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Optimization of Cutting Parameters on Machining Quality in Turning Operation Using Magnetorhelogical (Mr) Fluid Filled Tool Post

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Abstract: The objective of the paper is to improve the quality of machining and to produce by using optimization techniques such as Taguchi. The effects of cutting parameters were studied in turning process using magnetorhelogical (MR) fluid filled tool post. The surface roughness of the components is very important to increase the quality of machining. The direct and interactive effect of process factors on response within the range of examination can be studied with ease from the Taguchi analysis. Taguchi analysis is done for optimizing the process factors such as speed, feed, depth of cut and depth of cut. The trials have been as per taguchi's L9 orthogonal array. "Smaller is best" S/N ratio typical is used to determine the means and Analysis of Variance (ANOVA) table is produced to control the numerical association of the factors. Response graphs are plotted to determine the desired level for each parameter. The feed is greatest influencing factor and its percentage of contribution is 74% on surface roughness. The current is contributed about 11% on surface roughness. The depth of cut is contributed about 14.4% on surface roughness respectively. The normal probability plot graph is obtained in the form of straight line so the errors are distributed normally.

Key words: Surface roughness, Magnetorhelogical fluid, Taguchi, Regression, ANOVA, Plots

I. INTRODUCTION

The design and optimal turning of multiple tuned mass dampers (TMDs) to increase chatter resistance of machine tools structures. Chatter free critical depth of cut of a machine is inversely proportional to the negative real part of frequency response function (FRF) at the tool-work piece interface. Instead of targeting reduction of magnitude, the negative real part of FRF of the machine is reduced by designing single and multiple TMD systems. The TMDs are designed to have equal masses and their damping, stiffness values are optimized to improve chatter resistance using minimax numerical optimization algorithm. It is shown that multiple TMDs need more accurate tuning of stiffness and natural frequency of each TMD, but are more robust to uncertainties in damping and input dynamic parameters in comparison with single TMD applications [1-4]. Regenerative chatter is the most detrimental to any process as it creates excessive vibration between the tool and the work piece, resulting in a poor surface finish, high pitch noise and accelerated tool wear which in turn reduces machine tool life, reliability and safety of the machining operation. There are various techniques proposed by several researches to predict and detect chatter where the objective is avoid chatter occurrence in the cutting process in order to obtain better surface finish of the product, higher productivity and tool life [5-9]. The magnetorhelogical (MR) fluids are a class of new intelligent materials whose rheological characteristics change rapidly and can be controlled easily in the presence of an applied magnetic field. The devices based on MR fluids. Including dampers, brakes, clutches, polishing machines devices and hydraulic valves, etc. have a very promising potential future some of them have been used commercially in engineering application such as automobiles, polishing machines, exercise equipment, etc. A comprehensive review is then presented of the principles characteristics and engineering applications of the MR fluid devices (especially dampers) studied in the last decade. Finally, the application prospects of MR fluid devices are discussed. The stability of thin floor parts, defining what cutting parameters make chatter appear and proposing one solution to instability problem based on Magnetorhelogical fluid shock absorber. This improvement requires an optimization of the process, resulting on higher cutting parameters. In thin floor parts, being low rigidity structures, the increase of cutting parameters brings as a conclusion the emergence of instabilities during machining. Experiments were conducted on a precision center lathe and the influence of cutting parameters (speed, feed and depth of cut) was studied using analysis of variance (ANOVA) based on adjusted approach. Based on the main effects plots obtained through full factorial design, optimum level of surface roughness and cutting force were chosen from the three levels of cutting parameters considered. Linear regression equation of cutting force has revealed that feed depth of cut and the interaction of feed and depth of cut significantly influenced the variance. In case of surface roughness the influencing factors were found to be feed and the interaction of speed and feed. As turning of mild steel using HSS is one among the major machining operations in manufacturing industry the revelation made in this research would significantly contribute to the cutting parameters optimization [10-14].

