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A Review on Mechanical Behavior of Aluminium 6061 Reinforced with different Agro Ashes

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Abstract: ***In recent years the use of composites is increasing rapidly and likely to increase more rapidly in the future. In the present industrial scenario composites with Aluminium alloy as base are having importance within elevating fields of engineering. The application of Agro-ash like RHA, PKSA, CCA, and BA in reinforcement is becoming more relevant because of their ability to enhance the various properties of the composite material. Apart from increasing various properties of the material manufacturing cost of the composite reduces. Unnecessary use of synthetic filler can be avoided which leads to the safety of the environment. This paper highlights the use of Agro ash additives for producing a composite with good mechanical properties. In order to find out various mechanical behavior of AMMCs various tests are carried out by using different percentage of Reinforcements. Different types of fabrication methods are used produce the composite material added with Agro ash***

Keywords: Aluminium, Metal Matrix composites, Mechanical Properties, Reinforcement, Agro ash

I. INTRODUCTION

Material system consisting of systematically arranged mixture of two or more micro or macro constituents with an interface differentiating them in the form of chemical composition and shows insolubility in each other [1]. Aluminium is world's most abundant metal and is the third most common element, found in the earth crust. The versatility of aluminium makes it the most widely used metal after steel. This is be-cause aluminium has a unique combination of attractive properties [2]. AMCs possess unmatched combination of properties which are sought after in several industries and replace conventional alluminum alloys in numerous components. [3][4] Al6061 is extensively used in industries and possesses good castability, weldability, reasonable strength and corrosion resistance [5]

Current engineering applications require materials that are stronger, lighter and less expensive. Some of these property combinations include high specific strength, low coefficient of thermal expansion and high thermal resistance, good damping capacities, a superior wear resistance, high specific stiffness and satisfactory levels of corrosion resistance. MMCs are fast replacing conventional metallic alloys in so many applications like aerospace, automobile, defence [6]. The cost of aluminium metal matrix composites (AMMCs) remains high, which limits its applications.

The use of inexpensive reinforcements such as natural material might reduce the overall cost of AMMCs and may also increase the functionality in different applications.

The search for low cost options in AMMC production has led to a number of efforts tailored at utilizing Agro ash as reinforcement materials. With this approach many researchers have attempted to utilize Agro ash materials like rice husk ash (RHA), Bagasse ash, Coconut shell ash, groundnut shell ash (GSA), Palm Kernel shell ash, Bamboo leaf ash, Maize stalk ash, Corn cob ash as complementing reinforcements [7]. Addition to the advantages of low cost, availability in large quantities, and contributions to creation of more ecofriendly environment; is lower densities which most of the Agro ashes possess in resemblance with synthetic reinforcements like carborundum(Sic) and aloxite(Al_2o_3)[8].

AMCs reinforced with Agro ash particles were successfully produced by few re-searchers using various methods such as stir casting ,compo casting, Friction stir pro-cessing [9][10][11][12][13] Out of all the processing methods liquid metallurgy route has got wide acceptance but it cannot produce a homogeneous, non-agglomerated, less porous and without interfacial reaction and bonding problems so the improved method of producing high quality composite is friction stir processing[14].Some of the researchers have adopted double stir casting process but still unable to produce high quality casting. FSP enhanced the distribution of the reinforced particles which resulting more homogeneous and thermodynamically more stable in metallurgical proper-ties as the matrices and reinforcement have a strong interfacial bonding [15].

II. LITERATURE REVIEW

A. Rice Husk Ash Reinforced AMCS

Adnan Adib Ahamed et al.[16] fabricated Aluminium Metal Matrix composite reinforced with 3%,6%,9% volume fraction of RHA. The experimental study shows that with increasing volume percentage of RHA, the density of the composites de-creased. Tensile strength of the composite increased with increase in wt% of RHA. The strength of the Al6061 reinforced with-9% RHA was the highest. Hardness of the composite increased with increase in volume percentage of RHA hardness is maximum of BHN 33.6 with 9%Wt fraction of RHA. The properties, in particular the rate of increase of strength and hardness as well as the rate of decrease of density from Al+6%RHA to Al+9%RHA can be improved to some extent by incorporating an inert or closed system during stir casting by insulating the setup from the atmosphere. Hardness of the composites is increased from 22BHN to 33 BHN with addition of RHA and magnesium compared to unreinforced condition.

