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Wear Behaviour of Magnesium Metal Matrix Composites Fabricated By Powder Metallurgy Process

Satish J[1], Satish K G[2]
[1]Department of Mechanical Engineering, SJMIT, Chitradurga-577502
[2]Department of Mechanical Engineering, UBDTCE, Davanagere-577005

Abstract: Due to the lower density, magnesium and its composites were widely used in aerospace, marine and automobile industries. In present work, the magnesium metal matrix composites reinforced with silicon carbide and aluminum oxide fabricated by powder metallurgy technique and the wear behaviour of composites were studied under dry sliding condition. Wear test were carried out using pin-on-disc apparatus on all the samples for various speeds of 200, 400 and 600rpm, varying load of 2kg, 4kg and 6kg. The Hardness test was performed on the specimens prepared by powder metallurgy method. The results revealed that the micro hardness of composites was increased with the addition of silicon carbide and alumina particles in magnesium metal matrix composites. The wear results indicated that, wear resistance of composites increases with increase in the reinforcement weight fraction.
Keywords: Wear, Magnesium MMC, Powder metallurgy, Wear rate, Hardness

I. INTRODUCTION

The Hardness and wear behaviour plays an vital role in selecting the metal matrix composites for using in various industries, automobiles etc. Due to the attractive properties of Magnesium alloys, have become promising materials for aerospace and automotive components. Magnesium metal matrix composites are the most competent and extensively used materials because of their superior mechanical properties, low weight and lower production and maintenance cost and can be able to form from traditional powder metallurgy technique.

The intention of manufacturing magnesium metal matrix composites is to combine the important properties of metals and ceramics. However, there are some limitations in producing better quality metal matrix composites. The major difficulty is to accomplish excellent bond between reinforcement particles and metal matrix. We can beat the above issues by embracing Powder metallurgy technique for making magnesium metal matrix composites.

Particle fortified magnesium matrix composite has the notably improved properties including high strength, high stiffness and damping capacity compared with the unreinforced alloy matrix. Alumina and Sic particle reinforced magnesium composites have higher request in market than other sorts of metal matrix composites because of their significant mechanical properties, high performance, wear protection, high thermal conductivity and low thermal expansion coefficient. In this manner they are more focused on MMC market and find more extensive application in industries.

The magnesium alloy has been selected as the matrix material because it is more compatible with the reinforcement and has great mechanical property. Alumina has selected as reinforcement in the form of particle size 74µ. It is more steady with magnesium and withstands elevated temperature. It is an oxide ceramic having low affinity for the oxygen to form oxides. The particulate type of the reinforcement has better distribution in the matrix to give isotropic property to the composite. The Silicon carbide has been choose as the next ceramic which is a carbide type of ceramic. Because of good lubricating effect of SiC, it reduces vibration and noise during the relative motion.

When magnesium alloy matrix metal reinforced with combined Al2O3and SiC particles exhibits better mechanical properties compared with the composites strengthened with either alumina or sic alone. The addition of silicon carbide particulates enhances the hardness of the composite.

The composite has been fabricated by Powder metallurgy technique. The Powder metallurgy technique is one of the suitable and economical processing method for producing Magnesium metal matrix composite's. Powder metallurgy technique is suitable for large scale manufacturing of complex profiled composite components without harming the reinforcement particles. The properties of base metal and reinforcing constituents are shown in below table;

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TABLE I
PROPERTIES OF MAGNESIUM, SIC AND AL_2O_3

	Melting point(^{0}C)	Density (g/cm^3)	Poisson Ratio
Magnesium(Mg)	650	1.73	0.29
Silicon Carbide(SiC)	2200-2700	3.1	0.14
Aluminium Oxide(Al_2O_3)	2072	3.69	0.21