II. EXPERIMENTAL WORK

Turning is very important machining process in which single pint cutting tool removes unwanted material from the surface of a rotating cylindrical work piece. The cutting tool is fed linearly in a direction parallel to the axis of rotation. Turning operation using magnetorhelogical (MR) fluid filled tool post is carried on a lathe that provides the power to turn the work piece at a given rotational speed and to feed to the cutting tool at specified rate and depth of cut. Therefore, three cutting parameters namely cutting speed, feed depth of cut and current need to be determined in a turning operation. The turning operations using magnetorhelogical (MR) fluid filled tool post are accomplished using a cutting tool, the high forces and temperature during machining create a harsh environment for the cutting tool. Therefore, tool life is important to evaluate cutting performance. The purpose of turning operation using magnetorhelogical (MR) fluid filled tool post is to produce low surface roughness of the parts. Surface roughness is an important factor to evaluate cutting performance. Measure the surface roughness by using surf coder SE 1200 instrument as shown in the figure 1 for a probe movement of 2.5 mm, surface roughness readings were recorded at three locations on the work piece and the average value was used for analysis.

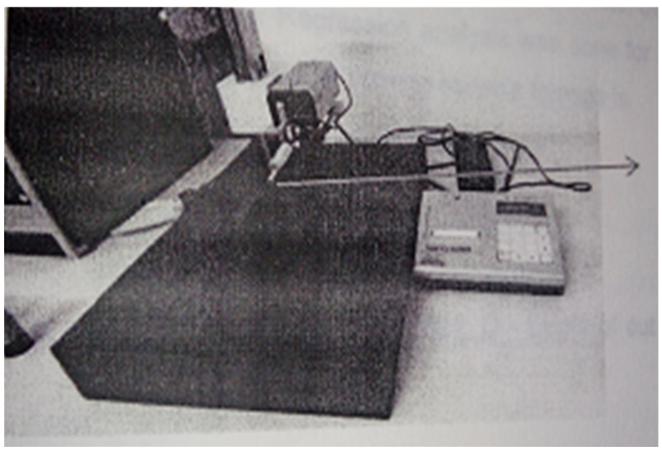

Fig 1. Surface coder SE 1200

III. CUTTING PARAMETERS

Speed, feed, depth of cut and current are the parameters chosen for the experiment. The cutting parameters like speed, depth of cut and current were calculated based on insert chosen. Feed were chosen based on machine capabilities.

Table 1 Cutting parameters for turning

Factors	Level 1	Level 2	Level 3
Speed (rpm)	360	580	800
Feed rate (mm/rev)	0.25	0.5	0.75
Depth of cut (mm)	0.3	0.6	0.
Current (A)	0	0.5	1

IV. DESIGN OF EXPERIMENTS

Taguchi method was espoused to optimize the cutting parameter preferred. An L9 type DOE was designated for the expediency of performing experiments.

Table 2 Taguchi L9 Design

Speed (rpm)	Feed (mm)	Depth of cut (mm)	Current (A)
1	1	1	1
1	2	2	2
1	3	3	3
2	1	2	3
2	2	3	1
2	3	1	2
3	1	3	2
3	2	1	3
3	3	2	1

Table 3 Taguchi L9 Design with responses

Speed (rpm)	Feed (mm)	Depth of cut (mm)	Current (A)	Surface roughness (µm)
1	1	1	1	4.576
1	2	2	2	7.047
1	3	3	3	8.929
2	1	2	3	6.521
2	2	3	1	5.803
2	3	1	2	9.567
3	1	3	2	3.384
3	2	1	3	8.586
3	3	2	1	8.714

V. RESULTS AND DISCUSSIONS

A. Determination of the Regression model and Evaluation of Statistical

The Regression equation, ANOVA and graph is generated by using Minitab software. The regression equation is give the relationship among Speed, feed, depth of cut, current and surface roughness. The equation is given by,

Surface roughness (R_a) = 2.62 + 0.022 Speed + 2.12 Feed Rate – 0.769 Depth of cut + 0.824 Current

Table 4 Regression Analysis

Predictor	Coefficient	SE Coefficient	T	P
Constant	2.617	1.1030	2.37	0.007
Speed	0.022	0.2701	0.08	0.939
Feed	2.1215	0.2701	7.85	0.001
Depth of cut	-0.7688	0.2701	-2.85	0.047
Current	0.8238	0.2701	3.05	0.038
S = 0.359413		R-Sq = 98.31%		R-Sq (adj) = 97.23%

The goodness of fit is elucidated by the determination coefficient (R-Sq).In this study, the value of determination coefficient is 0.983 which is indicated that 2% of the entire distinctions are not explained by the regression model. The adjusted determination coefficient is 0.972. So we observed that the adjusted determination coefficient is very closer to the determination coefficient which means a good relationship between the responses and the experimental results.

