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Compressive Strength Prediction in Material Non-Linearity by Analytical and Finite Element Method

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Abstract: The current work aims to determine the characteristics of AA7050 compression behaviour by conventional analytical method and the method of finite elements. This started with the synthesis of composites, which include reinforcing alloy elements, namely silicon carbide, fly ash and graphite particles, as well as the pure metal AA7050. This is achieved by means of a vortex method under the path of induction casting. Two standard size samples (H / D to 1 and 1.5 ratio) are made from each of the two different combinations listed, with pure AA7050. The sample was examined to see if the compression strength and deformation behavior by UTM INSTRON were without friction conditions. The plastic behavior of the sample was studied based on several efforts and was validated by the results obtained from finite element analysis and found to be a good match.
Keywords: Compression, AA7050, Materials, Sic/FA/Gr, Hydro static stress, FEM

I. INTRODUCTION

7050 is aluminium alloy, with copper as the main alloy element. It is used in applications requiring a high strength / weight ratio, as well as good fatigue resistance. It is only weldable by friction welding and has average machine capacity. Because of the low wear resistance, it is often coated with aluminium or Al-1Zn for protection, although this may reduce fatigue resistance. In older terminology systems, 7XXX alloys were known as duralumin, and these alloys were called 24ST. Al.7050 pops up commonly, and is also available in panels and lambs. Not usually forged

Table 1.1 Chemical composition of the prepared 7050 AA alloys (in wt%).

Al	Cu	Mg	Zn	Zr	Balance
89	2.3	2.3	6.2	0.12	0.08

The chemical composition of commercial alloys AA 7050 (in% by weight) is given in Table 1.1. It indicates that the chemical composition of the modified alloy corresponds to that of AA 7050 commercial alloys. Silicon carbide has a close density of aluminum, and is better for making compounds with good strength and good thermal conductivity. Silicon carbide powder has been produced in large quantities since 1893 for use as an abrasive. Silicon carbide pellets can be bonded more firmly by sintering to form a high-strength ceramic that is widely used in applications requiring high strength, such as car brakes, car clutches and ceramic plates in bulletproof vests. Diamond is similar in many important respects: it is transparent and hard (9–9.5 on Mohr scale, compared to 10 for diamonds), with a refractive index between 2.65 and 2.69 (compared to 2.42 for diamonds).Fly ash or combustion ash, also known as pulverized ash ash in the United Kingdom, is a coal combustion product consisting of particles (fine particles of burned fuel) removed from coal boilers along with flue gas called ash that falls to the bottom of the combustion chamber in the boiler (Usually called the combustion box) the lower ash. In modern coal power plants, fly ash is usually captured by electrostatic precipitators or other particle filtering equipment before the combustion gases reach the chimneys. Graphite is considered an ancient industrial mineral as it has been extracted due to its beneficial properties (lubrication, pigmentation, writing, etc.) thousands of years ago.

