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Experimental Investigations of Optimizing Turning Process Parameter of AA2014

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Abstract: The examination work intended to advance the cutting parameters like turning speed, feed, and depth of cut for minimization of Surface roughness and increase Material Expulsion Rate (MRR) in turning process. In this examination turning of Aluminum alloy AA2014 by using alumina coated and uncoated tungsten carbide tools in (both) dry and wet condition. Analyses were directed in view of the Taguchi method of trials (DOE) with L8 Orthogonal array (OA) and excel work is utilized to analyze the data.

The signal –to –noise (S/N) ratio is used to inspect the performance of turning operation. Optimal values of turning process parameters for preferred performance characteristics are obtained. The S/N ratio plot has proved that the most significant turning parameters for surface roughness are feed rate, speed and least significant factor is depth of cut. For Material Removal Rate (MRR) depth of cut, spindle speed is the most significant parameters and least significant factor is feed rate.

Keywords: **Taguchi , surface finish, Optimization, Turning, Design of Experiments, Surface Roughness,L8 Orthogonal array**

I. INTRODUCTION

Metal removing processes are constantly experiencing the issue of not running the machine devices at the ideal working conditions. Numerous modern experts and researchers are managing the issue of implementing different techniques for optimizing the process parameters. So, evaluating the optimum condition of input parameters is most required for industrial production.

Machining is a procedure which is utilized to change the size, shape and surface of a material through removal of materials by stressing the material by tool. In manufacturing industry, turning is a broadly utilized machining activity. Turning is a procedure in which single point cutting tool is used to remove the material of cylindrical job.

Surface roughness (Ra) is a check used to quality a product and it greatly affects manufacturing cost. Surface roughness is one of the major property of a turned product. It is one of the prime need of customers. In order to obtain less surface roughness, the appropriate setting of turning input parameters is essential before the process starts. In addition to that, Material removal rate (MRR) is another important characteristic for turning operation and high surface finish and MRR is always desirable for any machined component.

Aluminium is the least expensive metal that has strong resistance to corrosion. It is easily machinable and has good electrical and thermal conductivities. From the literature reviewed, it is evident that the research gap exists in considering Aluminum alloy AA2014 as the work material. In this work, a cylindrical rod Aluminum alloy AA2014 is turned using uncoated and alumina coated tungsten carbide tool.

Aluminium Alloy 2014 is a medium strength alloy commonly referred to as an architectural alloy. It is normally used in manufacturing intricate parts. It has a good surface finish; high corrosion resistance, good weldability and it can be easily anodized. 2014 is typically used in: aero space applications, extrusions, window frames, doors, shop fittings, irrigation tubing. The experiment is designed using Taguchi's orthogonal array (OA) with the three turning process parameters, speed, depth of cut, and feed at three levels. The results are analyzed in order to find the optimal parameter setting for minimum surface roughness and maximum material removal rate.

Taguchi method has a special design of orthogonal arrays to learn the entire parameter with few numbers of experiments. The experimental results are transformed into a signal-to-noise(S/N) ratio. The S/N ratio can be used to measure the deviation of the performance characteristics from the desired values.

Usually three categories of performance characteristics for analysis of the S/N ratio: (1) the lower-the-better, (2) the higher-the-better and (3) the nominal-the-better. For all categories, the largest S/N ratio is preferable, that is the optimum level of the process parameters is the level with the highest S/N ratio.

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II. LITERATURE REVIEW

Due to the significance of the subject, troubles of optimizing turning parameters, a a small amount of researches has been published, which are reviewed as follows:

1) Kadaganchi, R., Gankidi, M. R. Investigated the effect of the speed, feed and doc on surface roughness turning of Aluminium (2015) in cnc machine. The feed and speed are identified as the most dominant process parameters on surface roughness
2) Hema, P., & Ravindranath, K. (2017). has conceded out research on friction stir welding of dissimilar alloy such as AA2014 and AA6061using taper pin
3) Jaiganesh, V., Srinivasan, D., & Sevvel, P. (2017).) has carried out research on the topic of an optimization of process parameters of friction stir welding of AA2014.
4) Chand, G., Rao, G. V., & Sahu, U. K. have studied the use of Taguchi's technique for minimizing required surface roughness and maximizing the material removal rate in machining Aluminium Alloy 2014. The experimental results exposed that the feed is the most significant turning parameter for surface roughness followed by speed and doc.
5) Jayaraman, P. (2017). investigated the effects of cutting parameters like spindle speed, feed and depth of cut on surface finish and material removal rate of Aluminium 6063 and 6351 using various optimization techniques. Taguchi method also useful to optimize the parameters. Feed is the most significant factor influencing surface finish whereas material removal rate is significantly affected by cutting speed.

