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Study of Wear Behavior of Hard facings and Different Weld Patterns on Sugar Mill Rollers

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Abstract: ***Wear on sugar cane roll shells is costly maintenance problem for sugar cane mills. This research is conducted to understand the wear process in roll shells made of steel. In this process, sugarcane fiber – commonly called bagasse – is squeezed between grooved roll shells to extract sugar. A new test apparatus, based on the test machine, is built to study the wear caused by the slippage of bagasse on low-carbon steel under laboratory conditions. Contact pressure, mineral extraneous matter (MEM) within the bagasse, and velocity of the steel passing the bagasse can be varied. Silica sized in the range of 0.212–0.300mm is used as the MEM. Wear on the specimens is gravimetrically measured. Surface roughness and micro-indentation hardness is to be measured before and after testing. New surfaces and worn surfaces is to be analyzed by using optical and scanning electron microscopy. By using this test rig, the performance evaluation will give us test rig to find wear of roll shell material, best weld pattern to minimize wear, best welding electrode for hard facing deposition on roll shell, Facilitate to Carry out test on bagasse, bagasse + Silt and bagasse + Silt + sugarcane juice.***
Keywords: roll shell; hardfacing; electrodes; bagasse; silt.

I. INTRODUCTION

The sugar cane juice is extracted by crushing sugarcane between grooved rolls. A notable problem in sugar mills is wear on roll shells, this wear is caused by the friction between roll material and mineral extraneous matter (MEM). Major resion for wear is and mineral extraneous matter (MEM)which contains hard materials like silica, in the case of matter from the ground, metallic particles, which are detached from roll shell in previous stages of the process. To reduce wear hard facing alloys are used to increase the hardness of base material. This can be done by using welding process, on the surface of roll. These deposits helps to reduce wear of roll shell, they also reduce maintenance cost. The sugar industry as a matter of course employs welded hard-coated deposits to trim fatigue on sugarcane mill rollers. These welding deposits also having outstrip wear obstruction than base of operation apparatus (gray elect iron or simulate steel), show sufficient sprout roughness to facilitate helpful gripping between the sugarcane and the roller; therefore, welding deposits provide valuable feeding to the mill. On carbon comfort rollers, it has been observed that in places where hard-facing material has not being deposited or where it has being isolated, wear is higher resulting in removal of pattern of the teeth.

II. LITERATURE REVIEW

A. V.E. Buchanan

had conducted research for Microstructure and rough depress behaviour of shielded metal spin welding hardfacings material used in the sugarcane industry which investigates The abrasive behaviour of hypereutectic and hypoeutectic based Fe-Cr-C hardfacings are analysed and interpreted in respect of the microstructures. The coatings was deposited onto a grey cast iron sample by shielded metal arc welding using two hardfacing electrodes. The abrasive wear resistance test was performed on a modified block-on-ring apparatus that gives the wear conditions experienced in a sugar cane crushing roll.

1) Conclusion: The coarse wear behavior of commonly available iron chromium and carbon based hardfacing alloys, a hypereutectic quality (A1) and a hypoeutectic description (A2), that are routinely used in the sugar industry has been studied. It was observed that there was observable difference in their hardness's there was insufficient wear resistance under the experimental conditions.

B. Renzo Victoria Prado

had conducted study for Abrasive wear effect of sugarcane juice on sugarcane rolls which investigates, Corrosion seems to be an important factor affecting the wear of sugarcane rolls. This paper shows the results of a research undertaken to evaluate the corrosive effect of sugarcane juice on carbon steel rolls. Laboratory tests were performed on a prototype that approximately reproduces the wear conditions of sugarcane rolls. Laboratory tests were performed on low carbon steel (ASTM-A36), with and without a layer of welded stainless steel. The performance was quantitatively evaluated in a field test using a real roll. Field tests show's that improvement is not needed when roll is welded with steel. In laboratory tests it is observed that direct comparison could not be done between wear result on carbon steel and stainless steel

1) Conclusion **-** No improvement is needed when the roll welded with a buffer of austenitic stainless steel is observed in the field test. serious wear and detachment of the hard-facing deposits were observed. It is also observed that the corrosive effect of the sugarcane juice increased the wear of the specimens made of carbon steel, also when the test was done without MEM.

