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Surface Finishing of Nickel Alloy A-286 by Extrusion Honing Operation

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Abstract: ***Extrusion Honing is also known as Abrasive Flow Machining is an advance machining process or finishing process which is used to deburr, clean, polish, remove recast layer and radius surfaces and is used to machine complex shape by flowing pressurized semi-solid, abrasive laden putty through or across a work piece. This experiment is conducted using a developed Extrusion Honing machine and an experiment employing abrasive flow machining was conducted on Nickel Alloy A-286 which is one of the most difficult to machine because of high hardness and high strength at elevated temperature. In this paper, an investigation is done on the influence of the process parameters on the surface roughness of Nickel alloy A-286. The extruded surface were measured and analysed with the help of surface roughness measuring instrument and Scanning Electron Microscope (SEM) images. A significant improvement in surface finish is shown in the result.***
Keywords: Nickel alloy A-286, Surface finish, Extrusion Honing, Abrasive media, Surface Roughness Parameters.

I. INTRODUCTION

Abrasive Flow Machining is a Non-traditional type finishing process. It was first established in 1966 and also first patented in 1970 by the Extrude Hone Corporation. This process is used to removal of recast layer, polish of critical components, radius surface, deburr in aeronautical, automotive, medical, electronics and die-making industries. This process is capable of finishing regions which are difficult to reach by flowing abrasive which are mixed with polymer of special rheological properties. Extrusion Honing produces repeatable, uniform and predictable results based on a notable range of finishing operation. Some of the abrasive grains commonly used in Extrusion Honing process are Aluminium Oxide, Boron Carbide, Diamond and Silicon Carbide.

In Abrasive Flow Machining process, medium or tool used to machine the material comprises of polymer based on visco-elastic material matrix which is mixed with abrasive particle and additive, which is used to extrude different primitives of work piece. While extruded through the passage which is formed by the work piece and tooling, this medium tries to finish the work piece surface selectively. Here in the process tooling plays the important role. So the design of the fixture or tooling should be done carefully. One of property of the polymer is that the polymer chain holds the abrasive particle flexibly and movies them around in the direction of the extrusion pressure. Thus the medium is used as a multi-point tool cutter which starts abrading the work piece surface.

Extrusion process is one the most extended process used in wide range of industrial applications in the field of manufacturing which have different approaches of extrusion process. This finishing technique also reduces the human effort and provides the high quality surface finish.

II. LITERATURE REVIEW

1) *Manjunath L Naduvinamani and Raju H P (2017)* Published a Journal on "Study of Surface Parameters of Inconel 600 by Extrusion Honing Process", in which they reported that surface finish of specimen can be obtained by flowing pressurized semisolid abrasive laden visco-media through the specimen using built in Laboratory Extrusion Honing machine and concluded that a good surface finishing is shown when the extrusion honing process is carried out for 10 passes.
2) *Murali Krishna N L and Raju H P (2014)* conducted research on "Extrusion Honed Surface Characteristics of Inconel 625 Fabricated by EDM for Square Shape". In this work they concluded that at the exit side surface finish due to extrusion honing is better than the entry side that shows better contact of the abrasive particles in the media at the exit.
3) *Jain R K et.al (1999)* conducted research on "Modeling of material removal and surface roughness in Abrasive flow machining". In this work they carried out simulation of finished surface profiles and material removed considering the interaction of abrasive grain with work piece material.
4) *Loveless T R et.al (1994)* published a thesis on "Study of the effects of abrasive flow finishing on various machined surfaces" and explained the effect of viscosity of media on surface finish. They founded that the only parameter which effect the surface

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finish is its viscosity. They also found that the relationship between initial surface finish and percentage improvement in surface finish is non-linear.

III.OBJECTIVE

The Objective of this paper is to study the various surface parameters of Nickel Alloy A-286 of different diameter holes i.e. 4 mm, 5 mm, 6 mm and 8 mm using Extrusion Honing process.