III. EXPERIMENTATION

A. Work material

We have used AA2014 in this research work, in the form of cylindrical bar of diameter 25 mm.

Fig 1: Work material-AA2014

TABLE I
CHEMICAL COMPOSITION

Chemical Element	(Mn)	(Mg)	(Si)	(Cr)	(Cu)	Aluminium (Al)
% Present	0.6	0.5	0.8	0.1	4.4	93.8

TABLE II
PHYSICAL PROPERTIES

Properties	Density (g/cm3)	Melting Point (Deg C)
Metric	0.6	0.5

TABLE III
MECHANICAL PROPERTIES

Mechanical Property	Elastic Modulus (GPa)	Poissons Ratio
Metric	70-80	0.33

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B. Cutting tool material

The tool used for turning is tungsten carbide of side 12.77mm and thickness 4.99mm.

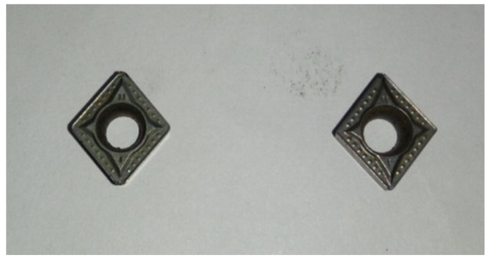

Fig 2: Alumina coated tungsten carbide tool

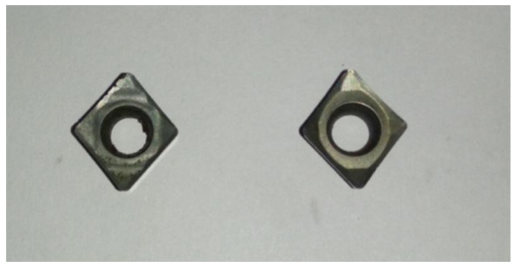

Fig 3: Uncoated tungsten carbide tool

C. Machine tool

Specification of Lathe machine used for turning

Type	:	170 G 2
Size	:	1960
RPM	:	65-1000
Cross slide	:	260 mm

Fig 4: Lathe machine used

D. Constraints

This experimental study considers three parameters each with two levels of values.

TABLE IV
MACHINING PARAMETERS AND THEIR VALUES

Parameter	Level 1	Level 2
Spindle speed(RPM)	290	465
Feed rate(mm/rev)	0.193	0.244
Depth of cut(mm)	0.5	1

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E. Experimental design using L8 Orthogonal array

TABLE V
L8 OA TAGUCHI DESIGN FOR THE EXPERIMENT

S.no	Speed (rpm)	Feed (mm/rev)	Depth of Cut(mm)
1	290	0.193	0.5
2	290	0.193	1
3	290	0.244	0.5
4	290	0.244	1
5	465	0.193	0.5
6	465	0.193	1
7	465	0.244	0.5
8	465	0.244	1

1) Uncoated Tool With Dry Condition

Fig 5: Specimen (Four different condition) after machining

TABLE VI
WIGHT DIFFERENCE OF TOOL IN DRY CONDITION

No. Of exp	Cutting Speed (rpm)	Feed (mm/rev)	Depth of cut (mm)	Wi(g) (initial wt)	Wf(g) (final weight)	Diff. (wf-wi)
1	290	0.193	0.5	3.66	3.65	0.01
2	290	0.193	1	3.65	3.64	0.02
3	290	0.244	0.5	3.64	3.62	0.01
4	290	0.244	1	3.63	3.62	0.01
5	465	0.193	0.5	3.68	3.67	0.02
6	465	0.193	1	3.67	3.65	0.01
7	465	0.244	0.5	3.65	3.64	0.01
8	465	0.244	1	3.64	3.62	0.02

F. Surface Roughness Calculations

Perthometer is a device used to measure the surface roughness. The average of the observed values of Surface Roughness (Ra) are tabulated below for both dry and wet condition using two different tools.