C. John J. Coronado

had conducted research on The effects of welding processes on abrasive wear resistance of hardfacing deposits in which he has evaluated four types of welding deposits welded through two different welding processes: flux cored arc welding (FCAW) and shielded metal arc welding (SMAW). The other parameters to be considered for the tests were the deposited layers. He has evaluated hardfacing deposits using the dry sand-rubber wheel machine according to procedure A of the ASTM G65 standard. for the characterization of the microstructure and worn surface of deposits, Optical and scanning electron microscopy was used According to this FCAW welds presented higher abrasive wear resistance than the SMAW deposits. The hardfacing deposit formed by uniformly distributed carbides rich in titanium presented the highest abrasive wear resistance. Abrasive wear resistance observed was higher when three layers were applied, except for SMAW-D deposit. In this test to obtained clear relation between hardness and the abrasive wear resistance of the deposits was not possible. The results showed that the most important variable to improve abrasion resistance is the microstructure of hardfacing deposits, where the carbides act as barriers to abrasive particle cutting.

1) Conclusion **-** Hard facing using flux cored arc welding presents higher abrasive wear resistance than hardfacing by shielded metal arc welding process FCAW-B is composed of a eutectic matrix with carbides rich in titanium, which act as barriers to cutting by abrasive particles which gives highest wear abrasive resistance.

III. RESEARCH GAP

From above discussion it is not clear that for hard facing of sugar mill roll's which welding pattern is best and which electrode is to be used.

A. Problem statement

The work focus on analysis, performance evaluation and optimization of sugarcane rollers considering the various welding pattern and electrodes. The aim is to find out best weld pattern and welding electrode for sugarcane roll's

B. Objectives

1) To develop experimental test rig to find wear of roll shell material
2) To find best weld pattern to minimize wear
3) To find best welding electrode for hard facing deposition on roll shell
4) Carry out wear test under three different conditions using bagasse, bagasse + Silt and bagasse + Silt + sugarcane juice.

C. Scope

Wear analysis on the surface of sugarcane crushing roll's is very important in any sugar industry as cost of sugarcane crushing roll is high and frequent maintenance is required if rolls are not working properly. Therefore there is need of experimental investigation for optimum solution by satisfying desired constraints to achieve desired objective.

D. Parameters Selection

Parameters to be considered are given bellow

1) Feed bagasse moisture content
2) Roll speed
3) Contact angle.

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4) Juice flow rate.
5) Slit flow rate.
6) These parameters are to be controlled during experimentation
a) Feed bagasse moisture content is to be monitored to know the state of bagasse coming in contact with specimen also moisture content will affect sugarcane juice absorption capability of baggase which is necessary for generating actual environment for experiment.
b) Sugarcane crushing Roll speed is to be changed and after some experiments best roll speed can be found out, roll speed also affects wear rate of roll shell as baggase is in contact with sugarcane crushing rolls.
c) Contact angle of board should be kept such that bagasse board should be in contact with specimen for maximum time. And it can be varied to vary baggase flow rate.
d) Juice flow rate -in this experiment we are supplying sugarcane guice to baggase to obtain actual practical environment, the flow rate of sugarcane juice will affect the chemical properties of baggase and it will show its effect on specimen.
e) Slit flow rate – in this experiment slit is used to understand behavior of specimen when it comes in contact with impurities or course material are we are planning to control the flow rate of slit too.Other than these parameters some other parameters are also considered in this experiment such as welding pattern
f) Circumferential welding pattern
g) Providing spot's
h) Other special pattern and effect of these welding patterns on wear rate

E. Calculations

Speed of roller in industry is 4 to 6 rpm
Diameter of roller is 1000 mm
Material of Roller is Special grade cast iron
Operation done on roller

1) Casting on shaft to form roll shell.
2) Grooving on roll shell material.
3) Arching on groves (hardfacing).