II. LITERATURE SURVEY

Several researchers have investigated the behavior of solid cylindrical samples during cold forging because of their great technical importance in the process of forming metals. Johnson and Maylor published a comprehensive review of them [1]. Another important aspect of symmetric shaft compression from the standpoint of testing the metal fabrication properties is its estimate of the formation limits for plastic instability and, accordingly, fractures, as Shaw and Avery have explained [2]. Friction cannot be completely eliminated during the modified forging process and it is necessary to find a correction factor for the pumping process while mold design. Kulkarni and Calbak Jian [3] examined the barrel of the barrel, which led to the assumption that it could be circular or equivalent in cross section. Meanwhile, Schley et al [4] presented a comprehensive report on the various engineering factors affecting the size and shape of the barrel. Banerjee and Narayanasami et al. [5] Theoretically demonstrated that the radius of the scan can be expressed as a (axial) deformation function and later confirmed by empirical analysis. Yang et al. [6] The upper limit theory was developed to determine the tamper-bearing load and the appearance of deformed swelling while changing the forging of cylindrical bars under different friction conditions varying on flat mold surfaces. Chen, Chen et al. [7] It developed a theoretical solution to predict flow pressures during a disturbing process, taking into account the impact of the survey. Gokler and others. [8] Conducted a comprehensive study on conical flipping using FEA (Finite Element Analysis). Narayanasami and Pandey [9] studied the effects of aluminum hard disk stacking on cold noise. Malayappan and Narayanasamy [10-11] performed experimental analysis of barrel phenomenon under different friction conditions with insertion of ejaculation restrictions in one. Ramakanth, VeeranjaneyuluKodeti, Dr. GVR Seshagiri Rao [12] provides dynamic analysis of 6065 aluminum alloy plates (BP), floor panels (MP), spring plates (SP) and bare dough spring plates (SMBP) within the limits of different conditions The mission of this project is to study the vibratory response of many Of persons in sheet boundary conditions with uncertain parameters at different frequencies. U. S. Ramakanth, Potti Srinivasa Rao [13] explains that the investigation examined the effect of such ash and flies on the wear and tear behavior of aluminum 7075/5 aluminum and the weight ratio of the hybrid complex. 7075 aluminum alloy reinforced with fly ash checked. This study investigates the efficacy of the formation of such compound in the compound to obtain corrosion reduction. Uppada Rama Kanth, Putti Srinivasa Rao, MallarapuGopi Krishna [14] This article reports on the ability of microscopic and mechanical behavior, aluminum and zinc alloys, enhanced with fly ash and silicon carbide (SiC). The preparation of the compounds promoted flies and ash weight in each of 0 to 10, with percentages.Particle size, 53% micro meter.

III. DEVELOPMENT AND TESTING OF AA7050 HYBRID METAL MATRIX

A. Development of AA7050 Hybrid Metal Matrix

The current revision refers to the method used to cast the induction shown in Figure 1.1 to Figure 1.3. In the introductory segment, the casting methodology was introduced by induction with a scheme to give an overview of the general process of casting metal matrix compounds. During this process, the molten matrix and Sic-Fly Ash-Gr were stirred with a mixture of 450 rpm. When the temperature of the matrix metallic materials decreased to near the melting point. What impedes the stirring process, the process is stopped, but the matrix material is heated again to 700 ° C to ensure homogeneity of the mixture. Mechanical agitation (carried out using an inductor driven by an electric motor) is used to break up silicon carbide particles into a matrix alloy. Preheated heating particles are added to the thaw and stirred at 650 rpm for 5 minutes. This is the presumed composition composition that will be mixed as specified in proportions giving different resistance specifications for the test sample. The largest force that can be gathered in this process will appear.