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1) Uncoated Tool With Wet Condition

TABLE VI
WIGHT DIFFERENCE OF TOOL IN WET CONDITION

No. Of exp	Cutting Speed (rpm)	Feed (mm/rev)	Depth of cut (mm)	Wi(g) (initial wt)	Wf(g) (final weight)	Diff. (wf-wi)
1	290	0.193	0.5	3.65	3.64	0.01
2	290	0.193	1	3.64	3.63	0.01
3	290	0.244	0.5	3.64	3.63	0.01
4	290	0.244	1	3.68	3.67	0.01
5	465	0.193	0.5	3.67	3.66	0.01
6	465	0.193	1	3.68	3.67	0.01
7	465	0.244	0.5	3.67	3.66	0.01
8	465	0.244	1	3.66	3.65	0.01

2) Alumina Coated Tool In Dry Condition

TABLE VIII
WIGHT DIFFERENCE OF TOOL IN WET CONDITION

No. Of exp	Cutting Speed (rpm)	Feed (mm/rev)	Depth of cut (mm)	Wi(g) (initial wt)	Wf(g) (final weight)	Diff. (wf-wi)
1	290	0.193	0.5	3.13	3.12	0.01
2	290	0.193	1	3.12	3.11	0.01
3	290	0.244	0.5	3.14	3.12	0.02
4	290	0.244	1	3.11	3.10	0.01
5	465	0.193	0.5	3.10	3.09	0.01
6	465	0.193	1	3.11	3.10	0.01
7	465	0.244	0.5	3.09	3.08	0.01
8	465	0.244	1	3.12	3.11	0.01

3) Surface Roughness Of Turned Specimens

TABLE IX
SURFACE ROUGHNESS TABULATION OF ALUMINA COATED TOOL WITH DRY CONDITION

No. Of exp	Speed (RPM)	Feed (mm/Rev)	Depth Of Cut (mm)	Ra (Average) (µm)
1	290	0.193	0.5	1.81
2	290	0.193	1	3.28
3	290	0.244	0.5	2.68
4	290	0.244	1	2.32
5	465	0.193	0.5	3.15
6	465	0.193	1	2.19
7	465	0.244	0.5	2.35
8	465	0.244	1	1.26

TABLE X
SURFACE ROUGHNESS TABULATION OF UNCOATED TOOL WITH DRY CONDITION

No. Of exp	Speed (RPM)	Feed (mm/rev)	Depth Of cut (mm)	Ra (average) (µm)
1	290	0.193	0.5	1.85
2	290	0.193	1	1.58
3	290	0.244	0.5	2.69
4	290	0.244	1	2.59
5	465	0.193	0.5	1.12
6	465	0.193	1	2.5
7	465	0.244	0.5	2.18
8	465	0.244	1	2.66

TABLE XI
SURFACE ROUGHNESS TABULATION OF UNCOATED TOOL IN WET CONDITION

No. Of exp	Speed (RPM)	Feed (mm/rev)	Depth Of cut (mm)	Ra (average) (µm)
1	290	0.193	0.5	1.55
2	290	0.193	1	1.48
3	290	0.244	0.5	2.48
4	290	0.244	1	2.38
5	465	0.193	0.5	1.01
6	465	0.193	1	2.01
7	465	0.244	0.5	1.36
8	465	0.244	1	2.46

TABLE XII
SURFACE ROUGHNESS TABULATION OF ALUMNA COATED TOOL IN WET CONDITION

No. Of exp	Speed (RPM)	Feed (mm/Rev)	Depth Of Cut (mm)	Ra (Average) (µm)
1	290	0.193	0.5	1.51
2	290	0.193	1	1.58
3	290	0.244	0.5	2.26
4	290	0.244	1	2.32
5	465	0.193	0.5	1.00
6	465	0.193	1	2.10
7	465	0.244	0.5	1.28
8	465	0.244	1	2.38

G. Analysis of the S/N Ratio

S/N ratio is the tool designed for analysis which measures the performance of each process parameters towards the surface roughness and MRR. The S/N Ratio for surface roughness was designed using 'smaller the better' characteristics. And larger the better S/N Ratio was calculated for MRR.

