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Enhancement of MIG Welding Process Parameter using Activated Flux on MS E34 by Taguchi Technique

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Abstract: ***The present research work started with the objective to deliver best process parameters for the enhancement of weld properties in Metal Inert Gas Welding (MIG) process for MS E34 material. Three different fluxes SiO_2, Al_2O_3 and ZnO were utilized to weld 5mm thick sheet of mild steel. Taguchi Technique is implemented for investigating the influence of individual process parameters as well as interaction effects among parameters. The welding tests were conducted by utilizing Minitab 19 Software with L9 Orthogonal Array. The result of this study appeared that the penetration increases in impressive amount with the utilize of SiO_2 and ZnO flux. Welding current is found to be the most influencing parameter followed by welding flux.***
Keywords: Activated MIG Welding, penetration, Taguchi Method, L9 Orthogonal array, ANOVA analysis, Filler Wire Sticking defect

I. INTRODUCTION

Metal Inert Gas welding is an arc welding technique wherein coalescence is done through heating the material with an electric arc generated among the workpiece and electrode feed constantly to the MIG welding gun. There is a trigger controlling device that's used to manipulate the velocity of the wire. The shielding gas is used to preserve the weld joint from contamination. The MIG is likewise referred to as Gas Metal Arc Welding (GMAW). In GMAW the welding may be achieved without difficulty in any position.

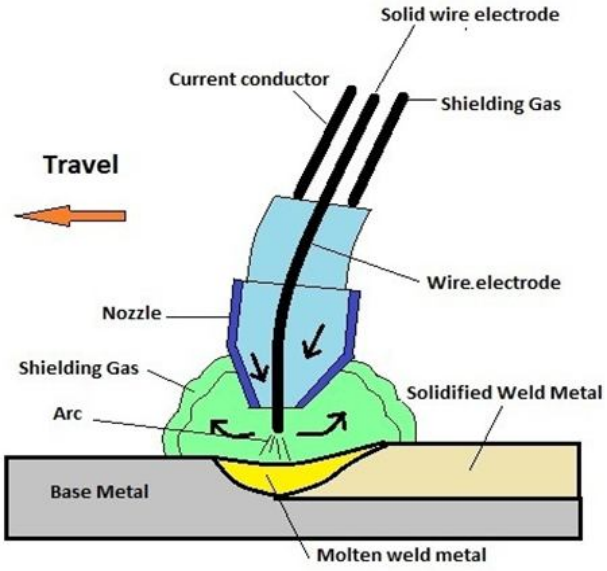


Fig. 1 MIG Welding Setup

The shielding gas used on this exprimentation is a aggregate of 80% argon and 20% carbon dioxide. This welding can be used for aluminium, carbon steel, stainless-steel and nearly on all metals. The activating flux has the oxides and halides in it. Oxide coating contains some factors like iron, calcium, cobalt, nickel, manganese, chromium, titanium, silicon, etc. Which play an essential function in the development of welding speed and weld quality. The test is executed on mild steel E34 sheet of dimensions 100×50×5 mm, which has large application in industry.

Vikas Chauhan et al. [1] founded on his examinations from that following conclusions are drawn which are MIG welding process is extremely successful to join stainless steel (SS-304) and low carbon steel. Voltage is the least influencing parameter for ultimate tensile strength while current is the highest. Erdal Karadeniz et al. [3] showed by his work that the welding current has the highest influence on penetration, up to 2.5 times greater than welding voltage and welding speed. Her-Yeuh Huang. [4] researched the effect of Activated flux on AISI 1020 carbon steel of 5mm thick material by MIG and found that the $MgCO_3$ flux give the best result than Fe_2O_3 and SiO_2 for getting dipper penetration and larger weld area. Patil S. R. et al. [5] showed in his experiment that welding speed has vital effect on tensile strength of weld. Sapkal S. V. et al. [6] found in his experiment that the optimal value from of 5.25mm penetration and 14.40 signal to noise ratio. Rakesh Sharma et al. [10] have studied the effect of different parameters on MS 5986 Fe 410 of MIG welded joint. He has given the optimum parameters for MIG welding for maximum penetration which are 42V voltage, 1mm/sec travel speed, 10 lit/min gas flow rate and 320A welding current.