IV.METHODOLOGY

A. Experimental Setup

The set up used is a one way type of Extrusion Honing process because the media flows in only one direction. The machine is consisting of hydraulic cylinder which is coupled to an abrasive media cylinder. The abrasive media cylinder has a piston cylinder arrangement with end cap which acts as a tooling to confine and direct the media flow through the specimen or work piece. The abrasive media is filled into the cylinder by removing the end cap from the cylinder arrangement and after filling the media the end cap is placed to the original position. A fixture arrangement is provided in the end cap to hold the specimen during the experimentation. A pressurized abrasive media enters the specimen from one side and extrudes out from other side. A collector is used to collect the extruded abrasive media.

Figure 4.1 Extrusion Honing Machine

B. Experimental Procedure

a) Preparation of test specimens.
b) Preparation of abrasive media.
c) Performing extrusion honing trials.
d) Measuring surface parameters at different locations of the specimen using surface roughness measuring instrument (Surfcom 130A)

C. Work material details

Nickel Alloy A-286 is an iron-based high temperature and high strength alloy. These Super alloys contain good oxidation and creep. These alloys can function under high mechanical stress and high temperatures and also in places that require high surface stability.

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Table 4.1: Chemical Composition

Element	Content (%)
Iron, Fe	54
Nickel, Ni	25.5
Chromium, Cr	14.8
Titanium, Ti	2.13
Molybdenum, Mo	1.30
Manganese, Mn	1.0
Silicon, Si	0.50
Vanadium, V	0.30
Aluminum, Al	0.18
Carbon, C	0.040
Phosphorous, P	0.020
Sulfur, S	0.015
Boron, B	0.0060

Table 4.2: Physical and Mechanical Properties

Properties	Metric
Density	7.94 gm/cm^3
Tensile strength	1035 MPa
Hardness, Brinell	304
Melting point	1399°C
Yield strength	759 MPa

Applications are:

1) Offshore and oils and gas components.
2) Jet engines and after burner parts and fasteners.
3) Exhaust parts, turbines and Nozzles in the oil industry.

D. Preparation of Test Specimens

Nickel Alloy A-286 specimens of 25 mm diameter and length 12 mm with hole diameter of 4, 5, 6 and 7 mm. The specimens were initially drilled using carbide drill bits and thoroughly washed with acetone to remove the clogged particles. A surface roughness measuring instrument (Surfcom 130A) is used to measure Surface roughness parameters before conducting the experiment.

Figure 4.2: Test specimens

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E. Preparation of Abrasive media

To prepare tool or abrasive media, the silicon carbide abrasive is thoroughly mixed with silicon polymer using silicon media mixer machine. The volume fraction of Silicone carbide abrasives with silicone polymer used is 40%.

Figure 4.3: Silicon media mixer

Figure 4.4: Silicon polymer with abrasive

F. Experimental Trials

In the beginning stage the Extrusion Honing machine is switched "ON", the lever is pulled so that the ram will push the pressurized silicon polymer with abrasive media to extrude through the hole of the specimen. The specimens are cleaned with acetone solution to remove dust particles and clogged polymer and surface roughness is measured using Surfcom 130A for each trials. Surface roughness parameter is measured at 2 location i.e. entry side of drill and exit side of the drill. This procedure is repeated for 10 passes and results are tabulated.

Figure 4.5: Abrasive media extruded through specimen

Figure 4.6: Surface roughness measuring instrument (Surfcom 130A)

Table 4.3: Process parameter of Extrusion Honing

Sl No	Parameters	Details
1	Pressure	60
2	Stroke length	600 mm
3	Temperature	Ambient
4	Volume fraction of Abrasive	40%
5	Abrasive mesh size	36
6	Hole diameter (mm)	4,5,6,7
7	Number of passes	10