II. MATERIALS AND METHODS

A. Material specification

Material of specimen is course grain special quality cast iron 180 to 210 BHN confirming to IS 210-1978 Specification of material is as given bellow:-

C%=3.15 to 3.30
Mn%=0.60 to 0.80
Silica%=1.60 to 1.90
phosphor %=0.11
P%= 0.11
S%= 0.30
Chemical composition of bagasse
C = 47%
H = 6.5%
O = 44%
F=2.5%

B. Preparation of samples

1) Casting of given composition of size Diameter 110mm thickness 40m
2) Machining in size 90mm diameter 20 mm thickness and 10 mm boss for fitting on shaft.

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a b

Fig. 1. Base maretial casing after machining a- sample 1, b- sample 2

3) Drilling and taping of M6 on boss

C. *Preparation of bagasse compact for experimentation*

Fig. 2. Bagasse briquet.

D. Selection of electrode

electrodes are selected on the basis of strength of weld

1) AZUCAR -80 Deposits a tough eutectic of austenite and metal that can withstand impact at medium loads under abrasive conditions the weld metal has a hardness of approx 550 HV (52 HRc) with it can retain up to 400 o C ESSEN DUR 650 KB. The weld metal is unmuchinable, but can be ground. The deposited metal is highly resistant to abrasive wear with moderate impact and is recommended for general harfacing applications

2) ESSEN DUR 650 KB has hardness up to 57-62 HRc use for effective surface protection of parts subjected to abrasion like Excavator buckets, Tooth points, Dozer blades etc.

E. Hard facing on specimen.

Welding is performed on base cast iron material by selecting different welding patterns

1) Circumferential parallel welding pattern. (by essen dur 650 kb
2) Providing spot's (Tear Drop by essen dur 650 kb**)**
3) Overlap welding pattern. (By Azukar 80)

a

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b

c

Fig. 3. Specimen's after hardfacing

F. Disc RPM

For Actual Roll:-

$$\omega = 2\pi N/ 60$$
$$= 2 \times \pi \times 5/60$$
$$\omega=0.5235 \text{ rad/sec}$$
$$\text{Linear velocity} = \omega \times R$$
$$= 0.5235 \times 500$$
$$V=261.8 \text{ mm/sec}$$

For specimen:-

$$V = V \text{ of roll}$$
$$V=261.8 \text{ mm/s}$$
$$\omega= V/r$$
$$\omega= 261.8/100$$
$$\omega=2.61799 \text{ rad/sec}$$
$$\text{rpm}=\omega \times 60/2\pi$$
$$\text{rpm}=25 \text{ rpm}$$

III. EXPERIMENTAL PROCEDDURE

The base material for disc is cast iron. And for welding two commercially available welding electrodes, commonly used for hardfacing, can be used to deposit the hard facings. The electrodes are designated as A1 and A2 and are of diameters 3 to 4 mm, respectively. Bagasse compact sample (briquette), which is made of compressed cane fire, is used as the counter face material in abrasion or wear test programmed

Wear test is to be conducted with a prototype based on the standard machines but this prototype uses bagasse of different combinations instead of clean and pure bagasse. The hard facings will be deposited on the periphery of a 110mm diameter X 20 mm wide cast iron disc at ambient temperature in the constant current mode. The welding is performed using direct current setting as 120 and 145A for A1 and A2 respectively which is recommended by the manufacturer. In sugarcane industry wear occurs on the welded surface of mill rollers, therefore in this study the specimens are prepared with similar surface finishes for laboratory control

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to enable critical experimentation. In milling the welded surface primarily supports gripping of the cane bagasse and draws it through the mill, this effect is not considered in this study.

The wear is to be evaluated using a modified test rig specially made to test roll shell. A schematic arrangement of the main section of the machine is illustrated in fig. Bagasse compact is placed on supporting plywood board or holder and the coated cast iron disc (specimen wheel) is attached to a rotating spindle.