G. Chaudhari et al. [14] used Taguchi Technique and AHP-MOORA & ASRS method to analyse the process and observed that the depth of penetration is higher with SiO_2 flux. as compared to without flux. Abrar Zaidi et al. [15] concluded in his experiment that with the use of flux the penetration and hardness are improved in considerable amount as compared to the traditional welding. H. R. Gazvinloo et al. [16] analyzed robotic Metal Inert Gas welding for material AA6061. He concluded that the depth of penetration increased by rising arc voltage and welding current. Aniket A. Kulkarni et al. [17] studied in his work that with the flux the penetration and strength of the weld is increased. Priyanka Shinde et al. [18] showed in her experiment that current is the most impacting parameter for penetration pursued by voltage and then gas flow rate. Nakul Agwan et al. [19] shows in his experimentation work by using Taguchi techniques and Regression analysis that penetration of the welded joint is increased by using activated flux powder of SiO_2, Al_2O_3 and ZnO.

II. EXPRIMENTAL WORK

A. Material and Activated Fluxes

The expriment is performed on Mild Steel and for that the sheet of dimensions 100 mm × 50 mm × 5 mm were taken. Three types of flux powders were used in the experiments which are Al_2O_3, SiO_2 and ZnO.

B. Application of Fluxes

The activated flux is in powder form and difficult to apply on the surface evenly, so paste is prepared by mixing it with acetone as indicated in figure 2. The acetone has a tendency to vaporise as soon as the oxide distributed evenly on their surface. The electrons are captured by outside region of the arc. The electric arc have low energy in week electric field and its attachment can done in the cooler regions. The high temperature and very high energy electrons will be dominated towards the centre of the arc in the region of strong electric field. Hence the flowing of current to the middle area of arc is restricted and which will increase the current density at anode and plasma resulting in thinner arc development and deeper size weld pool. The surface tension get changes from negative to positive due to increased in content of dissolved oxygen and which lead to a reversal of Marangoni effect.

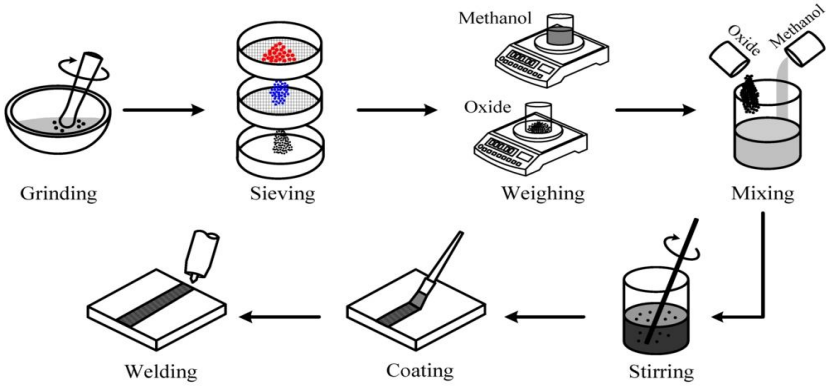


Fig. 2 Preparing and Applying Activated Flux Powder

The combination of the mentioned mechanisms only leads to improved penetration in A-Tungsten Inert Gas Welding by 300% and in Metal Inert Gas Welding to the considerable limit. In this paper, the effect of flux on depth of penetration and filler wire sticking defect is studied.

C. Welding Setup

The experiments are performed with mannual Metal Inert Gas welding process by keeping welding current, arc voltage and flux as a variable parameter. The response recorded is penetration and wire sticking defect. The chemical composition of the material are shown in table 1.

TABLE 1
Chemical Composition of Material

Material	Contents(%)
C	0.048
Mn	0.26
S	0.0087
P	0.015

D. Experimental Procedure

The samples were prepared to the required dimensions of 100×50×5 mm of mild steel sheet. The root face gap taken for the experimentation was 1mm, root gap of 0mm and groove angle was 60 degrees. The sheet is cleaned by rubbing it with silicon carbide paper to remove rust and impurities. The flux powder is mixed with the acetone to create a paste and applied over the area of the weld with the brush. The parameters that considerably affect the quality aspects were analyzed by Signal to Noise ratio. The penetration depth directly affects the quality of the weld. For maximizing the response larger signal to noise ratio is obtained.

Fig. 3 Welded Samples

E. Filler Wire Sticking Defect

I have completed my work in Badve Engineering Limited Waluj MIDC, Aurangabad. This defect was taken for the work because, the occurance of this defect daily is more than 45% of total defect. The MS E34 material has huge application in production of 3 wheeler chassis for Bajaj Auto. This defect is come under safety criteria, as due to this filler wire frequently accidents were occurred on production line.