Neelima Devi Chinta et al. [17] fabricated aluminium 6061 reinforced with Sic and RHA by varying Sic percentage 2%,4%,6% and keeping RHA is kept constant at 5%.The experimental study shows that as the percentage of Sic increases hardness increases due to intermetallic bonding of Alluminum with 5%RHA composite. Compressive strength increases up to 4% constituent in composite further increase in Sic percentage leads to decrease in Compressive strength.

T. Prasad et al.[18] fabricated Aluminium metal matrix Composite which was produced with rice husk ash 5%, 10%, 15% and 5%, 10%, 15% fly ash as reinforcing phase. The experimental study shows that tensile strength of composite will be maximum with reinforcement of 10%FLY ASH+10% RHA i.e 132Mpa further in-crease in reinforcement reduces tensile strength. Hardness of the composite increase with increase in reinforcement % up to 10%FLY ASH+10% RHA further increase in reinforcement percentage decrease hardness.

J. Alwyn kingsly Gladston et al. [12] studied the mechanical properties of allu-minium6061 reinforced with RHA with mass fraction of 2%, 4%,6%,8%. The AMC was fabricated using compo casting method. It was observed that the micro hard-ness of the AMC increases with increase in mass fraction almost linearly with mass fraction which says that strength of the material increases with RHA percentage. Highest microhardness value is observed for 8%RHA i.e 145HV. It was also observed Ultimate tensile strength of the AMC increases with increase in RHA percentage. Highest UTS strength of 242MPa was obtained for 8% RHA reinforcements. The results obtained in the above study predicts that RHA particles are uniformly distributed i.e load is transferred properly to reinforcement and no defects were observed. The study concludes that with increase in RHA percentage strength of the material increases which justifies the use of RHA as low cost reinforcement material in AMCs.

Isaac Dinaharan et al.[19] investigated the effect of RHA on mechanical and microstructural characteristics of Al6061.The composite was fabricated using friction stir processing method. The author has added 18% volume fraction of reinforcement (RHA) during friction stir processing. It was observed that maximum elongation strength of the as cast alloy and 18%RHA reinforced Al6061 were 220Mpa and 280Mpa which means significant rise in axial strength of the material. Since the inter facial bonding between aluminium matrix and RHA particle are very strong good mechanical properties can be obtained. No agglomeration of RHA was found in the composite which means RHA is uniformly distributed all over the matrix. Compared to the other studies author has introduced higher volume fraction of reinforcement and obtained good tensile strength.

C D Marini et al. [15] fabricated aluminium 6061 reinforced with RHA composited was fabricated using Friction stir processing method. The author has introduced 5% RHA into aluminium matrix to study the variation of mechanical properties. It was observed that average hardness value of AL6061+5% was higher compared to the FSPed AL6061.The hardness values observed were 131.7HV and 114.1HV.

B. Bamboo Leaf Ash Reinforced AMCS

Kammuluri.Baburaja et al.[20] studied the mechanical properties of aluminium 6061 reinforced with BLA in mass percentage of 2%,4%,6%,8% via stir casting route. Results showed that highest yield strength of 50KN obtained for 6% BLA rein forcement and Ultimate tensile strength also increase up to 6% BLA reinforcement further increase in BLA % reduces yield strength and tensile strength so the author has reported that 6% BLA reinforcement is the optimum Wt% for addition to AMC.

C. Bagasse Ash reinforced AMCS

M.Usman et al.[21] analysed the characteristics of AMC reinforced by Bagasse Ash as Reinforcement. The experimental study shows that the density of the produced composites decreases with the percentage volume of BA addition from 2840.242kgm-3 for the control sample to a minimum of 2292.208kgm-3.

The tensile strength i.e UTS increases up to 10%BA 176.683Mpa further increase in Wt% of BA leads to reduction in UTS of the composite. Good Impact strength of the composite can be obtained with up to 20%BA further increase in BA% leads to reduction of impact strength. The maximum impact strength of 128.262Jm-2 was achieved at 10% ash. The hardness of the produced composites rises approximately linearly with in-crease in BA addition from 70.467HRV for control sample to a maximum of 90.767HRV at 20vol% BA and then decreased to 75.067HRV at 30vol%. Fatigue strength of the MMC increases with Bagasse ash addition of 15% and reduces with further addition up to 30%.