B. Taguchi Analysis

This method uses a special set of arrays called orthogonal arrays. These standard arrays instructs the way of accompanying the nominal number of experiments which could give the full information of all the factors that affect the performance parameter. The crux of the orthogonal arrays method lies in indicating the level combinations of the input design variables for each experiment. The experiments were directed and the Surface roughness values were restrained from which the following graphs were drawn by using Minitab software.

Table 5. Response Table for Signal to Noise Ratios

Level	S	F	D	C
1	-16.40	-13.36	-17.17	-15.76
2	-17.0	-16.97	-17.35	-15.72
3	-16.02	-19.15	-14.96	-17.99
Delta	1.0	5.78	2.39	2.7
Rank	4	1	2	3

Table 6. Response Table for Means

Level	S	F	D	C
1	6.851	4.827	7.576	6.364
2	7.297	7.145	7.427	6.666
3	6.895	9.070	6.039	8.012
Delta	0.446	4.243	1.738	1.648
Rank	4	1	2	3

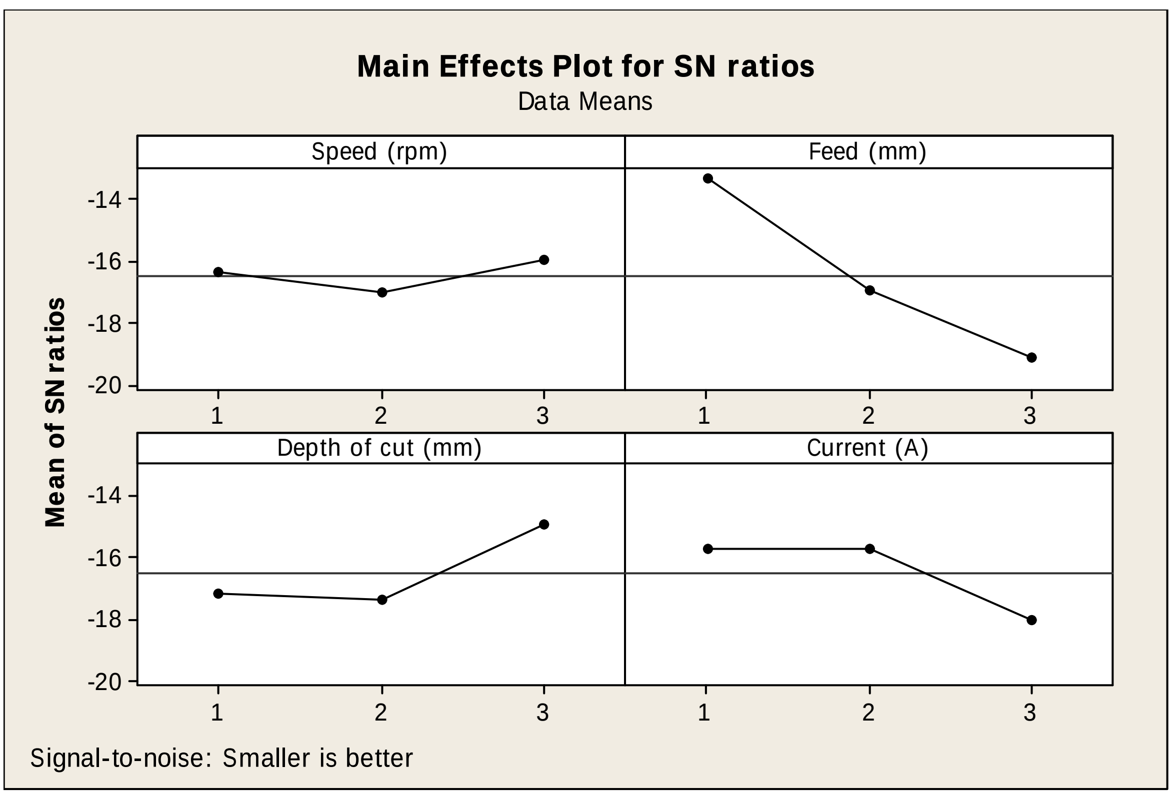

Fig 2: Signal to noise ratio graph

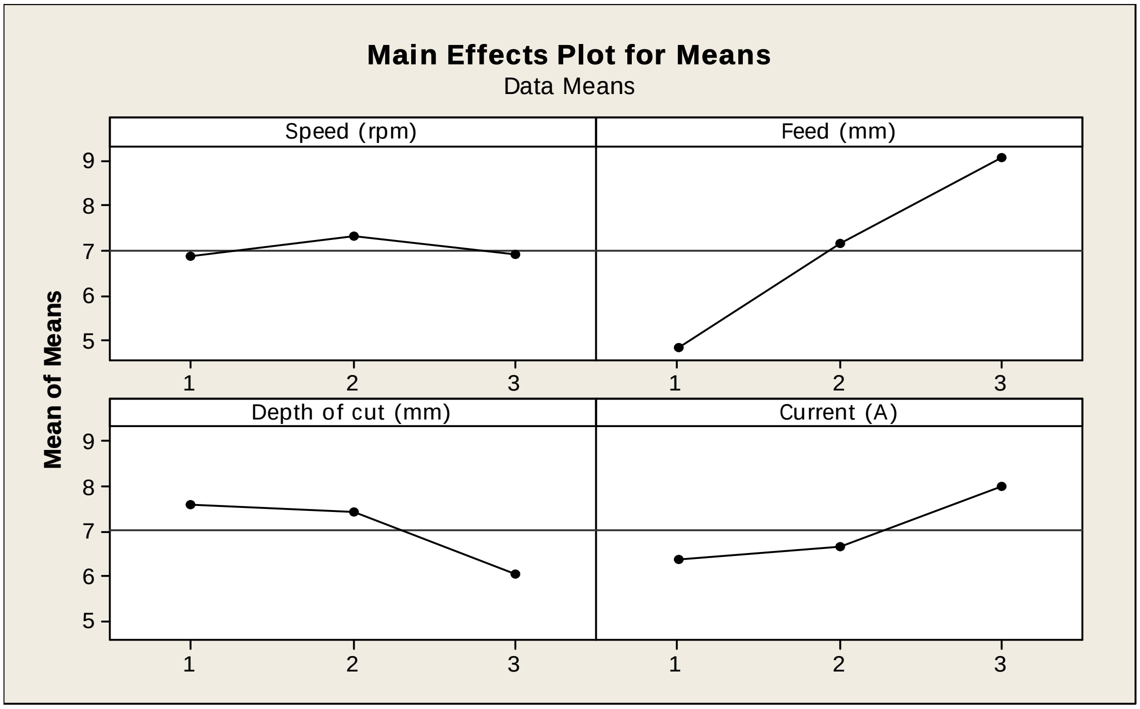

Fig 3 Mean Plot Graph

Taguchi analysis is finished as above we got signal to noise ratio graph and mean plot graph as shown in the figure 2 and 3. From which a major influencing factor is obtained such as feed rate. The second influencing factor is depth of cut, the third influencing factor is current and the fourth contribution factor is speed whose contribution is very less compared to other influencing factor.

C, Normal Probability plot Graph

The normal probability plot graph is attained by using the regression equation and the trials values. It is a graphical exemplification for evaluating whether data set is normally disseminated or not. The graph should provide nearly in a line. So the errors are distributed normally.

