iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 8 Issue: XII Month of publication: December 2020

DOI: https://doi.org/10.22214/ijraset.2020.32600

Experimental Investigation on Material Removal Rate, Surface Roughness of Stainless Steel 306 by EDM

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Abstract: EDM [Electrical Discharge Machining] is the most sophisticated technique of non-conventional manufacturing process to machine most brittle and electrically conductive metals. This technique is widely used in aerospace industry, machining holes on the blades of the gas turbine to promote cooling of blades is an apt example. It is also in practical use to machine intricate contours of die to make moulds and castings. The work piece selected in this project is SS-306 [stainless steel] because of its wide applications and suitable properties demanded by this project. The input parameters are CURRENT, PULSE –ON TIME, DUTY CYCLE. These parameters are selected as they are independent and are directly available on the machine and mostly these are the variables that will govern the expected output results of MRR and SR. Copper is selected as the electrode material because of its best suitable properties which are listed in this report in further readings. The whole experimentation is done by adopting guidelines laid by TAGUCHI METHOD including selecting of ORTHOGONAL ARRAY and way of conducting experiment. The final output of this project ends with the Optimum input variables that Maximizes the MRR and Minimises the SR
Keywords: MRR, Surface Roughness, Taguchi L-9 Array, SS-306

I. INTRODUCTION

In the Sinker EDM Machining process, two metal parts (cathode and anode) submerged in an insulating liquid called dielectric fluid (Dielectric fluid is initially an insulator for the electricity till a threshold limit is reached) connected to a source of current which is switched on and off automatically depending on the parameters set on the controller controlled by servo-controller unit installed on the same machine. When the current is switched on, an electric tension is created between the two metal parts. If the two parts are brought together to within a fraction of an mm, the electrical tension is discharged and a spark jumps across the dielectric fluid from one to another electrode and strikes that electrode. The metal is heated up so that it melts Sinker EDM, also called cavity type EDM or volume EDM consists of an electrode and work piece submerged in an insulating liquid such as, more typically, oil or, less frequently, other dielectric fluids. The electrode and work piece are connected to a suitable power supply. The power supply generates an electrical potential between the two parts with suitable amplitude and frequency set by installer or controller. As the electrode approaches the work piece, when current parameters reaches the threshold of the dielectric fluid, dielectric breakdown occurs in the fluid, forming a plasma channel, and a small spark jumps. These sparks usually strike one at a time because it is very unlikely that different locations in the inter-electrode space have the identical local electrical characteristics which would enable a spark to occur simultaneously in all such locations. These sparks happen in huge numbers at seemingly random locations between the electrode and the work piece. As the base metal is eroded, and the spark gap subsequently increased, the electrode is lowered automatically by the machine so that the process can continue uninterruptedly. Several hundred thousand sparks occur per second over a small area creating a huge spark density at a high frequency helping to heat the metal, erode and vaporise the base metal which is a work piece creating a cavity of machined surface. The actual duty cycle carefully controlled by the setup parameters depending on the melting point and thermal conductivity of metal being machined.

II. OBJECTIVES

The following are the objectives of this project

A. To experimentally investigate the Optimum cutting parameters for AISI SS-306 metal on the given machine [GRACE V5030 EDM] with copper electrode.
B. To understand and implement TAGUCHI method of optimizing the EDM process.
C. To find optimum value of MRR and its attributing variables limits.
D. To find optimum value of SR and its attributing variables limits.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue XII Dec 2020- Available at www.ijraset.com

III. EXPERIMENTAL METHODOLOGY

A. Work Material

The type of the work piece selected in this project is SS-306, which is basically a stainless steel. The following are the reasons for selecting this material.

1) *User Perspective:* This is the most commonly used STAILESS STEEL among all the SS used in the industry, **SS-316 also mostly used
2) *Technical Persective:* Stainless steel has more Ni content in austenite form hence this steel cannot be magnetised. So the error that can occur due to magnetising effects can be eliminated. This gives a scope of getting accurate results for understanding and evaluating the results.