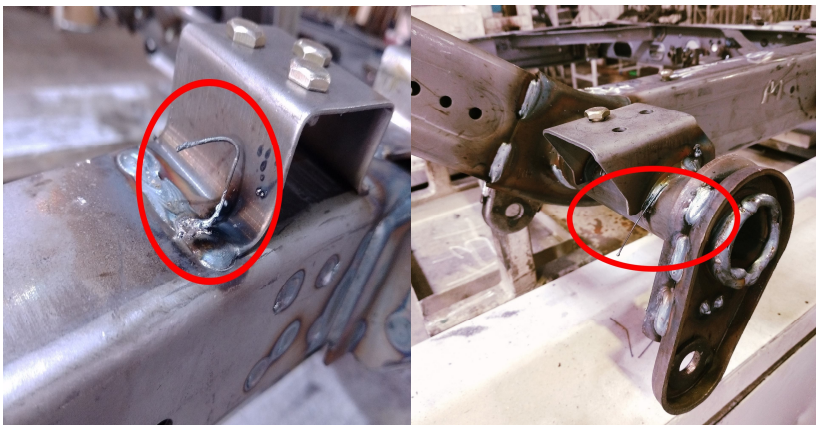


Fig. 4 Filler Wire Sticking Defect

F. Design of Experiment by Taguchi Technique

Taguchi method is widely used to enhance the quality of product and processes. The quality of product is improved when a higher level of performance is obtained consistently. Taguchi Technique is mainly used to find out optimum combination of design factor. In this research work for the design of experiments Minitab 19 software was used and number of experiments reduced by Taguchi technique.

Table 2. Levels of Design of Expriments

Levels of Parameters	Input Parameters		
	Current (Amp)	Voltage (Volt)	Flux Used
Level 1	170	18	SiO_2
Level 2	190	22	ZnO
Level 3	210	26	Al_2O_3

From the total number of factors and the levels, related orthogonal array is selected from the set of given orthogonal array. In this investigation L9 orthogonal array is selected on the basis of 3 factors along with their 3 levels are chosen. The levels for Design of Expriments is shown in Table 2.

TABLE 3. L9 Orthogonal Array

No. of Expriments	Welding Current (Amp)	Welding Voltage (Volt)	Activated Flux	Filler wire sticking defect
1.	170	18	SiO_2	Not Found
2.	170	22	ZnO	Not Found
3.	170	26	Al_2O_3	Not Found
4.	190	18	ZnO	Not Found
5.	190	22	Al_2O_3	Not Found
6.	190	26	SiO_2	Not Found
7.	210	18	Al_2O_3	Not Found
8.	210	22	SiO_2	Found
9.	210	26	ZnO	Found

III. RESULT & DISCUSSION

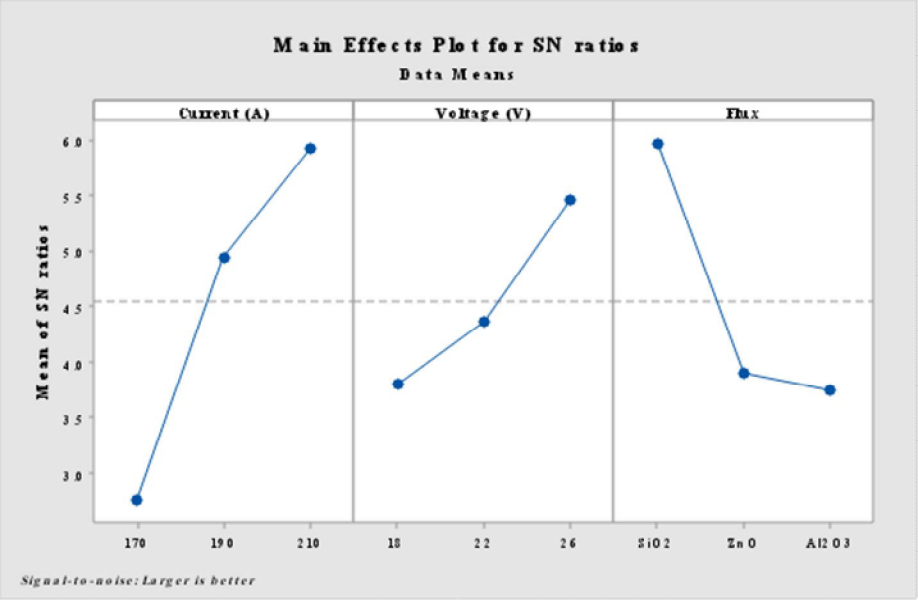
A. Result & Analysis for Depth of Penetration

The result for Metal Inert Gas welding with the activated flux powder for depth of penetration are shown in table 4. From result obtained from Taguchi Techiniques with Analysis of Variance, it is found that the SiO_2 flux gives maximum depth of penetration at higher value of current. The higher voltage is also responsible for getting higher penetration depth. From below table it is found that the SiO_2 flux with 210 Ampere current and 22 V voltage gives maximum depth of penetration.