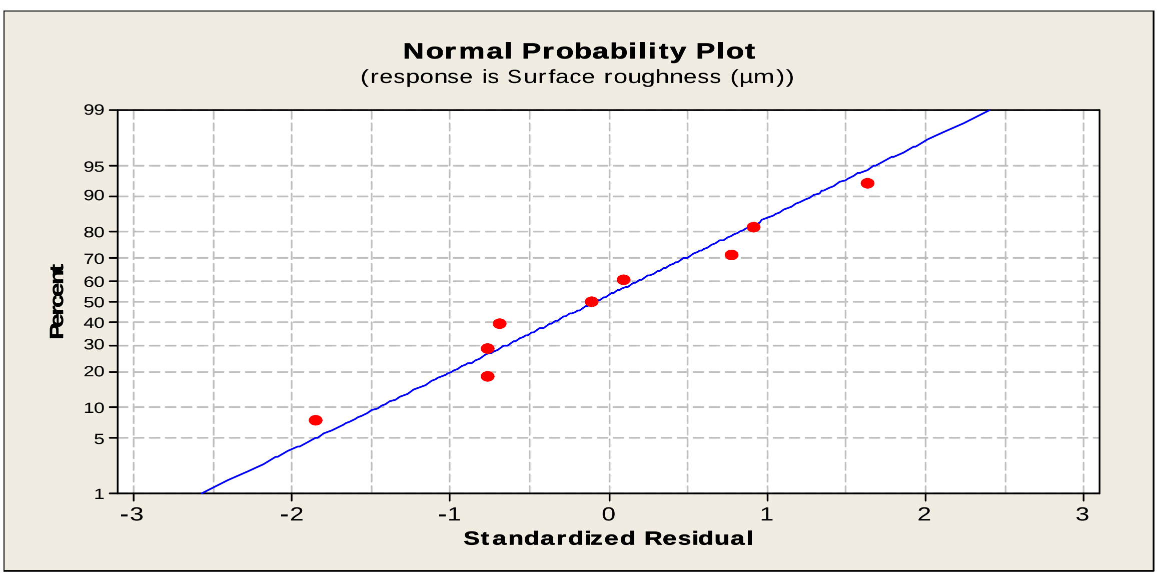

Fig 4 Normal probability plot

D. ANOVA

Analysis of variance (Anova) is a gathering of statistical models used to investigate the differences among group means and their accompanying procedures. ANOVA was performed by the Minitab Software which provide the operative values.

Table 7. ANOVA Table

Term	DOF	Seq. SS	Adj. SS	Adj. MS	F	P	% of Contribution
Feed	2	27.5667	27.5667	13.78	106.7	0.009	73.8
Depth of cut	2	5.3637	5.3637	2.6818	20.76	0.046	14.4
Current	2	4.1435	4.1435	2.0718	16.04	0.059	11.1
Error	2	0.2584	0.2584	0.1292			0.70
Total	8	37.3323					100

E. Confirmation Test

The L9 array are conducted which means 27 experiments are accompanied from which the percentage of error is calculated and tabulated (Table 8) at different conditions such as Speed, feed, depth of cut, current and surface roughness.

Table 8. Confirmation test results

S.No	Speed	Feed rate	Depth of cut	Current	Experimental value	Predicted value	% of error
1.	300	0.25	0.3	0	4.122	4.002	2.9
2.	360	0.35	0.7	0.7	5.014	5.111	1.9
3.	1000	0.8	0.5	1	8.819	8.905	1.05
4.	400	0.75	0.4	0.5	8.851	8.799	0.67

VI. CONCLUSION

In this paper, Taguchi Orthogonal is used to obtain the delamination factor in turning operation using magnetorhelogical (MR) fluid filled tool post. The following conclusions are done by this experiment,

A. The response such as and surface roughness can be computed proficiently through the linear model settled in this experiment. The direct and interactive effect of process factors on response within the range of exploration can be considered with ease from the Taguchi and

B. The process parameters for completing the desired response can be obtained from the mathematical model. ANOVA table is used to determine the percentage of contribution for significant factors and interactions. The feed is greatest influencing factor and its percentage of contribution is 74% on surface roughness.

C. The current is contributed about 11% on surface roughness. The depth of cut is contributed about 14.4% on surface roughness respectively. The normal probability plot graph is obtained in the form of straight line so the errors are distributed normally.