Signal-to-noise ratio is defined from the formula

$SNR = P_{signal}/P_{noise} = \mu/\sigma$

where

μ is the signal mean or expected value

σ is the standard deviation of the noise

IV. RESULTS AND ANALYSIS

The input and output parameters of the study are tabulated below.

The Surface roughness is the quality characteristic with the concept of "smaller-the-better".

Uncoated tool in Wet condition

Response Table for Signal to Noise Ratios

Smaller is better

Level	speed	feed	doc
1	-5.658	-3.341	-3.613
2	-4.160	-6.478	-6.205
Delta	1.498	3.137	2.592
Rank	3	1	2

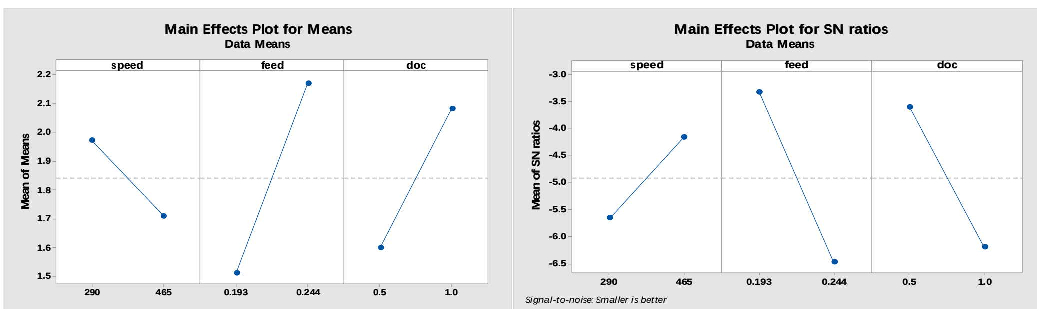

Fig 6: Plot of Means and S/N ratio of uncoated tool in wet condition

Alumina Uncoated tool in Wet condition

Response Table for Signal to Noise Ratios

Smaller is better

Level	speed	feed	doc
1	-5.486	-3.499	-3.201
2	-4.030	-6.017	-6.315
Delta	1.456	2.518	3.113
Rank	3	2	1

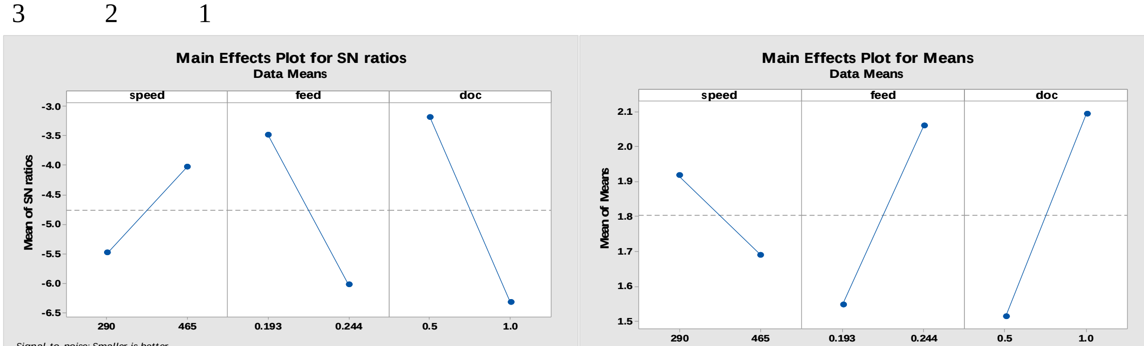

Fig 7: Plot of Means and S/N ratio of Alumina coated tool in wet condition

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UNCOATED TOOL WITH DRY CONDITION