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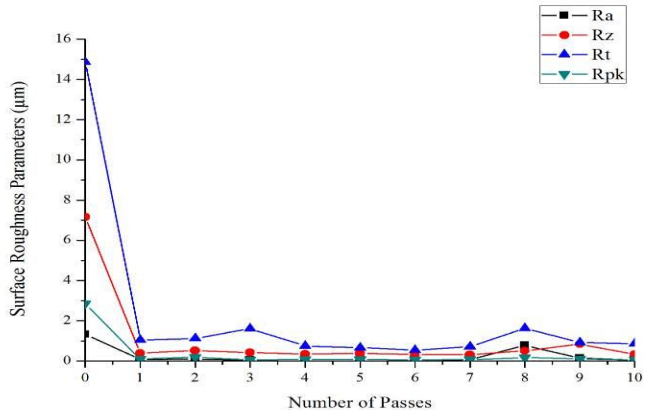
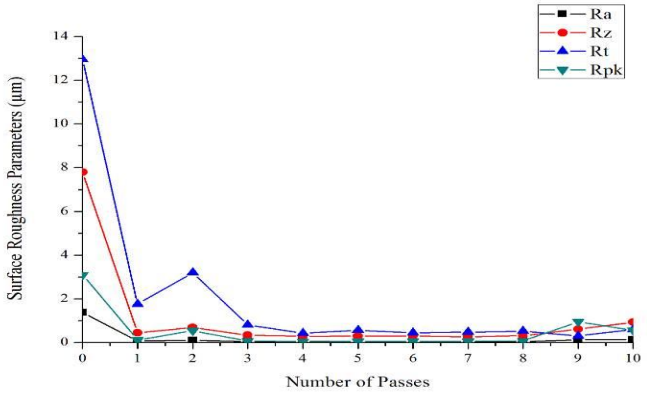
V. RESULTS AND DISCUSSION

The main use of Extrusion honing is to get good surface finish operation. The aim of the work is the evaluation of extrude honed surface of Nickel alloy A-286 is in terms of surface finish parameter. The variation of surface roughness parameters and material removed are plotted in the following graph for hole diameter of 4, 5, 6 and 7 mm specimens. Here specimen is measured at 2 location i.e. entry side and exit side and Ra, Rz, Rt and Rpk are used as surface roughness parameters.

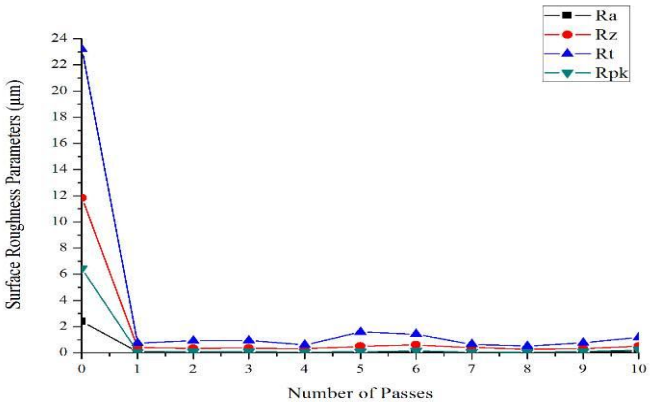


(a)

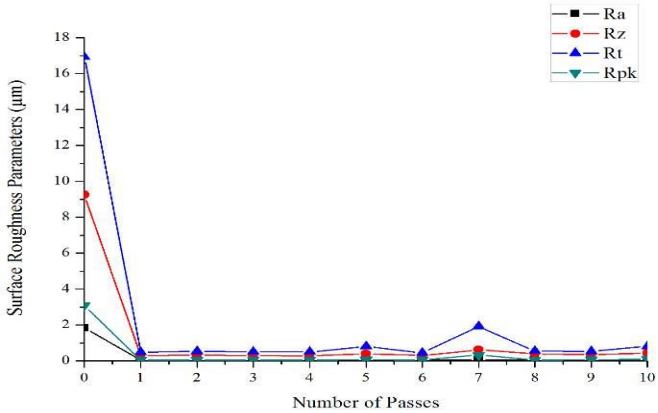


(b)

Figure 5.1: Hole diameter 4 mm Drill entry (a) and Drill exit (b) shows the effect of number of passes on surface roughness.