II. EXPERIMENTAL PROCEDURE

The atomized magnesium powder particle of size 63µ, silicon carbide 122µ and aluminium oxide 74 shown in the fig 1, were bought from Neeraj industries, Rotak, India. Blending thoroughly the silicon carbide and aluminum oxide with magnesium metal powder for different composition in a ball mill apparatus to achieve a uniform distribution of powder. After mixing, Compaction of powders is to be done by using die and punch having close tolerances. Usually, to prepare the green compacts, the mixed powder is poured into the hollow space of die and compacted by punch using Universal Testing Machine as shown in fig 2. The green compacts were kept in a vacuum furnace. Before sintering process, remove the oxygen in the furnace chamber in order to avoid quick oxidation of magnesium which is not desirable. The green compacts were sintered in a vacuum furnace of 550^{0}C for 150 min at the heating rate of 13^{0}C/hour and cooled at low cooling rate. During sintering process, the bonding between the powder particles takes place continuously at their zones of contact and results in development of grain boundaries.

Fig 1 : Pure Mg powder Al_2o_3 powder SiC powder

The composition percentage for the specimen shown in the below table was preferred from the literature. According to weight of magnesium, the percentage of reinforcement of aluminum oxide and silicon carbide are varied in steps of 5% to 15%.

TABLE III
SPECIMEN COMPOSITION

Specimen Code	Megnesium(%)	Silicon Carbide(%)	Aluminium Oxide(%)
A	100	0	0
B	90	5	5
C	80	10	10
D	70	15	15

The wear test was conducted on the specimens having dimensions of 10mm diameter and 35mm length for various percentage of reinforcements. The wear test is conducted by using pin-on-disc apparatus.2kg. 4kg and 6kg load is applied for 200rpm speed of disc for 5minutes and the same is repeated for 400rpm and 600rpm disc speed. To measure the amount of wear of specimen, the weight loss technique is followed. Vicker's Hardness tester was used to conduct the Micro Hardness test on the specimens. A load of 200gm was applied on the specimen for a period of 40seconds and at a total magnification of 400x, the Vicker's hardness number was obtained.

Fig 2: Compaction of powder by using UTM

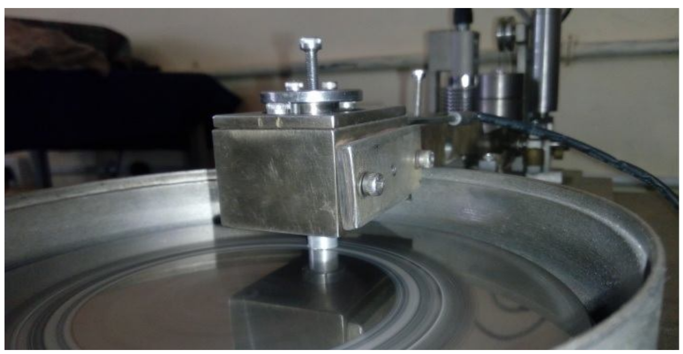

Fig 3 : Wear Testing Machine

III.EXPERIMENTAL RESULTS

A. Microhardness Test Results

Here diamond indentor is used to apply a load of 200gm without any jerk for about 40 seconds. Then measure the dimensions of the indentation by using vicker's hardness tester's microscope. The below Table shows the vicker's hardness number for Pure magnesium, 5% and 10% reinforcement of sic and alumina. Figure shows the graph plotted for vicker's hardness number against the reinforcements of specimens.

TABLE IIIII
VICKER'S HARDNESS NUMBER FOR VARIOUS COMPOSITION

Sl. No	Composition	Mean Hardness Number in HV
1	Pure Magnesium(Mg)	36.3
2	Mg+5%(Sic and Al_2O_3)	42.54
3	Mg+10%(Sic and Al2O3)	45.39