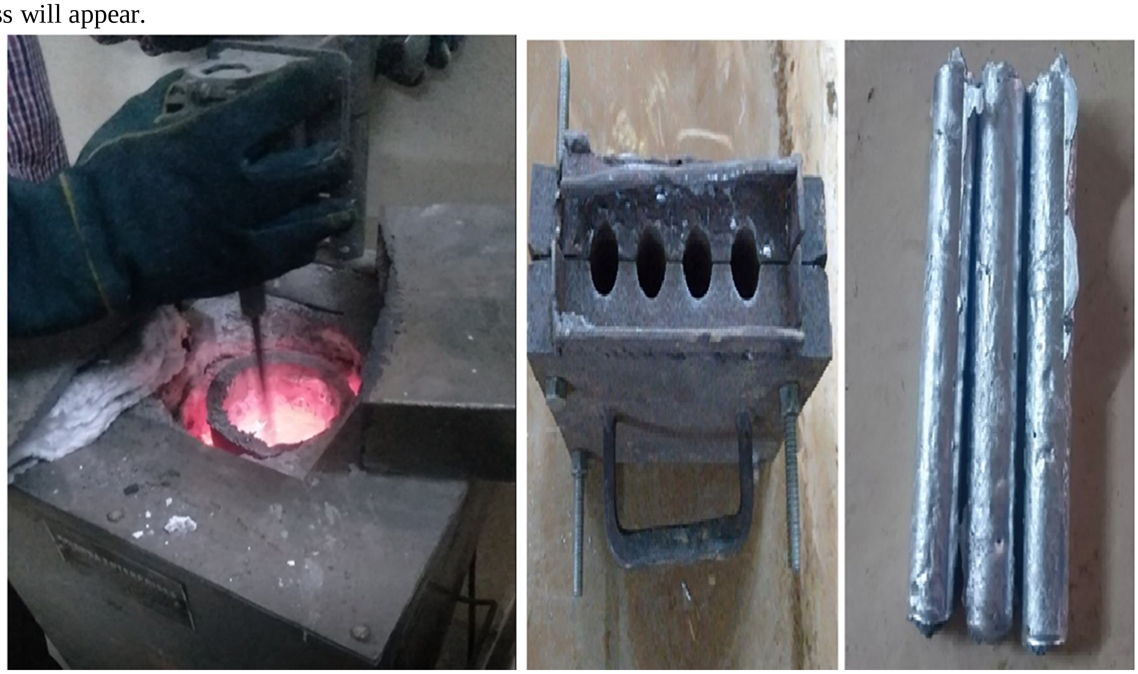

Fig 1.1 stir casting, Cast Iron Die and fabricated samples

B. Machining & Compression Test On UTM

After casting was done the prepared casting samples are machined and tested as shown in Fig1.2 on the turret lathe machine and other accessories used in machine tool lab. The compression samples of L/D ratio 1.0 and 1.5 were prepared finally. These fabrication samples were used in upset forging analysis. The UTM was (instron type) used for conducting on prepared samples made of AA 7050 and AA 7050/SiC/FA/Gr materials. The experiments were conducted for L/D ratio 1.0 & 1.5 for the two different materials like AA 7050 and AA 7050 /Sic/ fly ash/Gr. The test was carried out up to broken of the specimens. Fig 3.6 to 3.9 shown the strain stain curve data generated by UTM.

Fig 1.2 Machining the casted samples & Testing on UTM(Instron)

C. Design Calculations

The plastic behavior of L/D ratio 1.0 and 1.5 samples made of AA 7050 & AA 7050/SiC/FA/Gr materials were analyzed using the theory of plasticity.

% of Reduction in Height = $\left(\frac{\mathrm{H0-Hf}}{\mathrm{H0}}\right)*100$ 1

% of Reduction in Area $=\left(\frac{d_f^2.-d_0^2.}{d_0^2}\right)*100$ 2

$D_f = D_0 * \sqrt{\frac{H0}{Hf}}$

The axial and the circumferential strains were calculated for each element from the measurements obtained according to

$$\varepsilon_z = \ln\left(\frac{h_i}{h_0}\right) \quad \text{and} \quad \varepsilon_\theta = \ln\left(\frac{w_i}{w_0}\right) \qquad 3$$

Where *h0* and *w0* are the initial height and width of an element (Figure 4.1) respectively, and *hi* and wi are the current height and width of the element, respectively. This following Tables 4.1 to 4.4 gives us the complete information of the compression test results calculated using equations 1,2, and 3. The K (Strength coefficient) and n (Strain Hardening Exponent) values are increased with increasing of reinforcement content in the AA 7050 material. If K and n values are increased the material having get good elastic properties. Compare to AA 7050, the AA 7050/SiC/FA/Gr material having good elastic properties.
Table 1.2 & 1.3 Shows the Plastic Analysis Results for L/D Ratio 1.0 and 1.5.