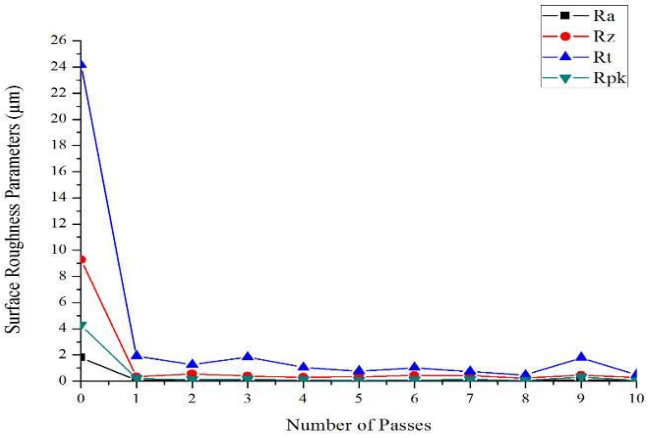


(c)

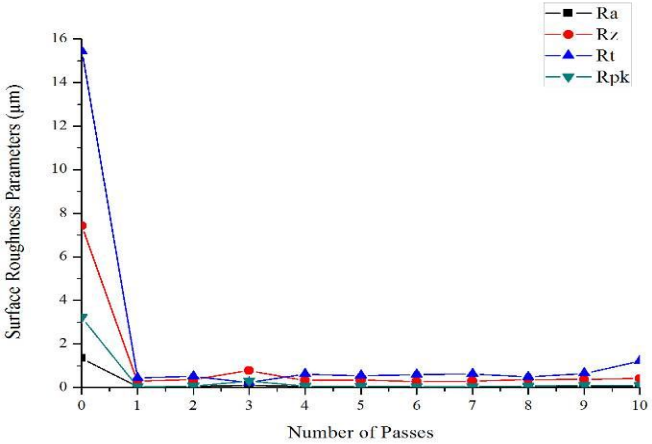


(d)

Figure 5.2: Hole diameter 5 mm Drill entry (c) and Drill exit (d) shows the effect of number of passes on surface roughness.



(e)



(f)

Figure 5.3: Hole diameter 6 mm Drill entry (e) and Drill exit (f) shows the effect of number of passes on surface roughness.

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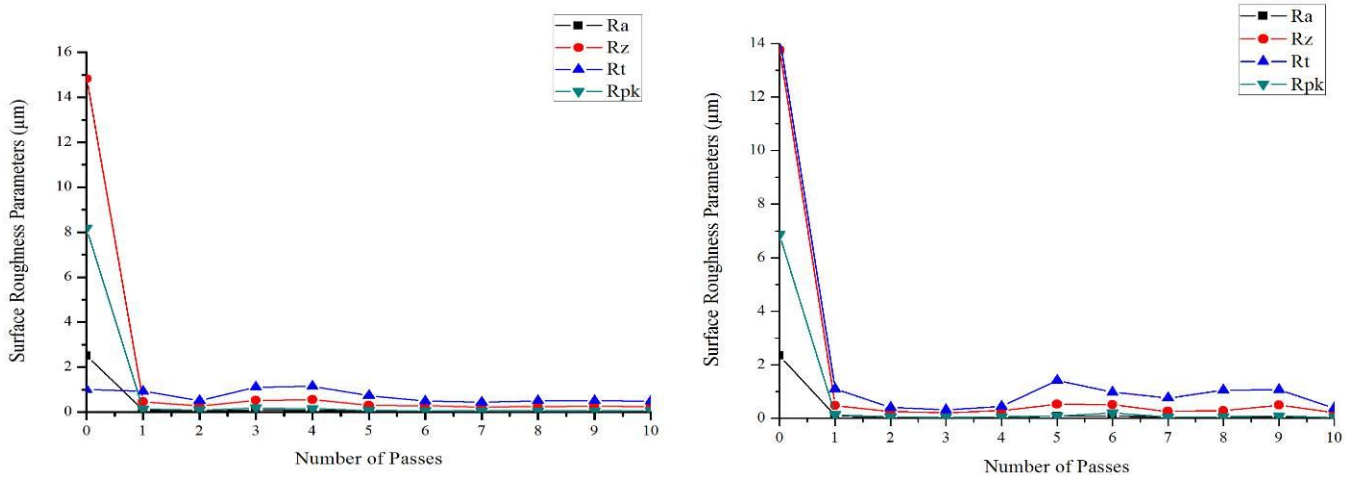
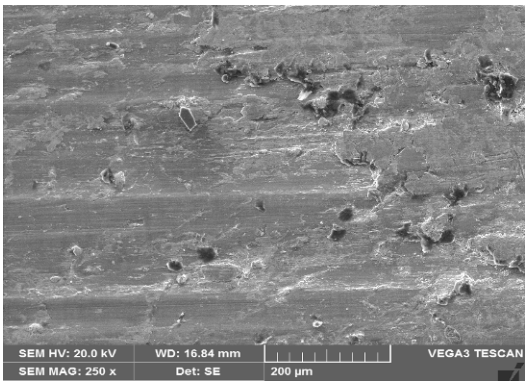