. Experiments is performed by considering following points

Fig. 4. Experimental set up

A. Experiment number 1

In this experiment weld pattern is simple parallel arching on circumference of specimen and bagasse board is placed at contact point of specimen, an arrangement is made such that bagasse feed can be made continuous by applying dead weight against it. An adjustment to press bagasse board against specimen is also provided in this test rig, it is done by dead weights. After 4 to 5 hrs reading are to be taken for effect of friction between bagasse board and specimen.

Sample 2 with simple parallel arching

Table5.1 Experiment details is given in table

Parameter	Value
weight of specimen before experiment in CT	6777.00
weight of specimen after experiment in CT	6775.00
Wear in CT	2.00
Dead weight attached in gm	1500
Angle of board	30
Rpm of disc	25

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B. Experiment number 2

In this experiment weld pattern is tear drop pattern on circumference of specimen and bagasse board is placed at contact point of specimen, an arrangement is made such that bagasse feed can be made continuous by applying dead weight against it. An adjustment to press bagasse board against specimen is also provided in this test rig, it is done by dead weights. After 4 to 5 hrs reading are to be taken for effect of friction between bagasse board and specimen.

Sample 1 with simple parallel arching

Table 5.2 Experiment details is given in table

Parameter	Value
weight of specimen before experiment	7035.00
weight of specimen after experiment	7030.00
Wear in CT	5.00
Dead weight attached in gm	1250
Angle of board	40
Rpm of disc	25

C. Experiment number 3

In this experiment weld pattern is 30 % overlap on circumference of specimen and bagasse board is placed at contact point of specimen, an arrangement is made such that bagasse feed can be made continuous by applying dead weight against it. An adjustment to press bagasse board against specimen is also provided in this test rig, it is done by dead weights. After 4 to 5 hrs reading are to be taken for effect of friction between bagasse board and specimen.

Sample 3 with simple parallel arching

Table 5.3 Experiment details is given in table

Parameter	Value
weight of specimen before experiment	7190.00
weight of specimen after experiment	7188.00
Wear in CT	2.00
Dead weight attached	1500
Angle of board in gm	30
Rpm of disc	25

D. Experiment number 4

In this experiment weld pattern is same as in experiment no 1 and bagasse board is placed at contact point of specimen, and silt is supplied by sand hopper and bagasse board is kept incline at 40 ^{0} with horizontal to allow silt to flow in contacting zone which my take part in wear of specimen and performing role of impurities coming with sugarcane in actual crushing of sugarcane. . After 4 to 5 hrs reading's are to be taken for effect of friction between bagasse board and specimen.

Sample 2 with simple parallel arching

Table 5.4 Experiment details is given in table

Parameter	Value
weight of specimen before experiment	6775.00
weight of specimen after experiment	6772.00
Wear in CT	3.00
Dead weight attached in gm	1500
Angle of board	30
Rpm of disc	25

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E. Experiment number 5

In this experiment weld pattern is same as in experiment no- 2 and bagasse board is placed at contact point of specimen, and silt is supplied by sand hopper and bagasse board is kept incline at 40 ^{0} with horizontal to allow silt to flow in contacting zone which my take part in wear of specimen and performing role of impurities coming with sugarcane in actual crushing of sugarcane to get actual situation sugarcane guise is fed to the contacting area between specimen, bagasse board and silt. After 4 to 5 hrs reading's are to be taken for effect of friction between bagasse board and specimen.

Sample 3 with simple parallel arching

Table 5.5 Experiment details is given in table

Parameter	Value
weight of specimen before experiment	7030.00
weight of specimen after experiment	7010.00
Wear in CT	20.00
Dead weight attached in gm	1250
Angle of board	30
Rpm of disc	25

F. Experiment number

In this experiment weld pattern is same as in experiment no- 3 and bagasse board is placed at contact point of specimen, and silt is supplied by sand hopper and bagasse board is kept incline at 40 ^{0} with horizontal to allow silt to flow in contacting zone which my take part in wear of specimen and performing role of impurities coming with sugarcane in actual crushing of sugarcane to get actual situation sugarcane guise is fed to the contacting area between specimen, bagasse board and silt. After 4 to 5 hrs reading's are to be taken for effect of friction between bagasse board and specimen.