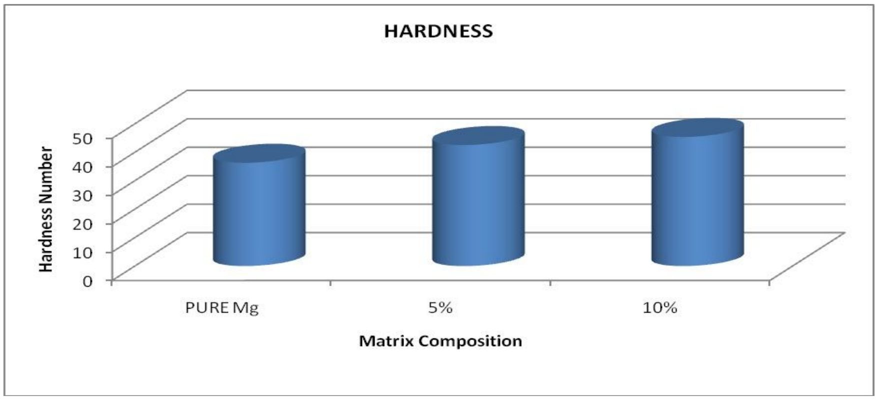

Figure 4 : Graph of Percentage composition v/s Vickers Hardness Number

The Graph and Hardness table shows that pure Magnesium having low hardness number and then the hardness number increases as the percentage of reinforcement increases. Hence from the above data we can say that the strength of the magnesium metal matrix composites increases with the increasing in the percentage of reinforcement of silicon carbide and aluminum oxide.

B. Wear Test Results

Using pin-on-disc (Ducom TR-20-PHM-400) type wear testing machine, Dry sliding wear test was carried out for the different composition of specimens, considering more number of parameters such as load, speed and sliding distance, which affect the wear mechanism and wear rate. The pin samples which are obtained after machined and polished were 35 mm in length and 10 mm in diameter. To ensure effective contact of fresh and flat surface with the steel disc, the surfaces of the pin samples was polished using emery paper earlier to test. wear track was cleaned by using acetone and samples are weighed(up to an accuracy of 0.0001 gm using microbalance) before and after conducting each test.