B. Designing Steps In Taguchi Method Of Optimisation Of EDM Process

The following are the key steps involved in conducting the experiment using TAGUCHI METHOD:

1) Selection of independent variables
2) Selection of number of level settings for each independent variable
3) Selection of orthogonal array
4) Assigning the independent variables to each column
5) Conducting the experiments
6) Analysing the data
7) Inference
8) The details of the above steps are given below:

IV. RESULTS AND DISCUSSIONS

A. Analysis for Material Removal Rate

Table No.1: Experiment for MRR with L-9 approach

SL. NO.	CURRENT (Amps)	PULSE ON TIME(μ S)	DUTY CYCLE(%)	MATERIAL REMOVAL RATE VALUES(mm3/min)
1	2A	50	70	1.632
2	2A	100	80	2.12
3	2A	150	90	2.27
4	5A	50	80	8.752
5	5A	100	90	9.61
6	5A	150	70	7.69
7	8A	50	90	17.51
8	8A	100	70	16.029
9	8A	150	80	17.33

The above table indicates the values of MRR at various levels carried out with the selected input variables at the desired levels. Here MRR is the rate at which metal is getting removed from the given **SS-306.**work piece.

1) Effect of current on MRR

Table no.2: The net effect of current on MRR is calculated as below.

	NET EFFECT (MM3/ MIN)	
EFFECT OF CURRENT ON MRR AT LEVEL 1	E A 1 = (E1+E2+E3)/3	2.007
EFFECT OF CURRENT ON MRR AT LEVEL 2	E A 2 = (E4+E5+E6)/3	8.684
EFFECT OF CURRENT ON MRR AT LEVEL 3	E A 3 = (E7+E8+E9)/3	16.956

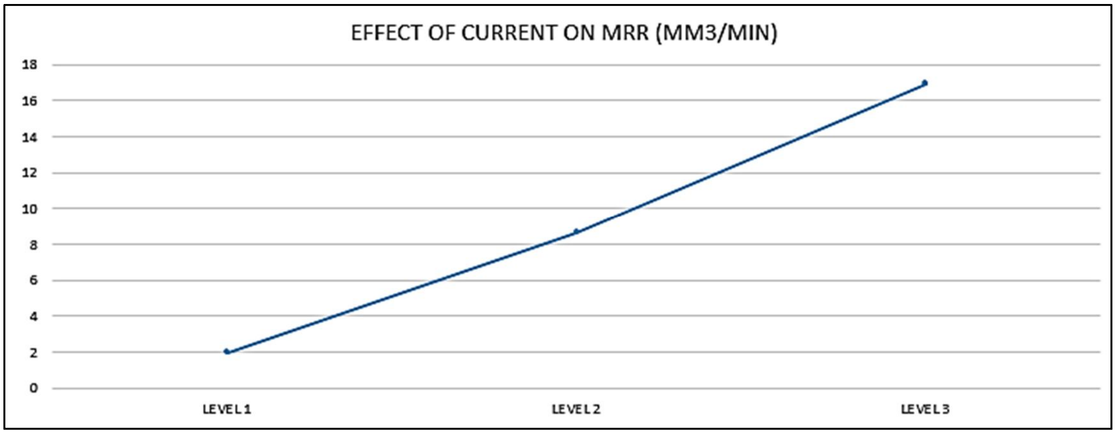

Fig no.1: graph shows the effect of current on MRR

The above graph shows the effect of current on MRR. It is shown that as current value increase MRR also increase linearly and indefinitely for the selected input variable levels.

2) Effect of Pulse On-Time on MRR

Table no.3: The net effect of pulse on-time on MRR is calculated as below.

	NET EFFECT (MM3/ MIN)	
EFFECT OF PULSE ON-TIME ON MRR AT LEVEL 1	E T 1 = (E1+E4+E7)/3	9.298
EFFECT OF PULSE ON-TIME ON MRR AT LEVEL 2	E T 2 = (E2+E5+E8)/3	27.759
EFFECT OF PULSE ON-TIME ON MRR AT LEVEL 3	E T 3 = (E3+E6+E9)/3	9.096