Rahul Bhatnagar et al.[22] studied the mechanical properties of aluminium rein-forced with Bagasse Ash as reinforcement. The investigation shows that the Hard-ness of the composite increases with increase in wt% of reinforcement. Maximum hardness of 76.25 of BHN is obtained for 14%BA reinforcement. Axial strength of the MMC increases with in wt% of reinforcement. The maximum tensile strength of 176Mpa is obtained for 14%BA reinforced composite. Impact strength of the com-posite reduces with increase in wt% of Bagasse Ash. The minimum impact strength of 6 Joules is obtained with 14% BA reinforced composite.

Anwesh k et al.[23] investigated the mechanical properties of aluminium 6061 reinforced with sugarcane bagasse ash. The MMC was fabricated using stir casting method. The author has fabricated mmc by adding 4%,8%,12% of reinforcement to aluminium 6061 matrix. The results obtained indicate that axial strength improves with rise in reinforcement percentage. Highest tensile strength of 200Mpa was ob-served for 8% SCBA reinforced composite further increase in Reinforcement percentage decreases tensile strength. Micro hardness value slightly decreases with increase in volume % of SCBA but further addition of SCBA improves microhardness. Findings by the author justifies that SCBA can be successfully used as reinforcement material.

D. Breadfruit seed hull ash

C.U.Atuanya et al.[24] analysed the characteristics of AMC rein-forced with breadfruit seed hull ash. AMC was fabricated using double stir casting method. The author has considered BSHA of grain size 500µm.The result analysis indicated that mechanical properties were improved with addition of BSHA. Microstructural study revealed that with increase in volume fraction of ash fracture strength increases.

E. Ground nut shell ash

J.M.Tile et al.[25] attempted to study the mechanical characteristics of Al-Mg-Si reinforced with groundnut shell ash as reinforcement. The composite was fabricated by conventional method of Stirring molten al alloy by adding GSA of predetermined quantity. The matrix was mixed with a wt fraction of 2%,4%,6%,8% and 10% groundnut shell ash. The study shows that yield strength improves with addition of reinforcement. Highest yield strength was obtained for 10% wt fraction i.e 47KN/mm2.The tensile strength increases with increase in reinforcement wt fraction percentage up to 4% i.e 110KN/mm2.The reinforced alluminum matrix shows better tensile strength compared to as cast alluminum. Hardness values increase progressively up to 44.5HRB (age hardened) and 23 HRB (as-cast) for 8 % addition of reinforcement of the ash particulate and then decreased thereafter hardness decreases with increase in reinforcement percentage. Fracture toughness increases with addition of GSA up to 8% i.e 48.95J further increases in reinforcement percentage reduces impact strength. Author has concluded that impact for the age hardened samples is higher than that of the as-cast samples.

F. Coconut shell Ash reinforced AMCS

Poornesh M et al.[26] studied the mechanical properties of aluminium metal matrix composite added with different quantity of CSA and Sic. Synthesis of MMC was done by conventional stirring method. The composites were prepared keeping 5% Sic constant and varying CSA content as 3%,5%,10%. During investigation results indicate that hardness increases with increase in CSA percentage. Maximum hard-ness is obtained for 10%CSA+5%Sic reinforced composite i.e 44HV .The density of the composite decreases with increase of reinforcing particles. The lowest density of 1.9gm/cm2is obtained for 10%CSA+5%Sic reinforced composites. The impact strength decreases with increase in percentage of reinforcement. There will be noticeable drop in the toughness value due to presence of brittle particles of Sic. the result of impact energy of hybrid composites is comparatively lower than the ones without the inclusion of ceramic particles. Impact energy varies from 13J to 8J with variation of reinforcement percentage.

K Varalakshmi et al.[27] analysed the properties of aluminium 6061 added with CSA. A composite was fabricated using conventional stirring method. Author has selected Reinforcement volume fraction of 0%,1%,3%,5% to add with base metal. The analysis results indicate that the density of material decreases as rise in reinforcement volume fraction which leads to reduction of weight. Micro Vickers hard-ness values have increased with increase in reinforcement percentage highest hard-ness is seen with 5% CSA reinforced with al6061 i.e 81HV.

It was also observed that there was a significant increase in axial strength with addition reinforcement Volume fraction. Maximum axial strength was found to be 143.66Mpa for the composite with 5% CSA addition. The author has also studied microstructural properties which completely justify the use of CSA as reinforcement with aluminium 6061.