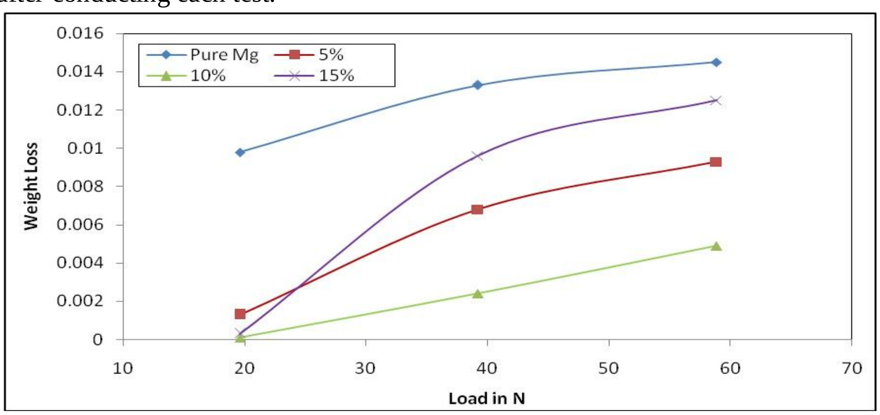

Figure 5 : Graph of Load v/s weight loss

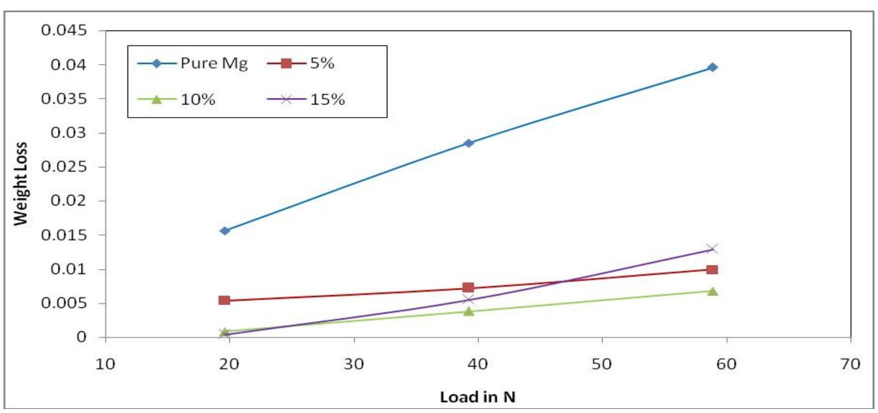

Figure 6 : Graph of Load v/s weight loss

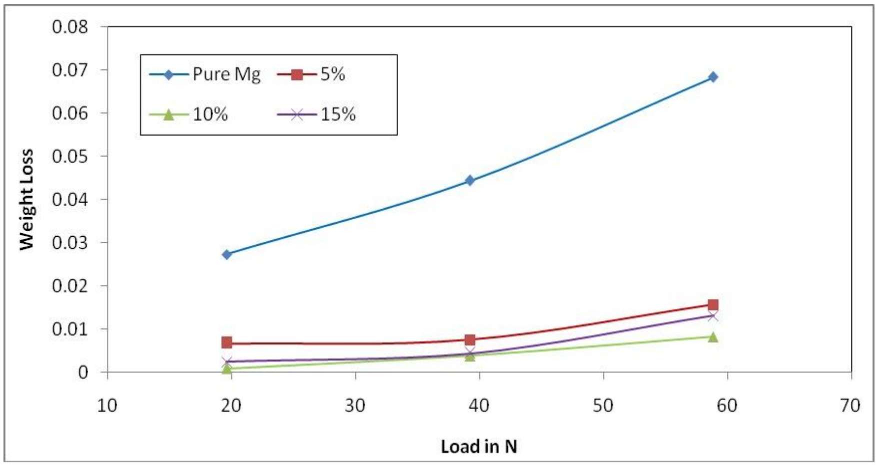

Figure 7: Graph of Load v/s weight loss

Figure 5, 6, 7 Shows the Graph Plotted for load v/s weight loss for different speed of disc 200, 400, 600 RPM having sliding distance of 282.74m, 565.48 m, 848.55m respectively, which shows that weight loss is increases with increasing the load. Also shows that due to the reinforcements of SiC and Al_2o_3, wear resistance of magnesium mmc's are increases with the increase in the percentage of reinforcements. At 15% composition, due to the weak bond between reinforcement particles and matrix, weight loss of specimens is increases with the increasing in the load as compared with 5% and 10% composition.

