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Design and Development in Rear Axle Line (RAL) Washing Machine

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Abstract: ***The crown wheel and pinion are the power transmitting components in the vehicle. When these components are failed then serious problems may occur in the vehicle. Therefore it takes more time to repair the gears. When a gear is fractured then the detailed analysis is to be done. The gear is failed due to the irregular compositions and manufacturing defects. During the manufacturing process of the crown wheels, operations performed are such as, crown wheel cutting, heat treatment, lapping, washing, testing, etching etc. Crown wheels and pinions are used to transmit the power in rear axle of an automobile. Washing machine consist of three stages such as loading and unloading station, spray washing station with vertical nozzle box, air blow station . The washing machine is used for to clean the crown wheel and pinion. To wash the lapping paste which is present on the crown wheel and pinion. This paste was used because of to proper meshing of the crown wheel, means gear and pinion. The different types of paste are use as like graphite powder which is mix with oil. Then a proper graphite paste is formed, is used for lapping operation.***

Keywords: Crown wheel and pinion, RAL (Rear Axle Line), Lapping paste, Millipore, Stoppers,

I. INTRODUCTION

Crown wheel and pinion are the important components of RAL (Rear Axle Line). Machine used to wash out the lapping paste from the teeth of crown wheel and pinion is a special purpose gear washing machine. Lapping paste is spread all over the teeth of both the gears for finishing purpose. This washing machine has three main stations, loading-unloading station, spray washing station and air blow off station. After loading the components on the pallet of the machine, pallet goes to the inner chamber of the machine at which high pressure jets washes out the entire lapping paste. In return journey of the pallet air blow off station blows comparatively cooler air than washing chamber onto the components. The temperature of the washing media is about 55-60degree Celsius. The quality of washing is checked by a process called as Millipore value test. Millipore value is checked once in a week for performance check of washing. This value should be in the predefined range every time the test is done. The Millipore value is in the range between 6mg to 8 mg. The test is conducted with the help of solution like thinner. This thinner is place in one tray which contains the crown and pinion. After that the liquid is passed to the laboratory to checking Millipore value. When a range of Millipore is in between 6mg to 8mg then the washing is properly done. The crown wheel and pinion are used in rear axle of the vehicle.

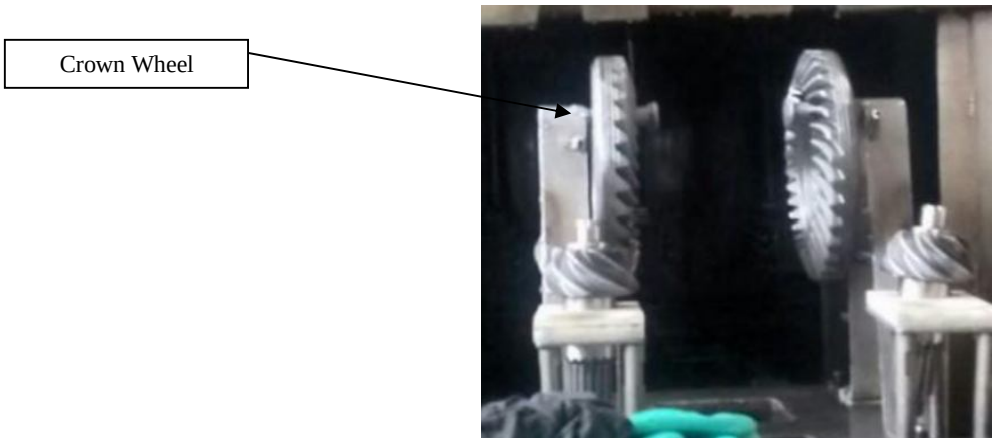

Fig No 1 Crown wheel load on old Trolley

II. LITERATIRE SURVEY

A. *Design and Analysis of Crown Pinion of A Differential Gear Box For Produced Number of Teeth To Improve Torque Transmitted, by A Bensely, S Stephen Jayakumar, D Mohan Lal, G Nagarajan and A Rajadurai (2006), "Failure Investigation of Crown Wheel and Pinion", Engineering Failure Analysis, Vol. 13, pp. 1285–1292.*

