechanical and wear properties of composites having base metal as Al7075 and reinforcement material as Al_2O_3 and graphite. Stir casting is used for manufacturing of composites as it provides proper mixing and avoids the formation of slurry. The percentage of Al_2O_3 is varied i.e. 2%, 4%, 6%, 8%, whereas the percentage of graphite is kept constant i.e. 5%. After increasing the percentage of Al_2O_3 hardness value increases. The addition of graphite value decreases the hardness but the presence of Al_2O_3 ceramic particles increases the strength due to the Orowan mechanism and it was evident from the tensile test also. The 10% of Al_2O_3 specimen showed the best result as it had a higher value of an ultimate tensile test. The wear rate is minimum at 2% Al_2O_3 and 5% graphite. After decreasing in wear rate,an increase in the % of Al_2O_3. Graphite enables the formation of a lubricating film which decreases the wear rate. Wear rate also depends upon machining speed.while there is *% of Al_2O_3 maximum hardness was 135.

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H C Anil Kumar, Et al.[6] The author used Al6061 and took 3 different sets of Fly-ash particles size of 4-25, 45-50 and 75-100 μm with varying percentages of Fly-ash i.e. 5, 10 and 15. Stir casting was used for the fabrication of specimen as it provides good mixing and for increasing the wettability 0.5% Mg was also mixed. SEM results show that there is proper bonding in between matrix metal and Fly-ash without formation of voids. Tensile strength and hardness of material increases while increasing in the percentage of fly ash. but an increase in size of particles, decrease the strength. Fly-ash of size 4-25 μm and 15% gives the best result. Due to weight percentage of fly ash hardness will increase but decreases in ductility. It was seen that when fly ash having particle size 5-20 μm, and 10 % reinforcement maximum hardness 133 get achieved.

Kesavulu A, Et al. [7] has done experiments on commercial Aluminium with varying percentages of Fly-ash (5%, 10%, 15%, and 20%). For fabrication, they used stir casting as it provides proper mixing and reduces the cost of fabrication. They performed the Rockwell hardness test and Ultimate tensile test and found that as increases the percentage of Fly-ash hardness value is going to be increased and the 4^{th} specimen shows the highest among all four specimen. In the case of the tensile test, the value increases up to the 3^{rd} specimen and then decreases.

B P Pawar, Et al. [8] investigated Aluminium as base metal and SiC as reinforcement metal of. 2.5%, 5%, 7.5%,10%. Stir casting is used for fabrication due to its low cost, uniform mixing and for increasing the wettability Borax powder is added. It was found that as increase the percentage of SiC hardness value increased and 5^{th} specimen with 10% SiC shows highest hardness 60.3. There is also homogeneity in MMC samples that shows there is proper bonding between Aluminium and SiC.

N E Rusu Chintaiah, Et al. [9] has used Al6061 as a base metal and reinforcement as Alumina of varying percentages 0,3,6,9,12,15,18. Different tests were conducted like flexural strength, compressive strength and hardness test from the results of these tests show that up to 9% the mechanical properties increases but after 9% of volume fraction the properties decrease. They get maximum hardness 134 for % of reinforcement.

S K Hyderali, **Et al.** [10] has used Al6061 as a base metal and reinforcement materials as Alumina and graphite having three samples of varying percentages Fly ash (0%, 3%, and 6%) and Graphite (0%, 6%, and 3%). Stir casting is used for fabrication of MMC because of its cost and uniform mixing. Different tests were performed like tensile strength and hardness. From this it was evident that specimen two having 3% fly ash has good hardness 30.26 as compared to other samples. There is uniformity in the microstructure of MMC.

C H Hima Gireesh, **et al**. [11] has manufactured Al composite by stir casting method with varying percentages of Alumina (5, 7.5, 10), Silicon carbide (5, 7.5, 10) and constant 5% fly ash. While comparing with the best metal the propose composite gives good improvement in the hardness having value 63 while Al2O3 is 7.5% and fly ash is 5 % but it is no significant change in impact strength. Due to increase in speed, the temperature and wear rate increases. Al6061 -81%, SiC -7.5%, Al_2O_3 -7.5%, FA -5% is a best composition.