Table 1.2 Plastic Analysis Results for L/D Ratio 1.0

RESULTS	AA 7050	AA 7050/SiC/FA/Gr
	ANALYTICAL	
Max Displacement (mm)	6	6
Axial Stress (Mpa)	220.25	167.4
Circumferential Stress (Mpa)	-58.64	-45.41
Hydro Static Stress (Mpa)	-1.13	-25.32

Table 1.3 Plastic Analysis Results for L/D Ratio 1.5

RESULTS	AA 7050	AA 7050/SiC/FA/Gr
	ANALYTICAL	
Max Displacement (mm)	9	9
Axial Stress (Mpa)	108.82	100.21
Circumferential Stress (Mpa)	-31	-30.31
Hydro Static Stress (Mpa)	-18	-0.4

D. Finite Element Simulation

In the present analysis model, it is analyzed using AA 7050 and AA 7050 / SiC / Fly Ash. From the given pressure pressure and pressure pressure, the effective stress and tension is calculated. The cylinder is designed with AA 7050 and AA 7050 / SiC / Fly ash, and the matrices are made of steel. Material models were chosen based on the characteristics of the tools and the pallet materials. Due to the high structural rigidity of the tools, the following flexible properties of the tools (H13 steel) are set on the assumption that the material is isotropic. Young Unit E = 210 GPa and Poisson Ratio _ = 0.30.Finite Element Analysis of Cold Deformation Behavior analysis of cylindrical samples was performed with dimensions of 1.0 and 1.5 for the AA 7050 and AA 7050 / SiC / Fly Ash / Gr samples, respectively. Since high-speed computing computers are now available on the market at a relatively cheaper cost, computing time is not an important constraint to solving the problems of small 3D models. It uses a 3-D top-tier quadrilateral element, 8 nodes, CONTA 174 (from ANSYS Library) that can be contained in solids or 3D envelopes with nodes on the middle side. It can be transformed into 3/3-nodes shapes 3-7. The contact surface has been mixed with CONTA 174. TARGET 170 (from the ANSYS Library) is used to represent many target 3D surfaces of linked communication elements. The contact elements overlap with the solid elements describing the boundaries of a potentially deformed object in contact with the solid surface of the target, defined by TARGET 170. Consequently, the target is only an engineering entity in space that detects and responds when one or more contacts move to a target slide element. Fig 1.3 shows the Holloman Power law stress – Strain curve and meshing obtained from ANSYS, Fig 1.4 &1.5 Contact Elements of Die and work piece, Max displacement and hydro static Stress for L/D Ratio 1.0 & 1.5 for AA7050.