P Lakhmikanthan et al.[28] attempted to understand the mechanical behavior of the aluminium 6061 added with CSA. A composite was synthesized using conventional stirring with pellet method. By using this method varying weight percentage of CSA 3%,6%,9%,12%,15% are introduced. It was observed that hardness values of composite increases with increase in reinforcement percentage up to 9% CSA reinforcement further increase in reinforcement percentage leads to reduction of hard-ness value. Highest hardness value 54.97BHN was observed. Tensile strength in-creases with increase in reinforcement up to 6% CSA further increase in reinforcement leads to decrease in tensile strength. The highest tensile strength observed was 160. 27Mpa.The author has also carried micro level study which reveals the invariable dispersal of reinforcement within composite material which in turn leads to the composite with good mechanical properties.

P.V Rajesh et al.[29] analysed the mechanical properties of al6061 added with CSA, Boron carbide. A composite was fabricated using conventional stirring meth-od. The author has varied reinforcement volume fraction of 1%to 8% and 0%to6% for CSA and Boron carbide respectively. The analysis shows that tensile strength fluctuates with variation in reinforcement percentage. Highest tensile strength is obtained for the combination 92%Al6061+6%B4C+2%CSA i.e 107Mpa.Hardness values of the composite fluctuates with variation with reinforcement volume fraction highest hardness is obtained for the combination of 90%Al+10%CSA i.e 60HV.Impact energy of the composite fluctuates with variation in reinforcement volume fraction highest impact strength was obtained for the composite with combination 92%Al+6% B4C +2%CSA i.e 0.475 j/mm2.

G. Lemon grass Ash reinforced AMCS

Jerin Jose et al.[30] carried out various tests to find out mechanical properties of Al6061 added with Lemon grass Ash. The metal matrix composites (MMCs) were prepared by the addition of 3%,5% and 7% weight fraction of LGA by compo casting technique The test results showed that the hardness value rises with rise in volume fraction of LGA.As cast aluminium alloy possess 51HV which is least and highest hardness value of 155HV is obtained with 7.5% LGA reinforced Al MMC. Elongation strength of al based composite increase with rise in weight fraction of LGA. Tensile strength varies from 160Mpa to 190Mpa with addition of 7.5%LGA as reinforcement. Elongation length in AMC reduces with rise in weight fraction of LGA. Minimum elongation is observed at 7.5%LGA reinforced AMC.

H. Palm kernel shell ash Reinforced AMCS

Isiaka Oluwole Oladele et al.[31] fabricated aluminium reinforced with PKSA. It was found that Maximum hardness of 325HRA is obtained for al mmc reinforced with 5% weight fraction of reinforcement. The results indicate that hardness of the aluminum MMC was enhanced by the PKSA up to 5wt% fraction. After which there was reduction in hardness with increase in volume fraction of PKSA. The test results indicated that sample 15T shows the highest impact strength of 18.38J with a com-position of 15wt% of treated PKSA added to Al-Si alloy. This was followed by 10T with impact strength of 13.22 J with a composition of 10wt% of treated PKSA added to Al-Si alloy. Control sample was observed to possess the lowest impact strength of 6.8 J. During tensile test it was observed that Alluminum reinforced with 5% Wt fraction of PKSA untreated with a value of 359.07MPa has the best result. The tensile stress and strain properties results revealed that the use of 5wt% and preferably from treated PKSA was the best for optimum performance. The results showed that Al mmc reinforced 5% Wt fraction of PKSA has the best modulus of elasticity property with a value of 328.52MPa y. Next to this was sample denoted as 15% PKSA untreated with a value of 297.49MPa and sample with 5% Treated PKSA with a value of 274.96MPa. These samples, when compared to the unreinforced as-cast aluminum alloy with a value of 225.10 MPa correspond to high enhancement of the modulus of elasticity for the materials. The author has reported that improvement amounted to about 45 % from the sample with the best result.

I. Maize Stalk Ash Reinforced AMCS

J.E. Oghenevweta et al.[32] Prepared an al MMC reinforced with Maize stalk ash with Wt% ranging from 2% to 10% with the interval of 2%.It was observed that hardness value increases from 6.80HRF to 20.20HRF with rise in additional quanti-ty of MSA. Tensile strength of the Al reinforced with MSA increases up to 8%MSA reinforced MMC further increase in MSA% reduces tensile strength. Maximum tensile strength of 85.60 N/mm2 is obtained for AL MMC reinforced with 8%MSA.