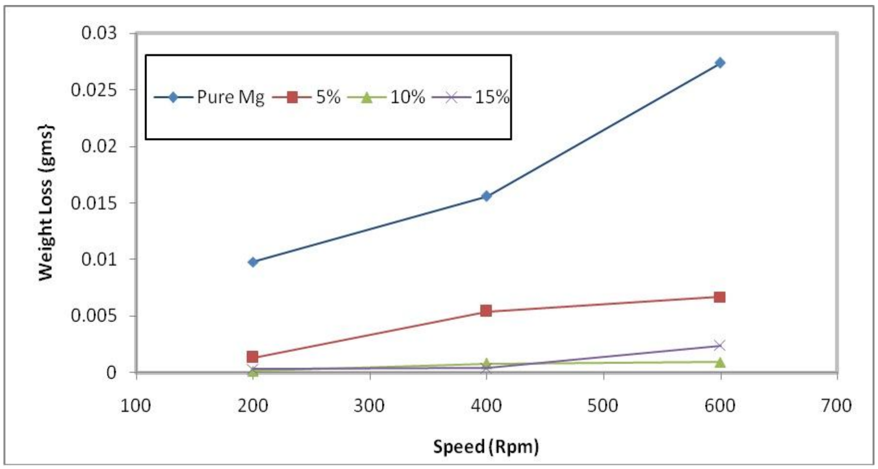

Figure 8 : Graph of Weight Loss v/s Speed

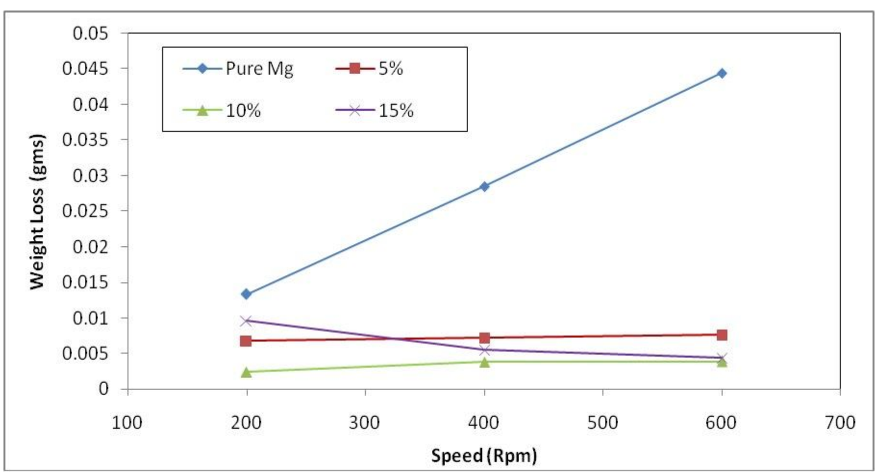

Figure 9 : Graph of Weight Loss v/s Speed

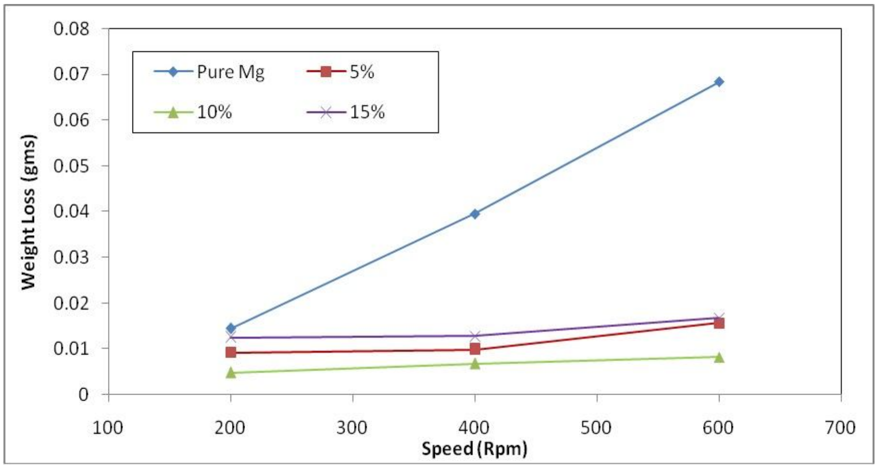

Figure 10 : Graph of Weight Loss v/s Speed

Figure 8, 9, 10 Shows the Graph Plotted for 2 Kg (19.62N), 4 Kg (39.24N) and 6 Kg (58.86N) of load having sliding distance of 282.74m for 200rpm, 565.48m for 400rpm, and 848.23m for 600rpm, time= 5minutes, shows that weight loss of the mg mmc's are increased with the increase in the speed of a rotating disc. Also shows that due to the strength of reinforcements of alumina and SiC, weight loss of specimens decreases with the increase in the reinforcement percentage.

IV. CONCLUSIONS

By powder metallurgy technique, Magnesium metal matrix composites reinforced with 5wt%, 10wt% and 15wt% Silicon carbide and alumina particles were effectively developed.

Hardness and Wear test were successfully carried out on test ready specimens.

The results reveals that, the hardness of magnesium metal matrix composites reinforced with 5wt%, 10wt% SiC and Al_2O_3 particulates were increased as compared with pure magnesium.

Wear rate found to increase with increase in sliding distance and load. Also found that wear resistance of composites increases with the increasing of reinforcement percentage.

By adding more than 15% of reinforcement to magnesium matrix alloy, the wear resistance of metal matrix composites decreases because of irregular distribution of reinforcement particles in the matrix alloy.