Ajeet Kumar Senapati, **Et al.** [12] has used alloy of Aluminium as the base metal and reinforcement material as Silicon carbide and Fly-ash of varying percentage. The composition of Silicon (0, 5, 0, and 2.5) and Fly-ash (0, 0, 5, and 2.5).Stir casting is used for the making of MMC because of its low cost and proper mixing of the mixture. From the hardness test, they have concluded that specimen 4 Aluminium (91%)/ Silicon 2.5%/ Fly-ash 2.5% gives maximum 7BHN. Silicon properly binds the mixture and increases hardness due to uniform distribution of molecules and due to the presence of fly-ash density goes decreasing.

Kamaraj M, Et al. [13] used MMC of Al6061 is reinforced with Silicon carbide by using sand casting method. The Al6061 percentage is kept constant and vary the percentage of silicon carbide (5%, 10%, and 15%). Impact energy and density increases with reinforcement in Al alloy. When there is 15% of SiC particles it gives maximum hardness of 80 BHN.

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Sanpeed Kumar Ravesh, Et al. [14] has investigated MMC of Al6061 is reinforced with fly ash and Silicon carbide by using the stir casting method. As the Al 6061 with 5% fly ash and vary the Silicon carbide (2.5, 5, 7.5, and 10). After increasing silicon carbide percentage, it increase tensile strength, hardness, toughness and decreases elongation (by stress-strain curve) with 5% fly ash. with 10% SiC, 5% fly ash gives maximum hardness 993BHN.

M Natraj, Et al. [15] By using stir casting mixing of Al6061 with the Silicon carbide and fly ash. As the Al6061 constant and vary the fly ash (10, 15, 20) and Silicon carbide (10, 8, 5) with different speed (125,150,175), different depth (0.25, 0.5, 0.75). different feed (0.05, 0.075, 1) and As the cutting speed (175 m/s^2) depth of cut (0.25mm) and feed (0.1 mm/rev) the surface finish increases. While percentage of SiC decreases and percentage of fly ash increases it gives increasing ultimate tensile stress and Young's modulus but the density and elongation goes decreases.

Amol Mali, Et al. [16] has improved the mechanical property with the help of a metal matrix composite of Al356 base metal and reinforce fly ash and alumina with the fabrication of the stir casting providing the proper mixing of materials. As the varying fly ash (2,4,6,8,10) alumina (2,4,6,8,10) As the compression ratio increases and tensile strength & hardness increases up to 12% of reinforcement after decreases.

Prakash Rao C R, Et al. [17] has kept Al6061 is constant and varying the fly ash (5, 10, 15) When there is addition of 15% of flash news good surface finish because of the presence of microporous density will be reducing mobile the percentage of fly ash increases the reason gives that maximum hardness 8.79 while there is the maximum percentage of fly ash that is 15%

Annoji Rao T M, Et al. [18] has worked on the MMC Al6061 as a base metal and reinforced fly ash and graphite by fabrication of the stir casting providing proper mixing composite. As the varying fly ash (3, 6, 9) and graphite (3, 6, 9) As an increasing percentage of the fly ash and graphite increasing tensile strength and hardness. Upto 9% graphite and 9% fly ash were easily fabricated. The 9%fly ash and 9% graphite give the best result of hardness and tensile tests.

B Ram Gopal Reddy, Et at. [19] has used Al6061as a base metal with reinforcement material as Fly-ash and Silicon Carbide of a varying quantity. The composition of Fly-ash (2.5%, 5%, 7.5%) and Silicon Carbide (2.5%,5%and7.5%). Stir casting was used for fabrication and different tests were performed like hardness tests, Ultimate tensile tests. It was found with increasing the percentage hardness and ultimate tensile strength increased.The3rd specimen Al6061 (85%)/ Sic (7.5%)/ Fly-ash (7.5%) showed the best result. It was also seen that particles of SiC was uniformly distributed and particles of Fly-ash were distributed on uniformly from SEM. ??????