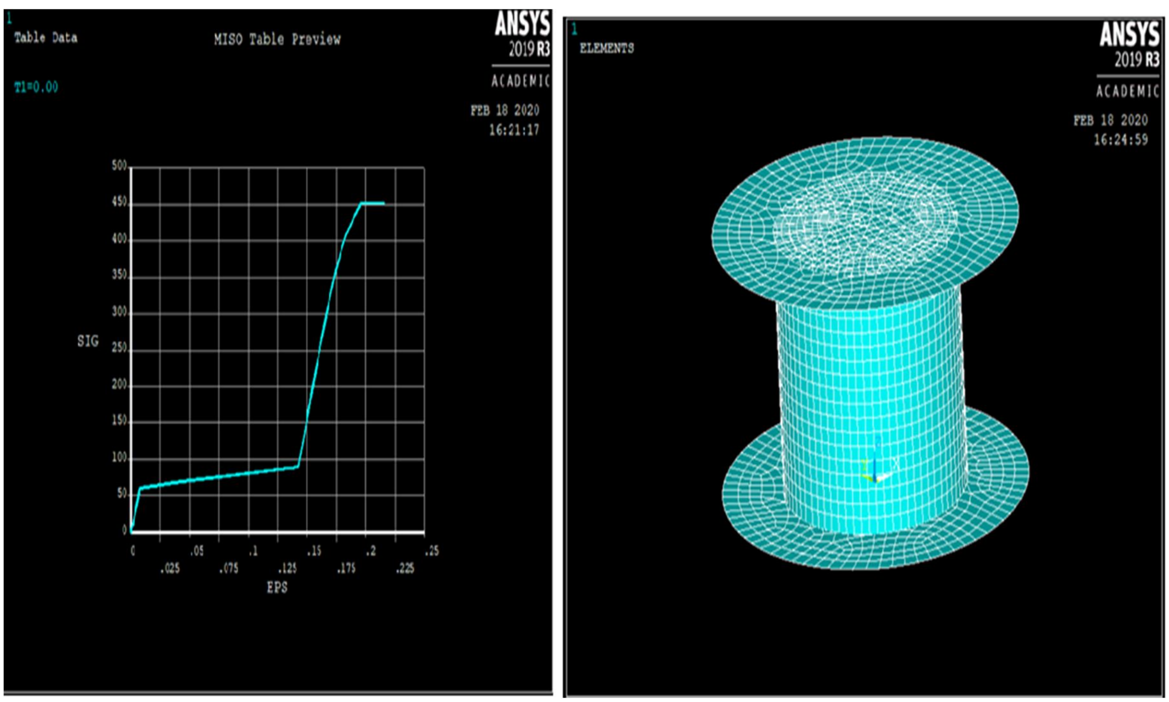

Fig 1.3 ANSYS stress-strain Curve and meshing for L/D Ratio 1.0 for AA7050

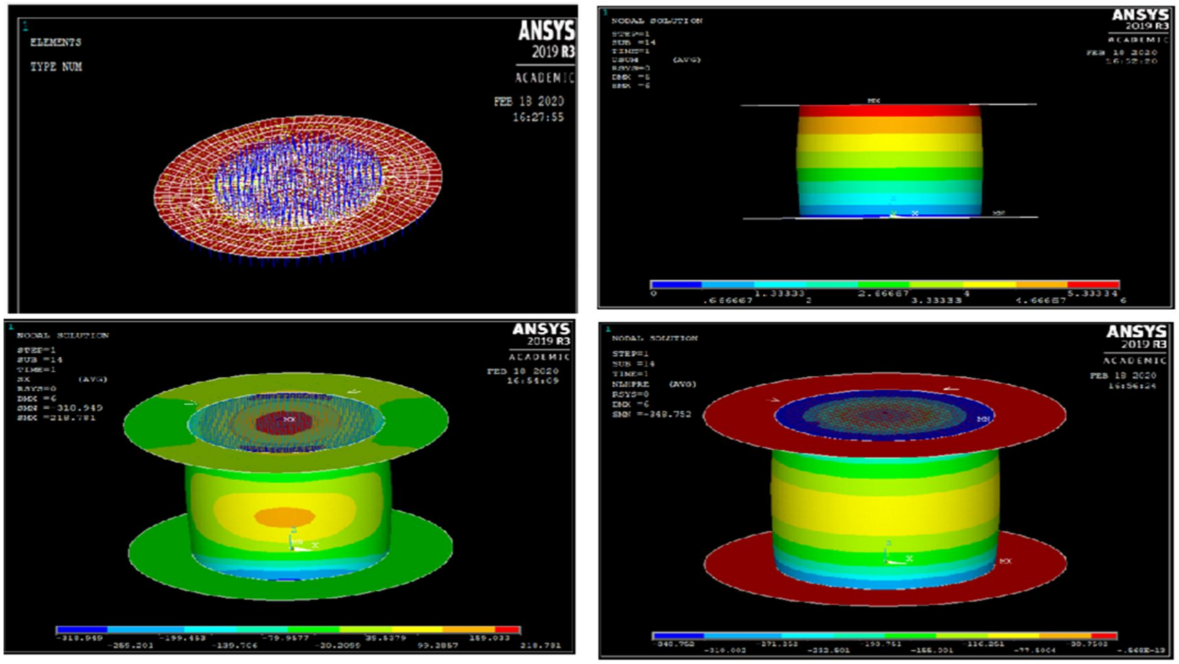

Fig 1.4 Contact Elements of Die and work piece, Max displacement and hydro static Stress for L/D Ratio 1.0 for AA7050