V. ACKNOWLEDGMENT

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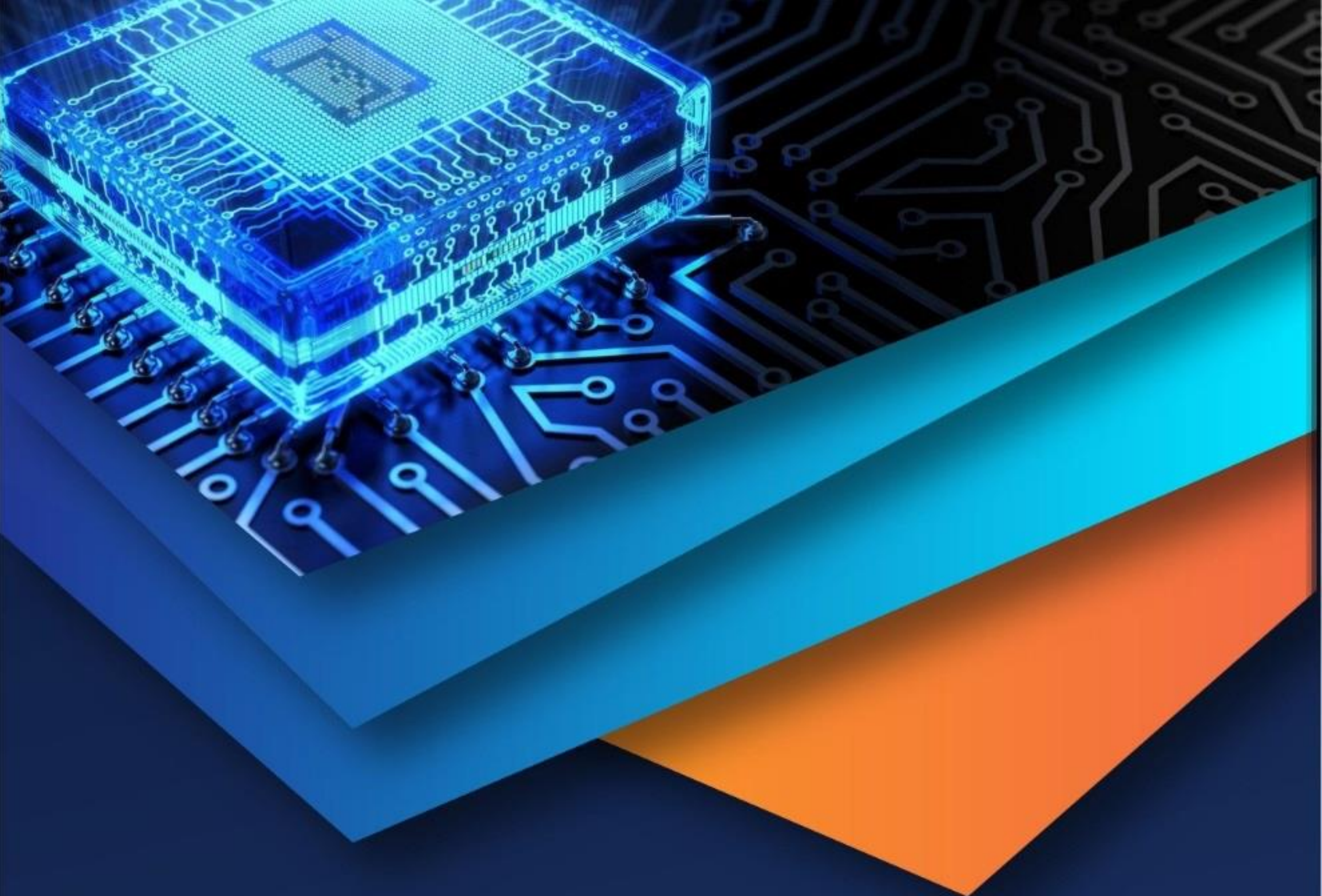

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