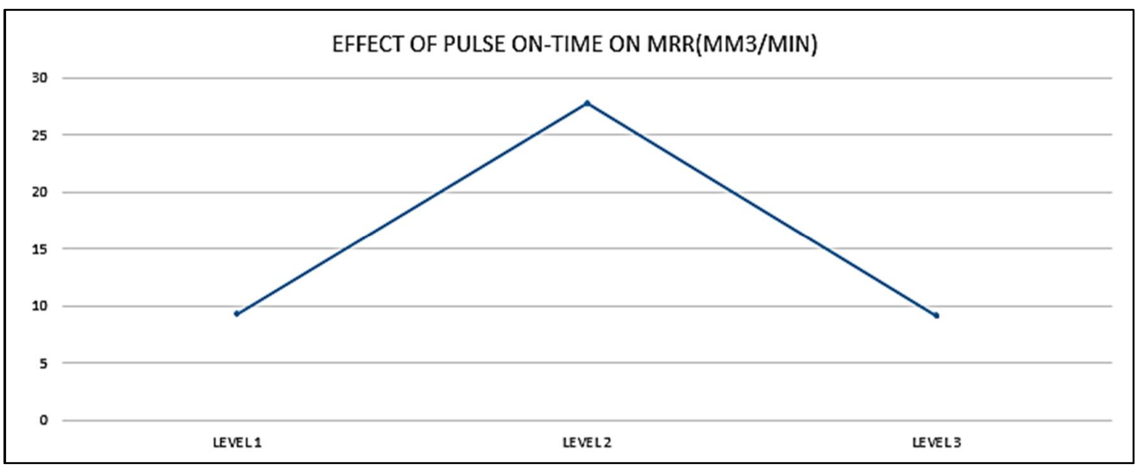

Fig.no.2: The above graph shows the effect of pulse on-time on MRR

3) Effect Of Duty Cycle On MRR

Table no. 4: The net effect of duty cycle on MRR is calculated as below

	NET EFFECT (MM3/ MIN)	
EFFECT OF DUTY CYCLE ON MRR AT LEVEL 1	E D 1 = (E1+E6+E8)/3	8.45
EFFECT OF DUTY CYCLE ON MRR AT LEVEL 2	E D 2 = (E2+E4+E9)/3	9.42
EFFECT OF DUTY CYCLE ON MRR AT LEVEL 3	E D 3 = (E3+E5+E7)/3	9.796

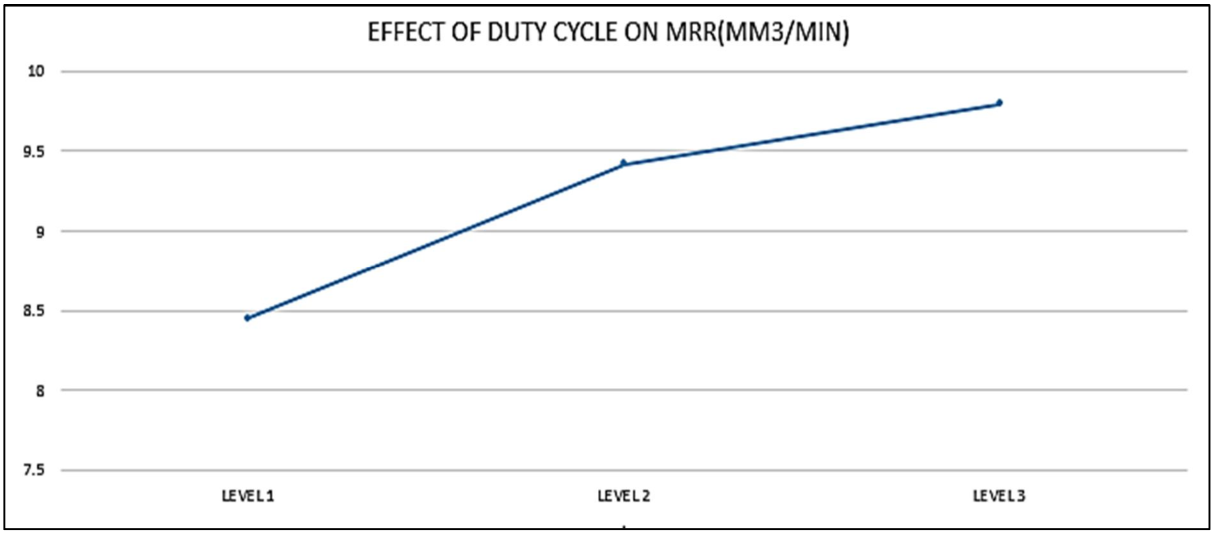

Fig. no.3: The above graph shows the effect of duty cycle on MRR

B. *Analysis for Surface Roughness*

The below table indicates the values of SR at various levels carried out with the selected input variables at the desired levels. Here SR is the surface roughness of the machined area for the given **SS-306.**work piece.