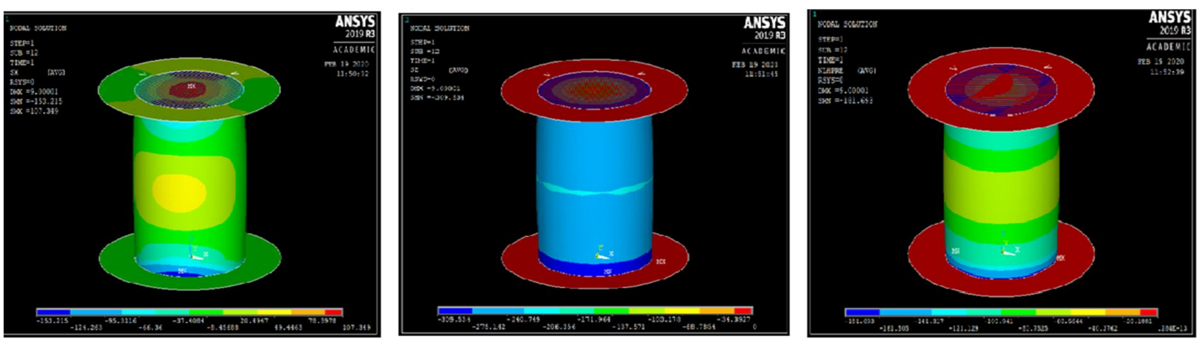

Fig 1.5 X, Z Component Stress and hydro static Stress for L/D Ratio 1.5 for AA7050

IV. RESULTS AND DISCUSSIONS

Hollomon Power Law Parameters True stress vs true strains were calculated using Load – displacement data; during the cold upsetting of alloy and composites. The calculated true stress vs true strains were fit into well-established Hollomon power law given by:□ = K□^{n} ,Where: □ = true stress,,□= true plastic strain ,K= strength coefficient, and n = strain hardening exponent

From the Tables 1.4 reports that K strength coefficient and n strain hardening exponent values of AA 7050 and AA 7050/SIC/FA/Gr materials of L/D ratio 1.0 & 1.5. The material is AA 7050/SIC/FA/Gr having good elastic properties compare to AA 7050 material for L/D ratio 1.0. The material AA 7050 is brittle in nature because the K and n values are low, if those values are low the material is brittle in nature in the after-elastic limit, these confirm by the many researches. Compare to L/D ratio 1.5 the L/D ratio 1.0 is good because the K and n values are positively obtained in this project work. The pistons and springs today they are taken L/D ratio 1.0 for Aluminium alloys. The new invention material AA 7050/SIC/FA/Gr is excellent material properties than a traditional AA 7050. Table 1.5 & 1.6 Plastic Analysis Results for L/D Ratio 1.0 &1.5 obtained from ANSYS.

Table 1.4 show the K & n Values of L/D ratio 1.0 & 1.5 for AA7050 & its composites

Type of Material	L/D 1.0		L/D 1.5	
	K	n	K	n
AA 7050	407.48	0.535	354.6	0.528
AA 7050/SiC/Fly Ash /Gr	1127	0.738	808.35	0.702

Table 1.5 Plastic Analysis Results for L/D Ratio 1.0 obtained from ANSYS

RESULTS	AA 7050	AA 7050/SiC/FA/Gr
	ANALYTICAL	
Max Displacement (mm)	6	6
Axial Stress (Mpa)	218.18	178.05
Circumferential Stress (Mpa)	-64-0	-49-0
Hydro Static Stress (Mpa)	-56e-13	-32-0

Table 1.6 Plastic Analysis Results for L/D Ratio 1.5 obtained from ANSYS

RESULTS	AA 7050	AA 7050/SiC/FA/Gr
	ANALYTICAL	
Max Displacement (mm)	9	9
Axial Stress (Mpa)	118.82	107.34
Circumferential Stress (Mpa)	-39-0	-34.39-0
Hydro Static Stress (Mpa)	-22-0	-0.284e-13

V. CONCLUSIONS

The following conclusion can be reached based on the present investigation.

A. AA 7050 alloy prepared in the laboratory was in tune with the commercial alloy.
B. Metal-metal composites of AA 7050 reinforced with Sic, Gr and fly ash alloy particulate have been successfully fabricated.
C. Resultant composites were produced by direct hot extrusion.
D. Composite with reinforcements have shown improved mechanical properties interns of density and ductility.