Tensile modulus also increases from 43.42 to 70.25 N/mm2 as the carbonized maize stalk particles increases. Impact energy decreases with increase in Wt% MS. Impact energy varies from 18J for as cast MMC to 14J for 10% reinforced MSA. Elongation of AL mmc reinforced with MSA reduces with increase in Wt % of MSA.

J. Corn Cob Ash Reinforced AMCS

Oluwagbenga Babajide Fatile et al.[33] fabricated aluminium 6061 reinforced with CCA with Wt% ranging from 0%to10% with two stage stir casting process. When the samples were analysed for mechanical properties it was found that Hardness value decreases with increases in wt% of CCA i. e93HVN to 81HVN.Maximum tensile strength of 185Mpa is obtained with 0%CCA and 163Mpa is obtained with 10%CCA.

The specific strength of 1 wt% CCA containing composite is comparable to that of the sample without CCA which shows that comparable strength to weight ratios can be achieved using cheap CCA as complementing reinforcement in the production. From the study it was observed that there is no difference between as cast al mmc and 1%CCA reinforced al mmc in terms of elongation which justifies CCA reinforced AMC possess good ductility.

The fracture toughness of the compo-site produced possess slight increase in fracture toughness up to 4% CCA reinforce-ment at which al MMC possess highest fracture toughness.

K. Palm Sprout Shell ash Reinforced AMCS

Ram Babu Matta et al.[34] prepared Al mmc reinforced with palm sprout shell ash in various weight fraction like 1%,2%, 3%.MMC was prepared via stir casting method.

It was observed that from the microstructural study that PSSA has disperse uniformly all over the matrix. Hardness value of the mmc increase with increase in weight fraction of reinforcement material. Maximum hardness of i.e 100BHN is obtained for 3% weight fraction of SPSA.

The author has found that Increase in hardness value was due to the Sio2 and Al2o3 content available in the PSSA. Observation shows that specific impact factor of the MMC increases with rise in weight fraction of SPSA. All the findings in this study justifies that PSSA can be used as reinforcement along with aluminium mmc and good mechanical properties can be achieved.

L. Neem leaf ash ash Reinforced AMCS

S.C.Prasanna et al.[35] studied mechanical properties of aluminium 6061 rein-forced with 10% Neem leaf ash and 5% Sic as reinforcement. It was fabricated using stir casting method.

The results obtained in the tests show that hardness value of NLA reinforced MMC is the highest compared to other combination of reinforcement materials like Fly ash and Sic.

Fabricated composite possess good mechanical properties and also possess good wear resistance properties. Scanning electron microscopy studies show that the NLA and Sic particles are fairly uniformly distributed. The findings by the author justifies that NLA can be used as reinforcement.

3.13 L Natrayan et al.[36] analysed the mechanical properties of aluminium 6061 reinforced with tamarind leaf ash. The author has introduced the TLA reinforcement along with Sic in the ratio of 0.75:075 as reinforcement using conventional stirring process. Test results shows that TLA reinforced Al6061 has higher hardness com-pared to unreinforced matrix. Wear resistance of the MMC increases with addition of TLA. It has been observed that TLA can be used as reinforcement for aluminium 6061 successfully and good mechanical properties can be obtained.

M. Marula Ash Reinforced AMCS

Sani A.Salihu et al.[37] attempted to produce aluminium alloy for the production of brake pad. Author has fabricated the composite material by stir casting process. The author has reported that hardness, Tensile strength and yield strength increases with increase in reinforcement weight percentage.

Author has varied reinforcement volume fraction from 1% to 8%. Highest hardness and tensile strength are obtained for 8% volume fraction of Marula ash. The maximum values of hardness, Tensile strength and yield strength are 40HV, 76Mpa and 55Mpa respectively. The results obtained from the above study justifies the use of marula ash as reinforcement material for Aluminium composites

III. CONCLUSIONS

The above review for the aluminium 6061 reinforced with Agro ash material leads to the following conclusions

A. Majority of authors have successfully utilized stir casting method to manufacture metal matrix composites.
B. Reinforcing Alluminum 6061 alloy with Agro ashes has shown an appreciable in-crease in its mechanical properties.
C. Tensile strength, yield strength and hardness values of all the alluminum 6061 reinforced with above studied Agro ash increases progressively up to certain percent-ages.
D. Impact strength of the coconut shell ash and Maize stalk ash reinforced aluminium 6061 reduces with increase in reinforcement weight percentage.
E. Fracture strength of SCBA, BSHA, and CCA reinforced aluminium 6061 MMC in-creases significantly with increase in weight percentage.
F. Density and ductility of the MMC's decrease with increase in reinforcement weight percentage.
G. The microstructural studies reported by authors indicate that the reinforcement material is fairly uniformly distributed and possess good interfacial bonding which means that good mechanical properties can be expected.