RESPONSE TABLE FOR SIGNAL TO NOISE RATIOS

Smaller is better

Level	speed	feed	doc
1	-6.544	-4.565	-5.423
2	-6.052	-8.032	-7.174
Delta	0.492	3.467	1.751
Rank	3	1	2

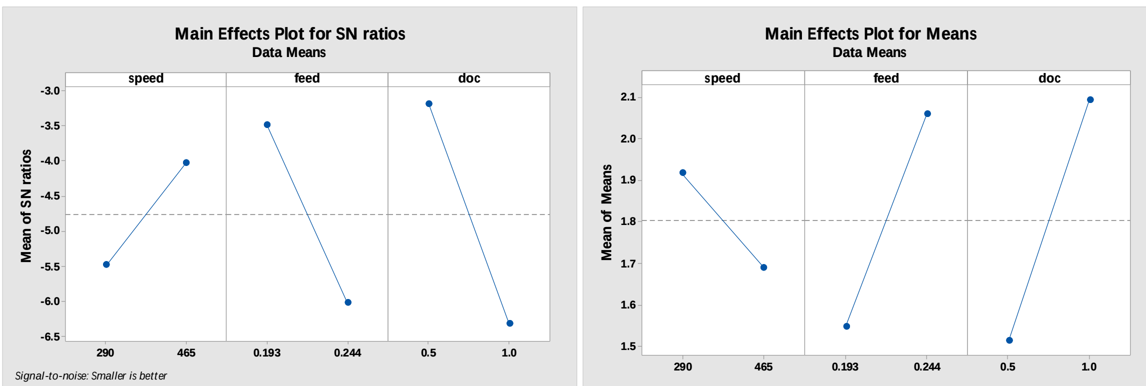

Fig 8: Plot of Means and S/N ratio of uncoated tool in dry condition

ALUMINA COATED TOOL WITH DRY CONDITION

RESPONSE TABLE FOR SIGNAL TO NOISE RATIOS

Smaller is better

Level	speed	feed	doc
1	-7.836	-8.062	-7.776
2	-6.551	-6.325	-6.611
Delta	1.285	1.736	1.165
Rank	2	1	3

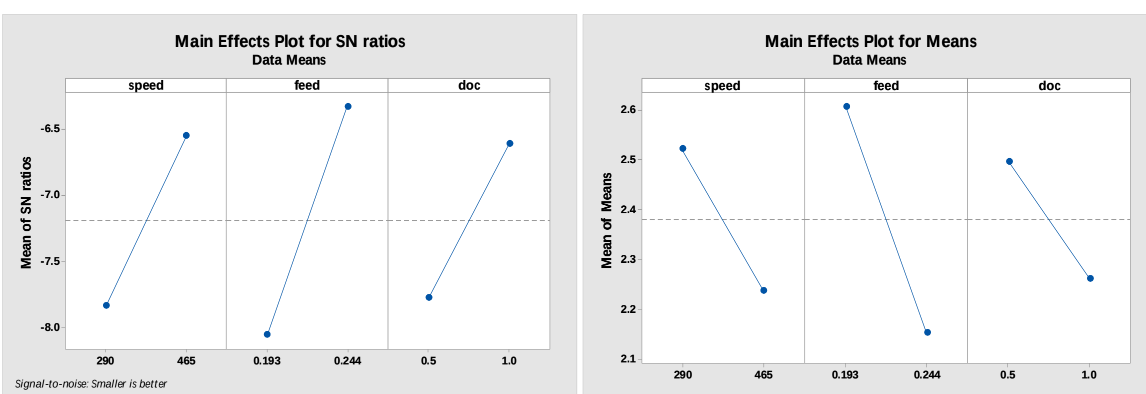

Fig 9: Plot of Means and S/N ratio of Alumina coated tool in dry condition

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V. CONCLUSION

A. From the effect of turning process parameters of AA2014 on Surface Roughness (Ra) for S/N ratio (Fig.6 - 9), it is evident that the optimal values of speed, feed and depth of cut for the low surface roughness of the turned product are 290 RPM, 0.193 mm/rev and 0.5 mm with Wet condition.