Sample 3 with simple parallel arching

Table 5.6 Experiment details is given in table

Parameter	Value
weight of specimen before experiment	7188.00
weight of specimen after experiment	7183.00
Wear in CT	5.00
Dead weight attached in gm	1500
Angle of board	30
Rpm of disc	25

G. Experiment number 7 –

n this experiment weld pattern is same as in experiment no- 3 and bagasse board is placed at contact point of specimen, and silt is supplied by sand hopper and bagasse board is kept incline at 40 ^{0} with horizontal to allow silt to flow in contacting zone which my take part in wear of specimen and performing role of impurities coming with sugarcane in actual crushing of sugarcane to get actual situation sugarcane guise is fed to the contacting area between specimen, bagasse board and silt. to allow the silt to pass over the bagasse board, which is also contained between two side plates so that the silt is constrained to pass through the wear zone.. The silt can be sieved into a particle size range 212–300 m size using a mechanical sieve shaker. Prior to testing, the specimens are to be washed with soap and water, rinse in acetone, dry and then weigh. Load ranging the laboratory test can be carried out with appropriate air temperature range

After 4 to 5 hrs reading's are to be taken for effect of friction between bagasse board and specimen. This is last experiment to be

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performed and results are supposed to be obtained.

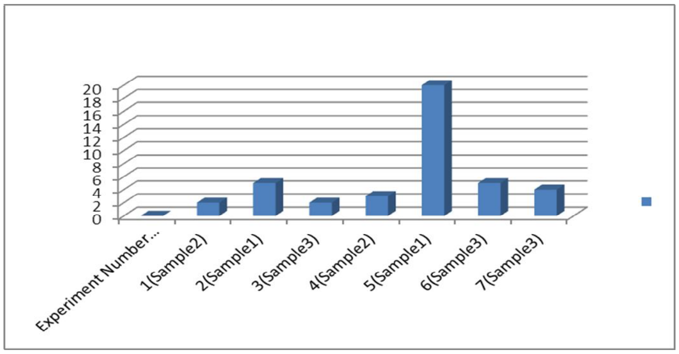
Table 5.7 Experiment details is given in table

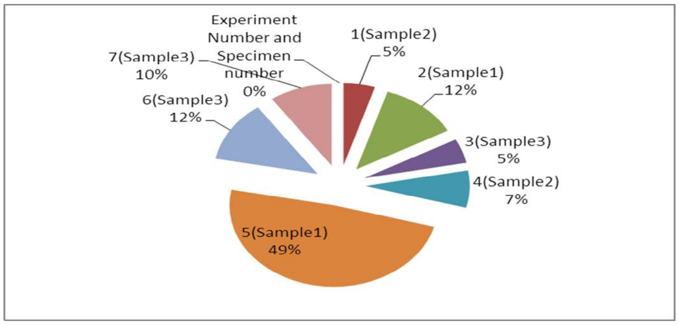
Parameter	Value
weight of specimen before experiment	7183.00
weight of specimen after experiment	7179.00
Wear in CT	4.00
Dead weight attached in gm	1500
Angle of board	30
Rpm of disc	25

IV. EXPERIMENTAL RESULTS

Experiment Number and Specimen number	weight of specimen before experiment in CT	weight of specimen after experiment in CT	Wear in CT	Dead weight attached in gm	Rpm of disc
1(S2)	6777.00	6775.00	2.00	1500	25
2(S1)	7035.00	7030.00	5.00	1250	25
3(S3)	7190.00	7188.00	2.00	1500	25
4(S2)	6775.00	6772.00	3.00	1500	25
5(S1)	7030.00	7010.00	20.00	1250	25
6(S3)	7188.00	7183.00	5.00	1500	25
7(S3)	7183.00	7179.00	4.00	1500	25

Best welding electrode for hard facing deposition on roll shell may be A2 type electrode





V. CONCLUDING REMARK

A. This performance evaluation will give us

1) Test rig to find wear of roll shell material.
2) . Best weld pattern to minimize wear.
3) Best welding electrode for hard facing deposition on roll shell.
4) Facilitate to Carry out test on bagasse, bagasse + Silt and bagasse + Silt + sugarcane juice.