Table 4. Depth of Penetration

Welding Current (Amp)	Welding Voltage (Volt)	Activated Flux	Penetration (mm)	S/N Ratio
170	18	1	1.678	4.48030
170	22	2	1.134	1.06157
170	26	3	1.450	3.23335
190	18	2	1.587	3.61398
190	22	3	1.787	5.05706
190	26	1	2.066	6.26046
210	18	3	1.579	3.96214
210	22	1	2.485	7.90303

210	26	2	2.147	6.63259



Graph 1. Means Plot for Penetration

From above chart it is concluded that 210 Amp current, 28 V voltage and SiO_2 flux are the optimum parameters.

B. ANOVA and Main Effect Plots for Depth of Penetration

The final response is depends upon the contribution of individual factor and its knowledge is important to get the accurate result. The ANOVA is a common statistical technique used to determine the contribution of every individual factor for the experimental results. ANOVA of Mild Steel E34 (MS E34) material data for Depth of Penetration is as shown in Table 5.

Table 5
ANOVA Table for Depth of Penetration for Mild Steel E34 Material

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Current	2	0.44421	55.58%	0.8333	0.4167	3.13	0.032
Voltage	2	0.13852	15.10%	0.1667	0.08333	0.31	0.039
Flux	2	0.6388	22.22%	0.3334	0.1667	0.71	0.042
Error	2	0.13111	07.10%	0.6667	0.1333		
Total	8	1.35393	100%	1.5000			
S =0.365148		R-Sq = 87%		R-Sq (Adj) = 82.56%			

From the Taguchi ANOVA computations it is found that the % contribution of current is highest which is 55.58%, followed by flux with 22.22% and then voltage with 15.10%.

C. Confirmation Test for Depth of Penetration

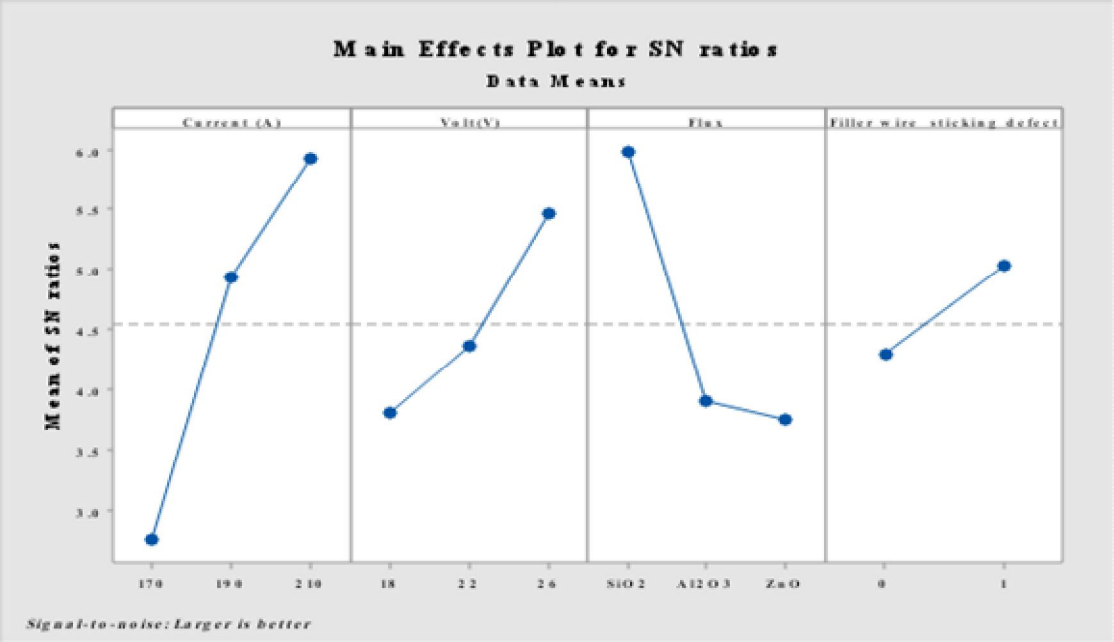
The result obtained from confirmation test is shown in table 6 below.

TABLE 6
Result of Confirmation Test for Depth of Penetration

Test	Predicted Value	Experimental Value	Error
Penetration	2.450	2.324	5.14%

D. Result & Analysis for Filler Wire Sticking Defect

Considering 1 for getting defect and 0 for no defect. From graph with Taguchi Technique, it is shown that the chances of occurrence of defect is high at higher welding current and at higher voltage. The SiO_2 flux is more prone to defect, while with others the chances of occurrence of defect is very less.