(g) **(h)**

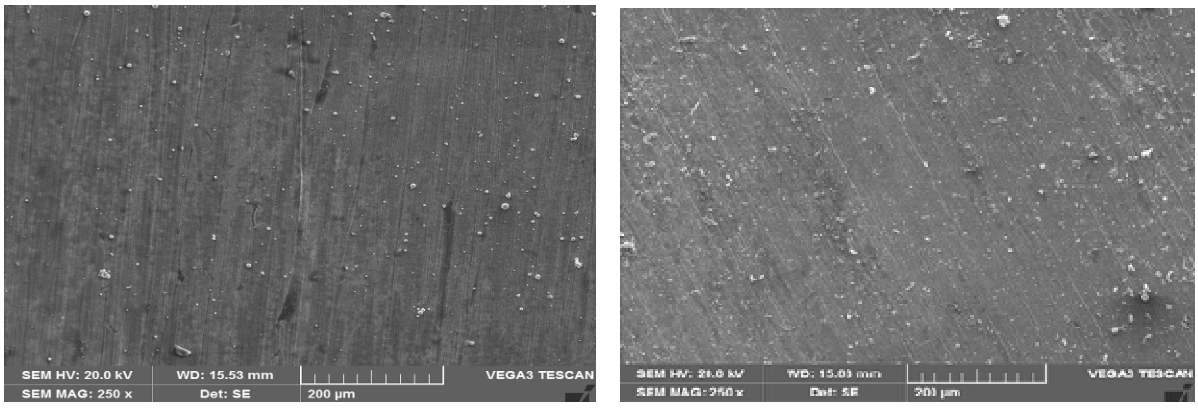
Figure 5.4: Hole diameter 7 mm Drill entry (g) and Drill exit (h) shows the effect of number of passes on surface roughness.

From all the above graphs it shows the initial surface roughness for the zero pass before extrusion honing. From the figures its shows the drastic change in the first pass of the surface roughness parameters. There will be a gradual improvement in surface roughness when the number of passes increases. Later the surface roughness parameters will rise in 3rd or some passes. Further the surface roughness parameters improve as the number of passes increases. Later till the 10th pass the surface roughness improves. Further 10th passes the surface roughness starts deteriorating.