Table No.5: Experiment for SR with L-9 approach

SL. NO.	CURRENT (Amps)	PULSE ON TIME(µ S)	DUTY CYCLE(%)	SURFACE ROUGHNESS (µm)
1	2A	50	70	4.821
2	2A	100	80	4.712
3	2A	150	90	3.928
4	5A	50	80	6.732
5	5A	100	90	8.213
6	5A	150	70	7.823
7	8A	50	90	7.498
8	8A	100	70	9.327
9	8A	150	80	10.231

1) *Effect of Current on SR*

Table.no.6. the net effect of current on SR is calculated as below.

	NET EFFECT (µm)	
EFFECT OF CURRENT ON SR AT LEVEL 1	E A 1 = (E1+E2+E3)/3	4.487
EFFECT OF CURRENT ON SR AT LEVEL 2	E A 2 = (E4+E5+E6)/3	7.589
EFFECT OF CURRENT ON SR AT LEVEL 3	E A 3 = (E7+E8+E9)/3	9.018

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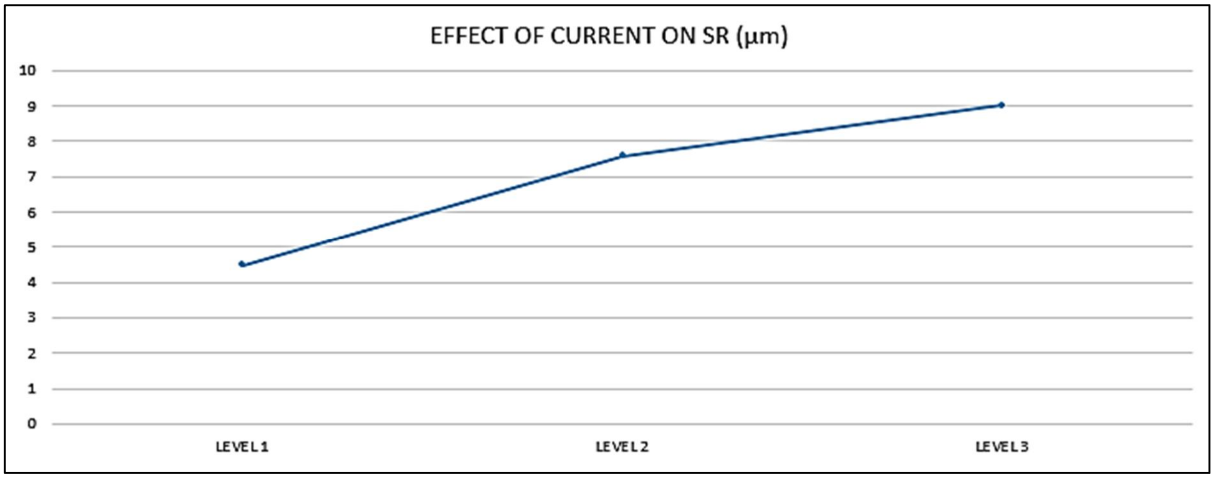

Fig. no.4: The above graph shows the effect of current on SR

2) Effect of Pulse On-Time on SR

Table.no.7. the net effect of pulse on-time on SR is calculated as below.

	NET EFFECT (µm)	
EFFECT OF PULSE ON-TIME ON SR AT LEVEL 1	E T 1 = (E1+E4+E7)/3	6.35
EFFECT OF PULSE ON-TIME ON SR AT LEVEL 2	E T 2 = (E2+E5+E8)/3	7.417
EFFECT OF PULSE ON-TIME ON SR AT LEVEL 3	E T 3 = (E3+E6+E9)/3	7.327