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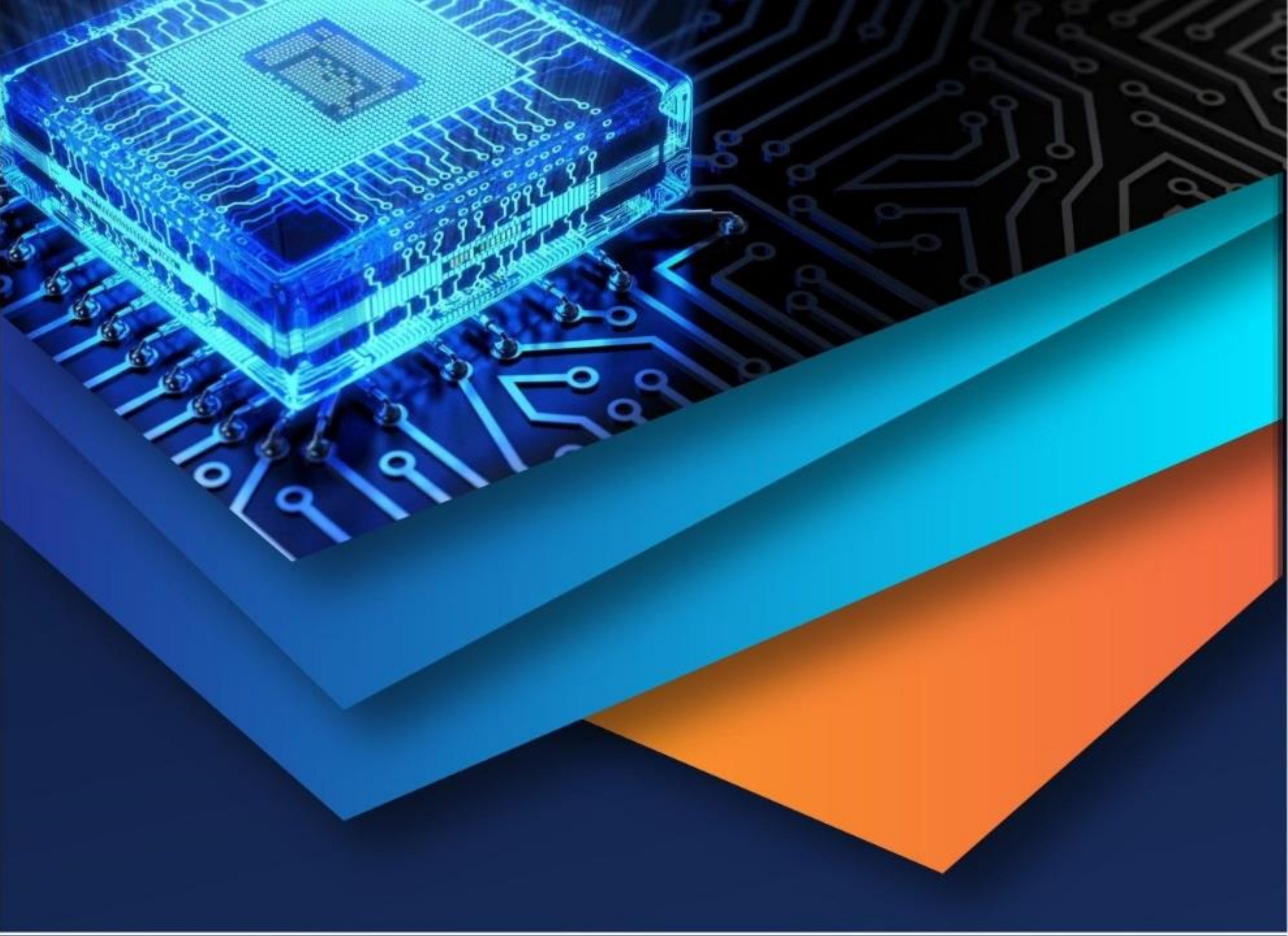

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