Swapnil S Mukadam,Et al. [20] uses Al6061 as the base metal with reinforcement material as Fly-ash and Silicon carbide with varying percentages. The composition of Fly-ash(0,0,5,10,5)and Silicon carbide (5,10,0,0,5) Stir casting was adopted for fabrication of MMC. Ultimate tensile test and hardness tests were performed and it was noticed that with the combination of Fly-ash and Silicon carbide the ultimate tensile increased. In the case of hardness, the MMC with 10% Fly-ash showed the best result and also the coefficient of friction was less which is suitable for brake rotors. The 4th specimen showed best result Al6061 (90%)/ Fly-ash (10%).

V Bharati, Et al. [21] has used Aluminium Alloy LM25 with reinforcement material as a Fly-ash of varying percentages of 2.5% and 5%. Higher the surface area finer will be the grain size and offer more resistance top plastic formation which leads to higher strength. Hardness test was performed and it was found that the higher the percentage of Fly-ash more will be the hardness i.e.67 BHN for 5% of fly ash addition as reinforcement. There is strong bonding between reinforcement and base metal which offer more resistance to wear. In squeeze casting there exists a force that eliminates voids and porosity.

J Babu Rao, Et al. [22] The author used AA2024 as a base metal with reinforcement as fly-ash of varying Percentages (2%, 4%, 6%, 8% and 10%). Brinell

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hardness test was performed which concludes that with increasing the fly-ash percentage hardness increases. From the Stress-Strain curve, it is evident that increasing the fly-ash content improves hardness value. From experiment it was found that addition of fly-ash leads to formation of pitting which encourages the corrosion phenomenon. Specimen with an 8% fly-ash possesses the best properties.

Sachin Malhotra, Et al. [23] has done an investigation on Aluminium 6061 alloy fly-ash and zirconia MMC. The result shows the effect of reinforcement on mechanical properties of aluminum alloy composite which is manufactured by stir casting. It was observed that the best properties were found in Fly-ash 10% + zirconia 10% as compared to the base metal.

Himanshu Chauhan, Et al. [24] has used Al2O3 as a base metal with reinforcement material as Fly-ash and Al2O3 with varying percentages. The composition of reinforcement material is varied by 10%, 15%, and 20%. Stir casting is used for the fabrication of MMC. From the test conclude that reinforcement of 20% exhibits good mechanical properties. Increasing the percentage of reinforcement increases the hardness, tensile strength.

Umashankar, Et al. [25] worked on Al6061 alloy as the matrix and bottom ash as the reinforcement to produce the composite by stir casting. Micro hardness and tensile strength of the composites increase with the increase in wt% of bottom ash particles. During the investigation, it was that after 9% wt of fly-ash the micro hardness of composite decreases.

Prerana Evangeline, Et al. [26] used Al6061 as a base metal with SiC, Fly-ash as a reinforced material with varying percentages. The composition of Silicon carbide (3% and 6%) and Fly-ash (6% and 3%) were taken. Fabrication of the specimen is done by stir casting. From the result, it found that with increasing the percentage of SiC, tensile increases while tensile strength decreases with increasing the percentage of Fly ash. The impact strength increases with increasing the percentage of Fly-ash. The wear resistance decreases with increasing the composition percentage. The best composition is Al2O3 (91%)/SiC (6%)/ Fly-ash (3%).

2. Conclusion

Various challenges has been addressed to re-strengthen different usage of AMMC's such as effect and impact of reinforcement and manufacturing technique on mechanical properties. The findings of previous work can be summarized as

1. The percentage of reinforcement increases, the hardness of MMC under the test is increases.
2. Industrial waste, organic reinforcement materials like fly-ash, rice husk ash and coconut shell ash has improves the mechanical properties of AMMC's.
3. It also helped in the development of Aluminium material as a composite with different reinforcement which is used in application of different sectors like Aviation, Automobile, Defense, and in General engineering applications.

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