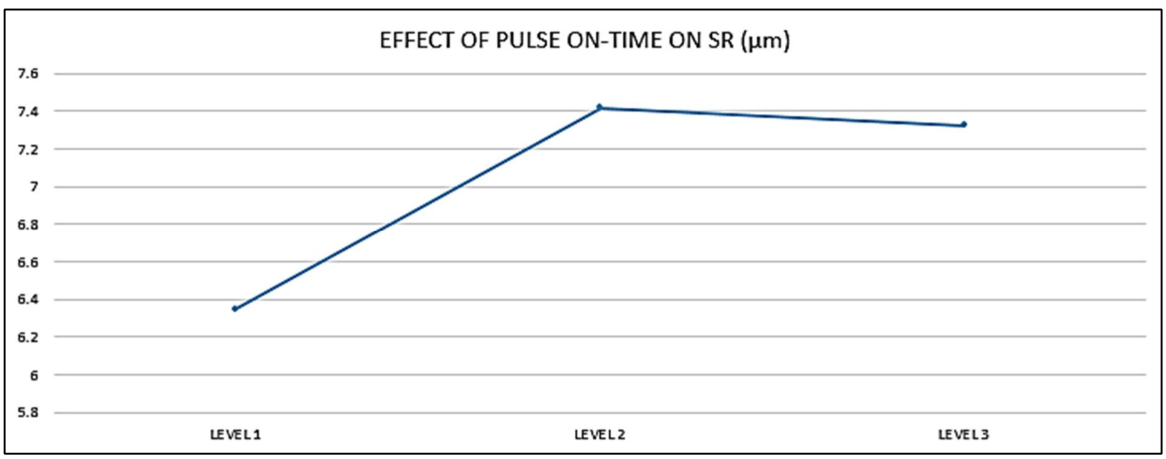

Fig. no.5: The above graph shows the effect of pulse on-time on SR

3) Effect Of Duty Cycle on SR

Table.no.8. the net effect of duty cycle on SR is calculated as below.

	NET EFFECT (µm)	
EFFECT OF DUTY CYCLE ON SR AT LEVEL 1	E D 1 = (E1+E6+E8)/3	7.323
EFFECT OF DUTY CYCLE ON SR AT LEVEL 2	E D 2 = (E2+E4+E9)/3	7.225
EFFECT OF DUTY CYCLE ON SR AT LEVEL 3	E D 3 = (E3+E5+E7)/3	6.546

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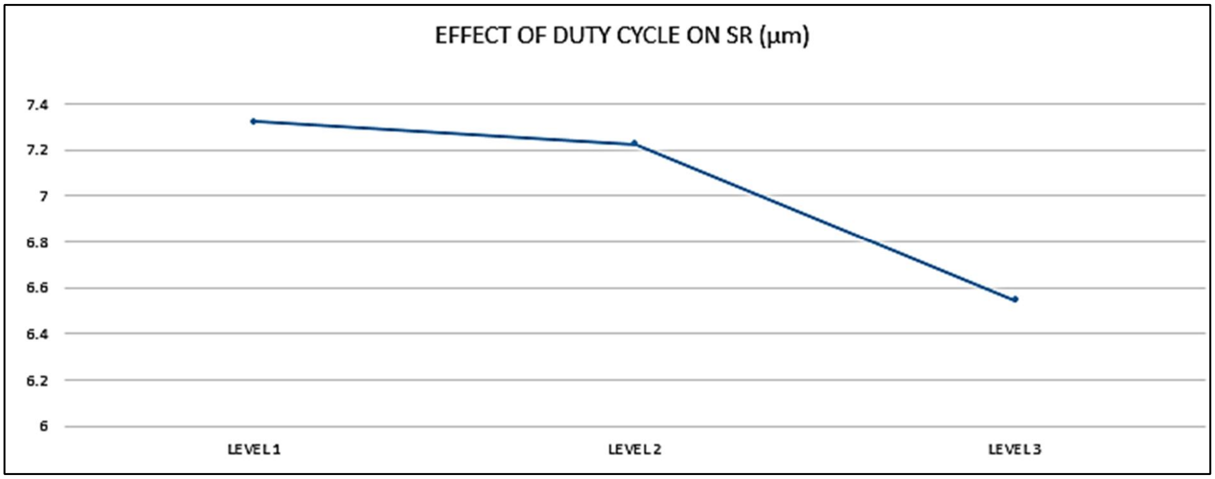

Fig. no.6: The above graph shows the effect of Duty cycle on SR.

V. CONCLUSIONS

The final output of this project ends with the Optimum input variables that Maximizes the MRR and Minimises the SR

A. *For MRR*

1) The effect of current is to increase MRR continuously. When current changed from 2-5 amps the effect to increase MRR at high rate, however this rate increases drastically when current is changed from 5-8 amps.
2) When pulse on-time is change from 50-100 micro seconds there is a increase in MRR but when it is further increased to 150 micro seconds the MRR decreases.
3) When Duty cycle is changed from 70-80% the MRR increases at higher rate but when it is further increased to 90% the MRR increases but at slower rate.

B. *For SR*

1) When current increases from 2-5 amps the effect to increase SR at high rate, however this rate increases slowly when current is changed from 5-8 amps.
2) When pulse on-time is change from 50-100 micro seconds there is a increase in SR but when it is further increased to 150 micro seconds the SR decreases.
3) When Duty cycle is changed from 70-80% the SR decreases and when it is further increased to 90% the SR decreases at higher rate.