Graph 2. Means Plot for Filler Wire Sticking Defect

IV. CONCLUSIONS

A. The present work concluded that in order to get crucial selections of a MIG welding employing MS E34 material; it is necessary to consider possible options and characteristics like different ranges of parameters.

B. The percentage contribution of several parameters in the research work for Depth of Penetration are as follows: 55.58% welding current, 22.22% activated flux and 15.10% welding voltage.

C. The optimum condition of penetration are found to be 210 Ampere Current, SiO_2 flux and 22 Volt Voltage.

D. The filler wire sticking defect is mainly caused due to the higher welding current, higher voltage and with SiO_2 flux.

V. ACKNOWLEDGMENT

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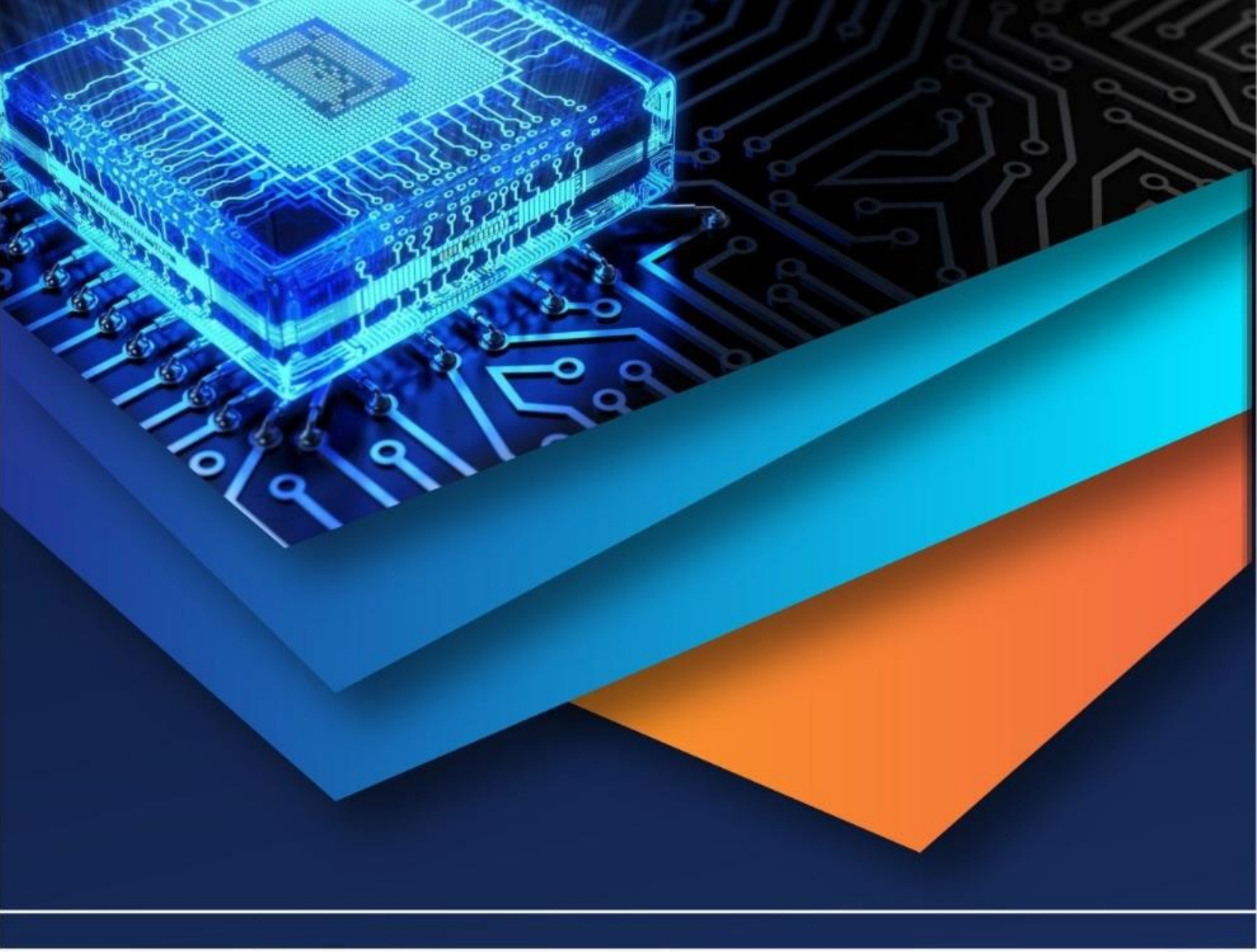

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