(a)

Figure 5.5: SEM Images for Zero pass (a) of 250 Magnification



(b) **(c)**

Figure 5.6: SEM Images Hole diameter 4 mm for Ten pass (b) and Hole diameter 5 mm for Ten pass (c) of 250 Magnification

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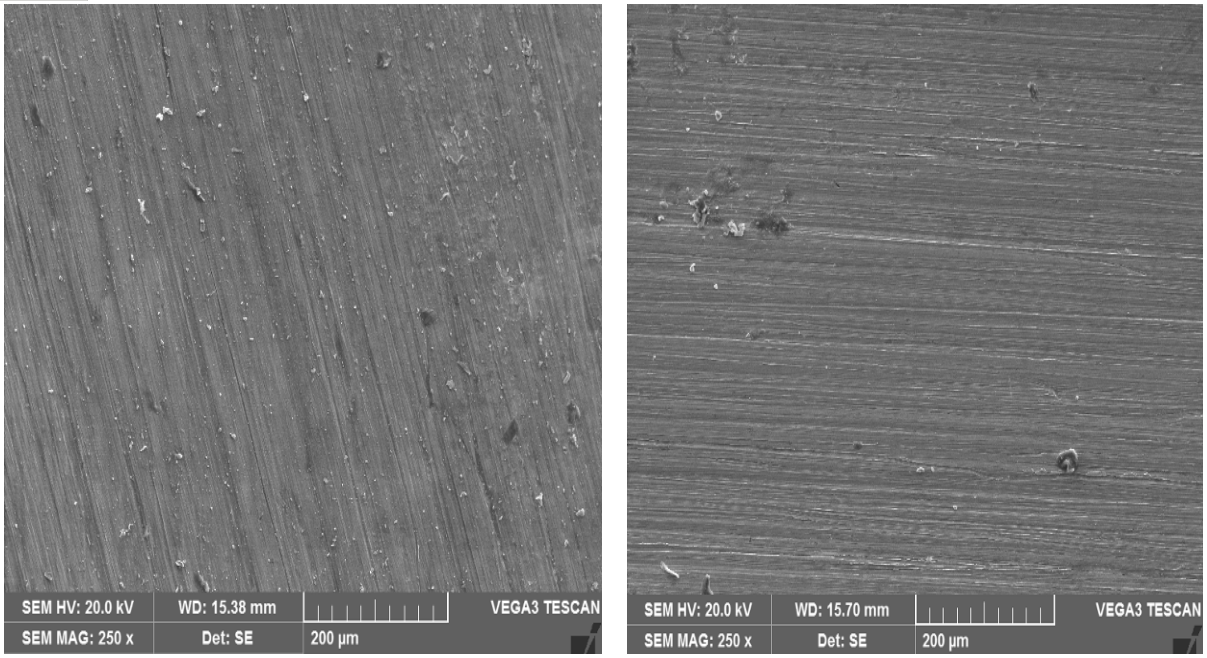

(d) **(e)**

Figure 5.7: SEM Images Hole diameter 6 mm for Ten pass (d) and Hole diameter 7 mm for Ten pass (e) of 250 Magnification

An observation is under taken using Scanning electron microscope of drilled and extrusion honed surfaces of Nickel alloy A-286. The SEM image is taken for 10 passes of hole diameter 4 mm, 5 mm, 6 mm and 7 mm of the specimen. The bored lay pattern is revealed in figure 5.5 (a). A progressive improvement in surface finish is shown in Figure 5.6 (b) and (c) and Figure 5.7 (d) and (e) for 10 passes.

VI. CONCLUSIONS

From this study the extrusion honing of Nickel alloy A-286 has been carried out with tool or media of silicon polymer with (Silicon Carbide) abrasive, a conclusion is drawn as follows

A. In the extrusion honing the grade selected for polymer medium can be used as abrasive carrier medium.
B. A good surface finishing is shown when the extrusion honing process is carried out for 10 passes at 60 bar pressure and abrasive particle size of 36 mesh.
C. At the early stage within the 3rd pass there is a drastic reduction in the surface finish parameter at the entry side of the specimen, after that continuous improvement is seen in surface finish parameters up to the 9th pass, beyond which surface deteriorating take place.
D. During the Honing process it is observed that the surface finish deteriorates at the entry side, but core roughness is obtained at the exit side.
E. At the exit side better surface finish is obtained than the entry side of media.