From the observations made we can say that there is a considerable scope and opportunity to develop many Agro ash reinforced composite materials with Al6061 as matrix.

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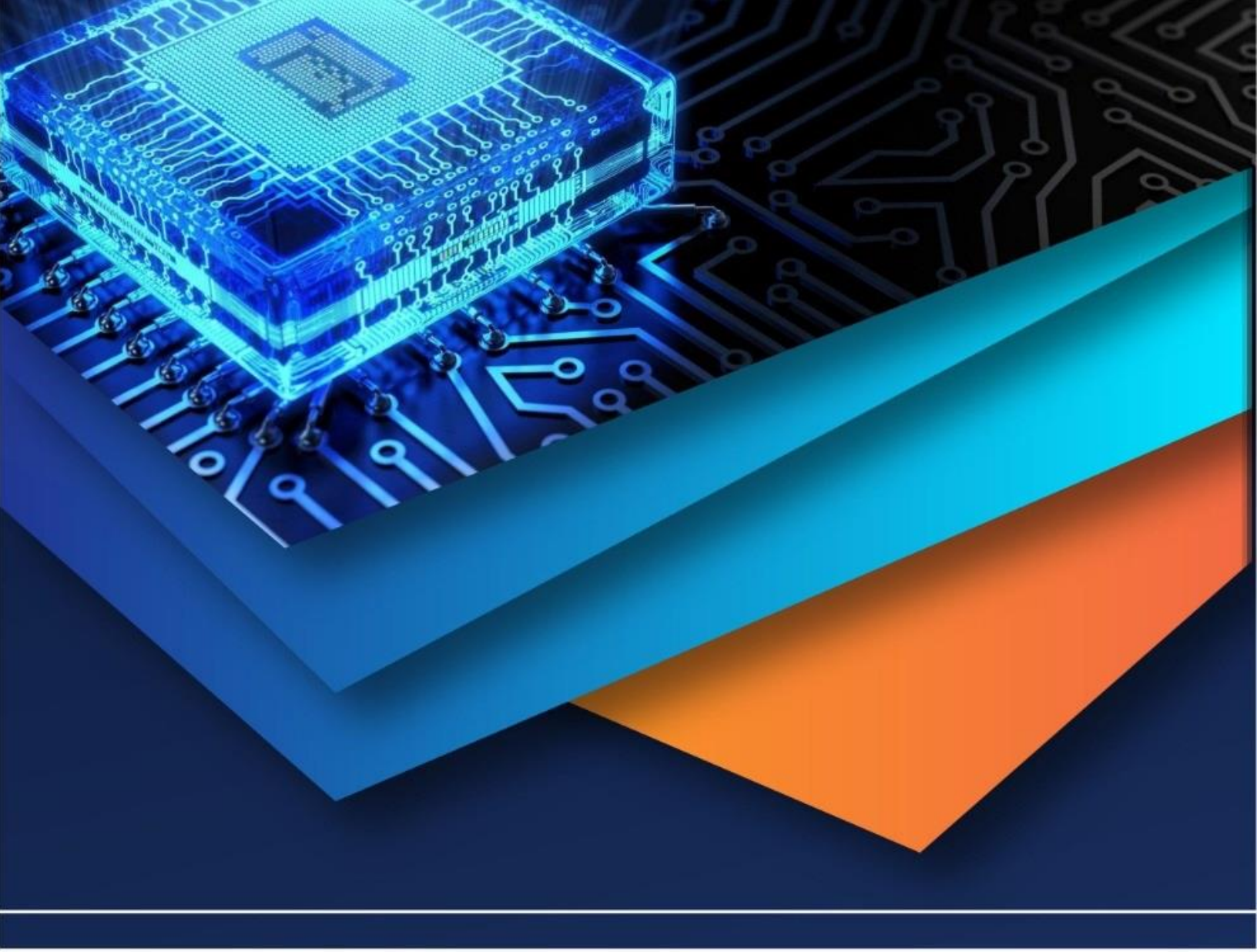

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