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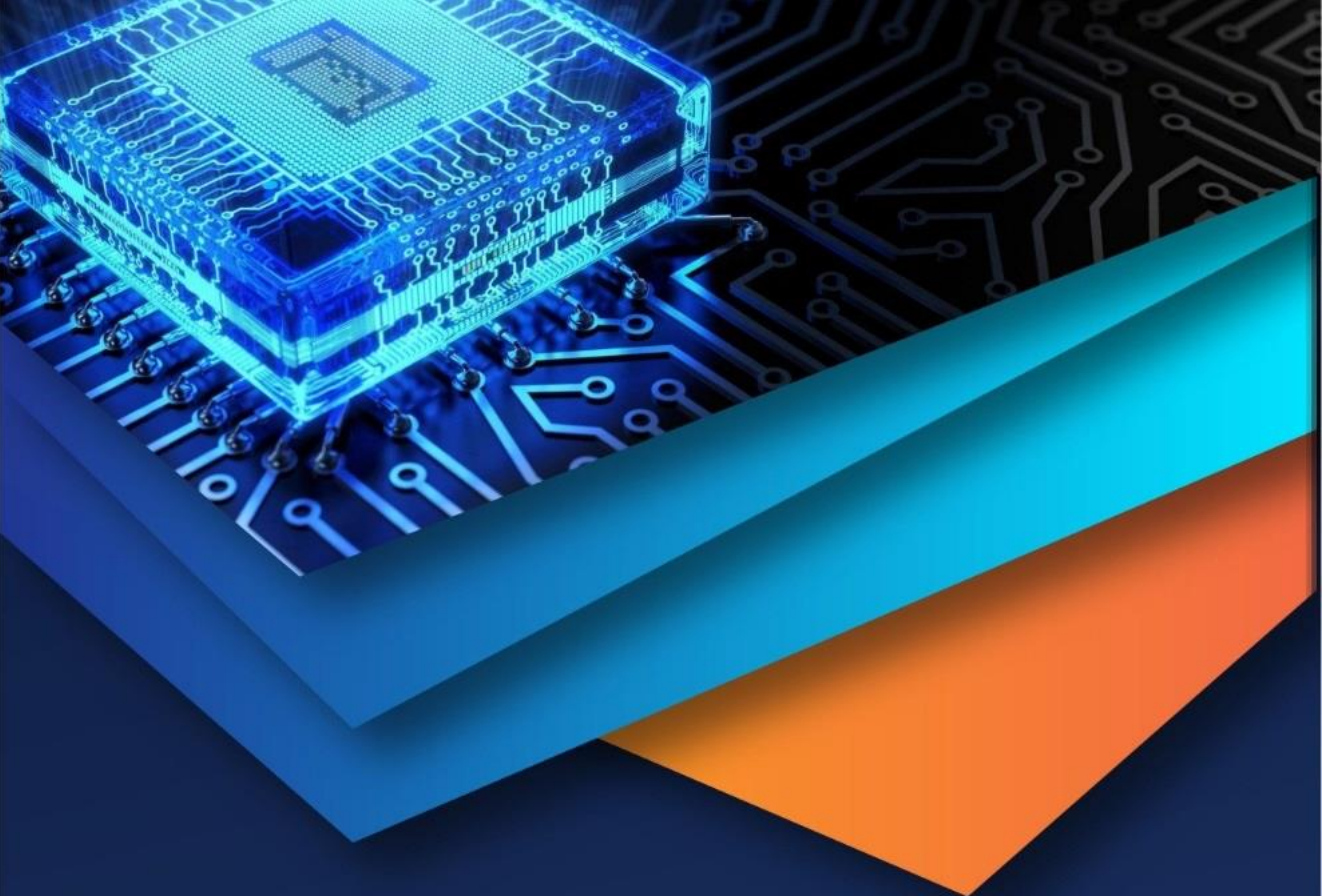

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