VII. ACKNOWLEDGMENT

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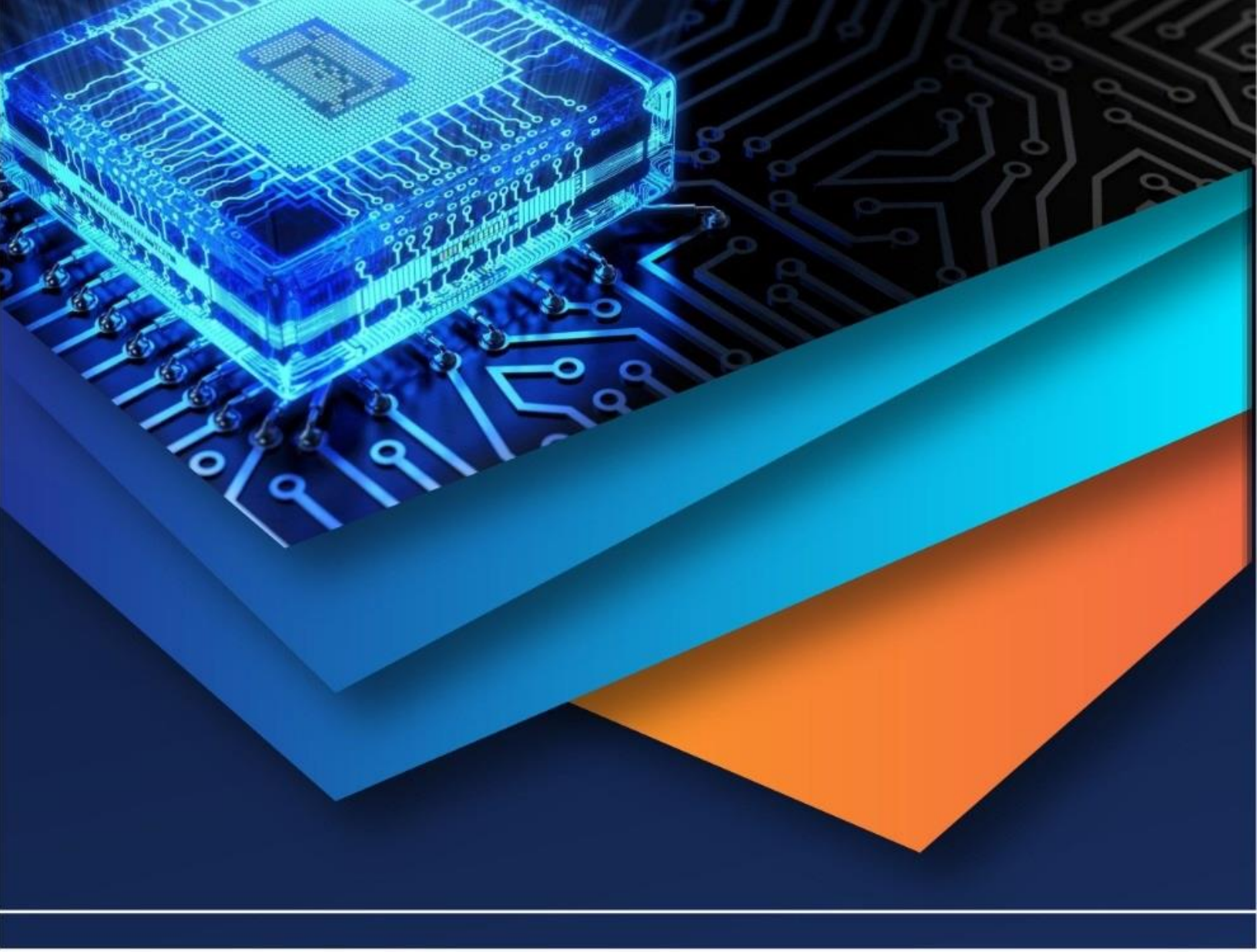

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