D. In Regression analysis, the adjusted determination coefficient is very closer to the determination coefficient so evaluation of delamination factor is done by effectively and efficiently.

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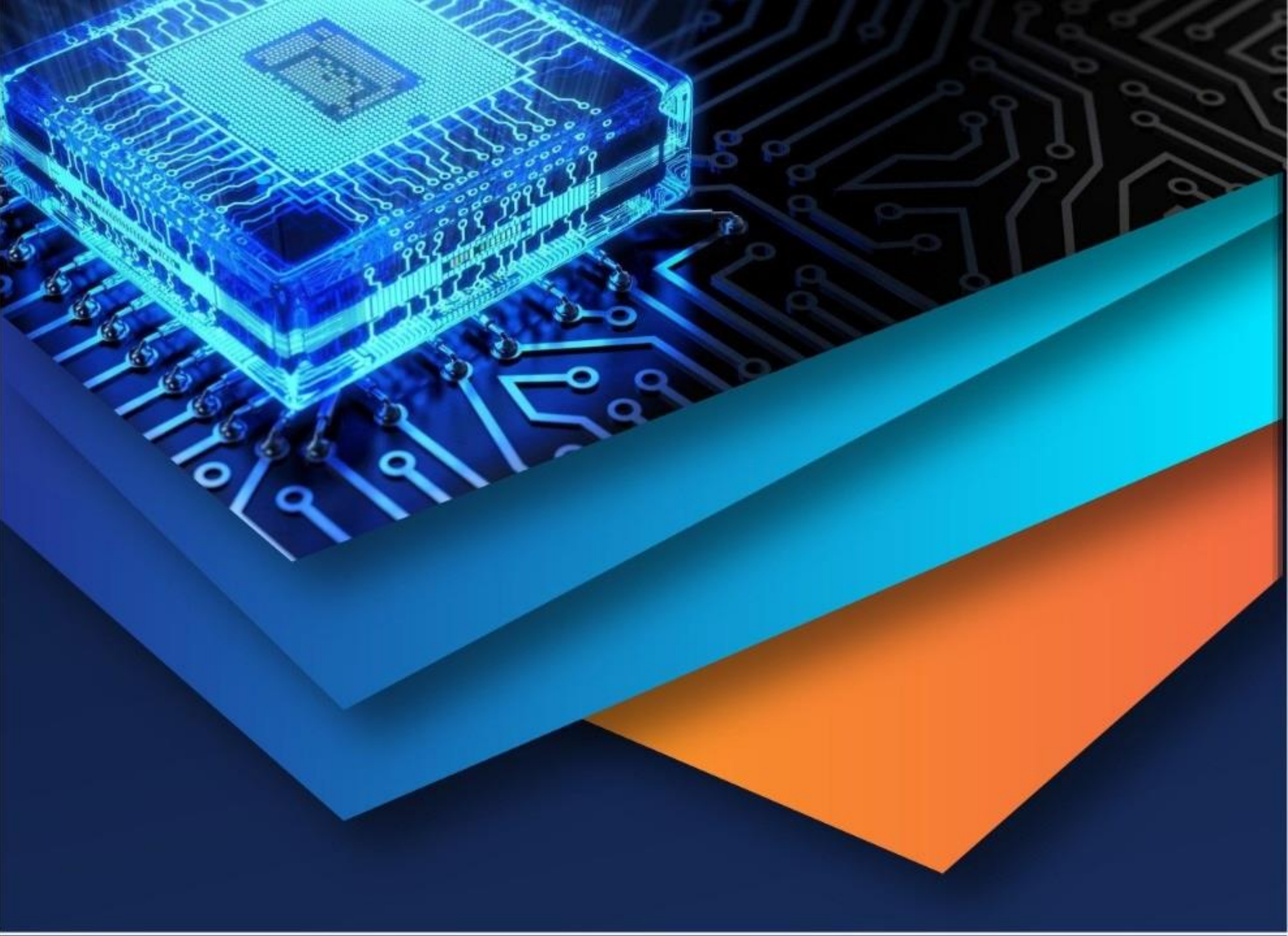

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