So, it is concluded that in order to get the maximum material rate [MRR] the current should be kept at 8 Amps, Pulse on-time at 100 micro seconds and duty cycle at 90%. Similarly, to get lowest surface roughness the current should be kept at 2 Amps, pulse-on should be kept at 50 microseconds and duty cycle should be kept at 90%. So the increase in current can increase the MRR and decrease the SR the level at which it should be kept is decided by the cost trade-off, application and requirements of the manufacturer.

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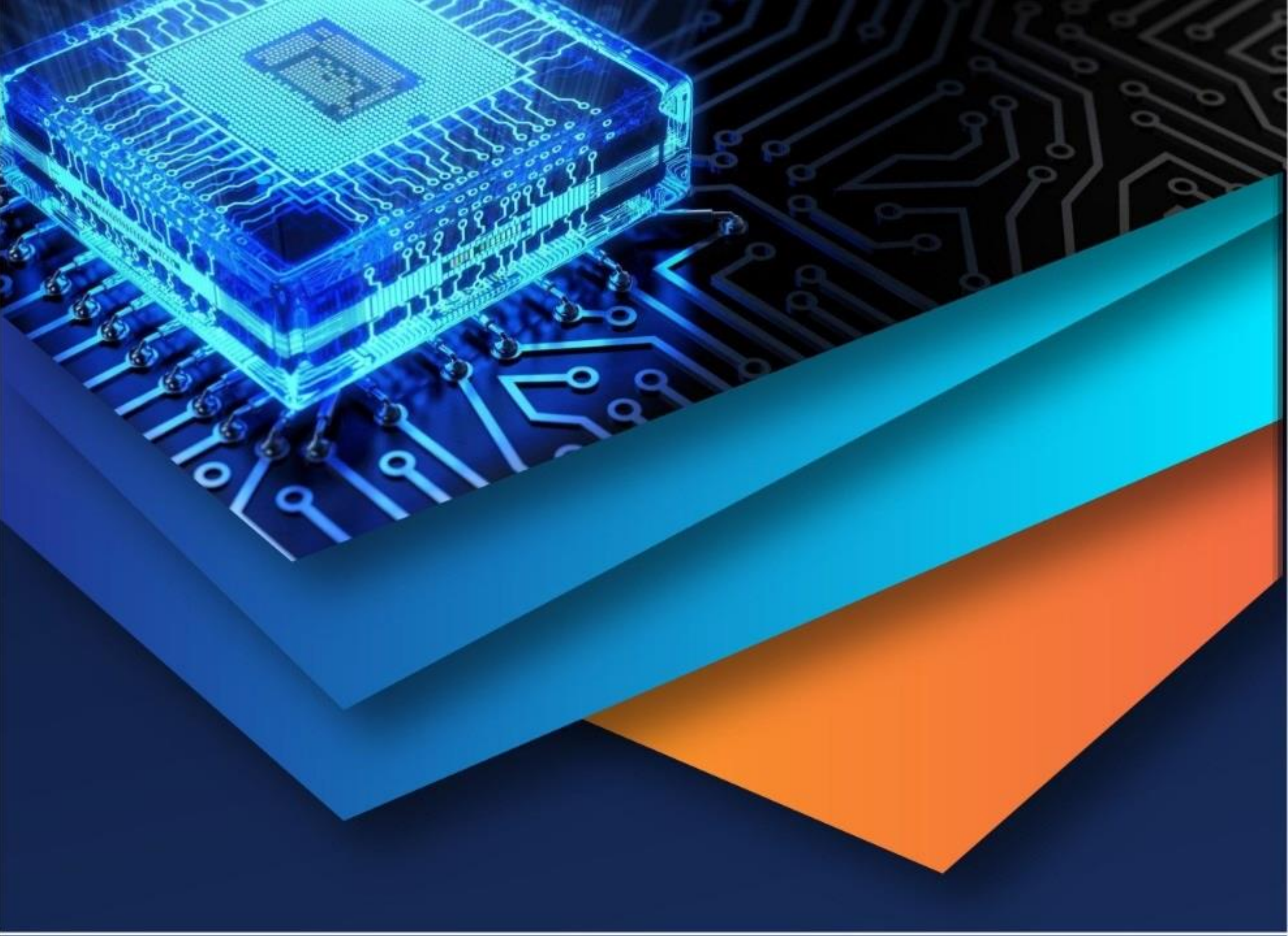

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