B. Feed is the most significant factor obtained from the response table for S/N ratio and the next is depth of cut.

C. The interaction reveals that the effect of speed on surface roughness is depending on the values of feed and depth of cut, effect of feed is independent and effect of depth of cut is slightly depending on speed value.

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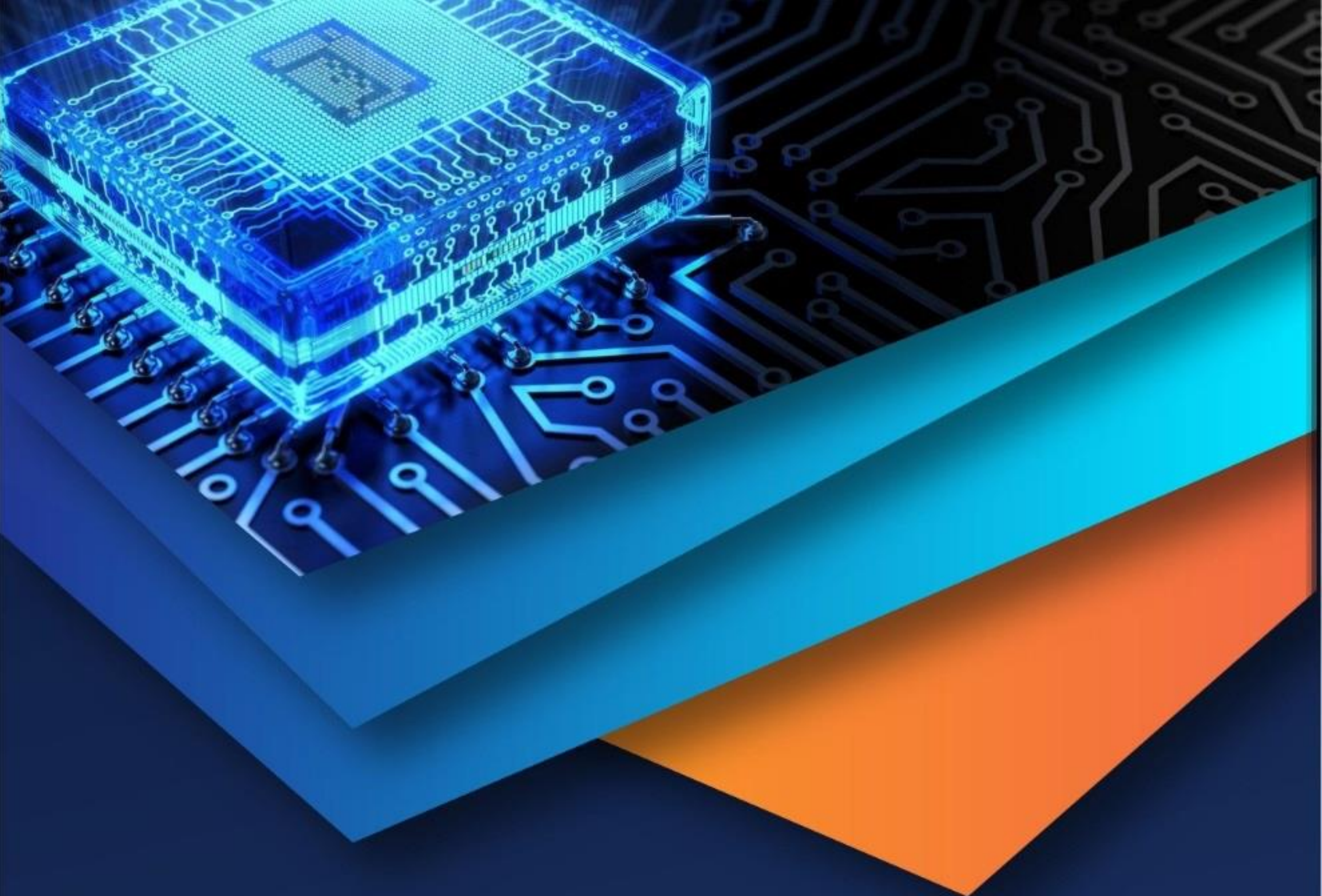

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