In this paper mechanical design of crown wheel and pinion in differential gear box of MFWD (FWA) Axle (of TAFE MF 455) is done. Detailed modeling, assembly and analysis of tooth of crown gear and pinion is performed in Pro-E. Finite element analysis is performed to analyze the crown gear tooth for working load. Induced equivalent stress is less than allowable stress. From this it is concluded that design is safe. In this work, spiral bevel pinion present in the differential assembly is redesigned. The selected pinion is the existing part of the bolero pickup vehicle. The material used to manufacture the existing pinion is SAE 4130 steel. To provide the same or higher margin of safety to the redesigned pinion, SAE 9310 steel material is chosen.

B. *Gear Design And Development, Axle And Manufacturing, By Author-Jack Masseth, AGMA Technical Paper, 06FTM02, 2006.*

Hypoid gears are widely used in automotive industries to transfer the rotation between non-intersecting axes in rear wheel drive, and 4WD vehicles. C0pmpared to other option for gear types such as spiral and straight bevel gears. The hypoid gear has more advantages which allows this type of gears. In hypoid gears non-intersecting axes the sliding velocity is higher. Sliding friction is other main factor for power loss sources in addition to rolling friction. Therefore in hypoid gears the high mechanical power during the mesh than intersecting types of bevel gears.

C. *Case Study-Strengthing Of axle Shaft By Heat Treatment To Overcome Twist, By Author-Yatish Rao, SAE Technical Paper, 07NVC-27, 2007*

This paper gives the information about ,an important use of axle shaft is use to transmit the power between two parallel planes. Axle shaft can experience severe impact load when there is sudden drop in clutch pedal during the vehicle operation under the loaded condition. I Yatish Rao have studied case study strengthing of axle shaft by heat treatment to overcome twist. This case study gives the information about ,an important use of axle shaft is use to transmit the power between two parallel planes. Axle shaft can experience severe impact load when there is sudden drop in clutch pedal during the vehicle operation under the loaded condition. Insufficient case depth and lower core hardness.

D. *Effect of Hydrofluoric Acid Etching Duration on the Roughness and Flexural Strength, By Lucas Villaça ZOGHEIB1 Alvaro DELLA BONA1 Estevão Tomomitsu KIMPARA2, Braz Dent technical paper J (2011) 22(1): 45-50*

The aim of this study was to examine the effect of different acid etching times on the surface roughness and flexural strength of a lithium disilicate-based glass ceramic. Ceramic bar-shaped specimens (16 mm x 2 mm x 2 mm) were produced from ceramic blocks. All specimens were polished and sonically cleaned in distilled water. Specimens were randomly divided into 5 groups (n=15). Group A (control) no treatment. Groups B-E were etched with 4.9% hydrofluoric acid (HF) for 4 different etching periods: 20 s, 60 s, 90 s and 180 s, respectively. Etched surfaces were observed under scanning electron microscopy. Surface profilometry was used to examine the roughness of the etched ceramic surfaces.

III. PROBLEM STATEMENT

A. Suggest the suitable design for the pallet of the washing machine.
B. While designing the pallet body frame of the machine is constrained.
C. Ultimate aim is to increase the rate of production.(crown wheel and pinion sets)

IV. METHODOLOGY

In above project our main aim is to increase the productivity of the gear washing machine by changing the design of pallet of the machine suitably. Pallet is like a trolley, arrangement for mounting crown wheel and pinion sets. While redesigning the pallet of the pallet of the machine the entire machine assembly should be constrained this is the only condition. Before redesigning the pallet, the capacity of the older pallet was 2 sets of crown wheel and pinion. After making suitable changes in the pallet, the capacity becomes double than the previous one. The below fig. 3 shows the drawing of the new pallet sketched on design software Catia.

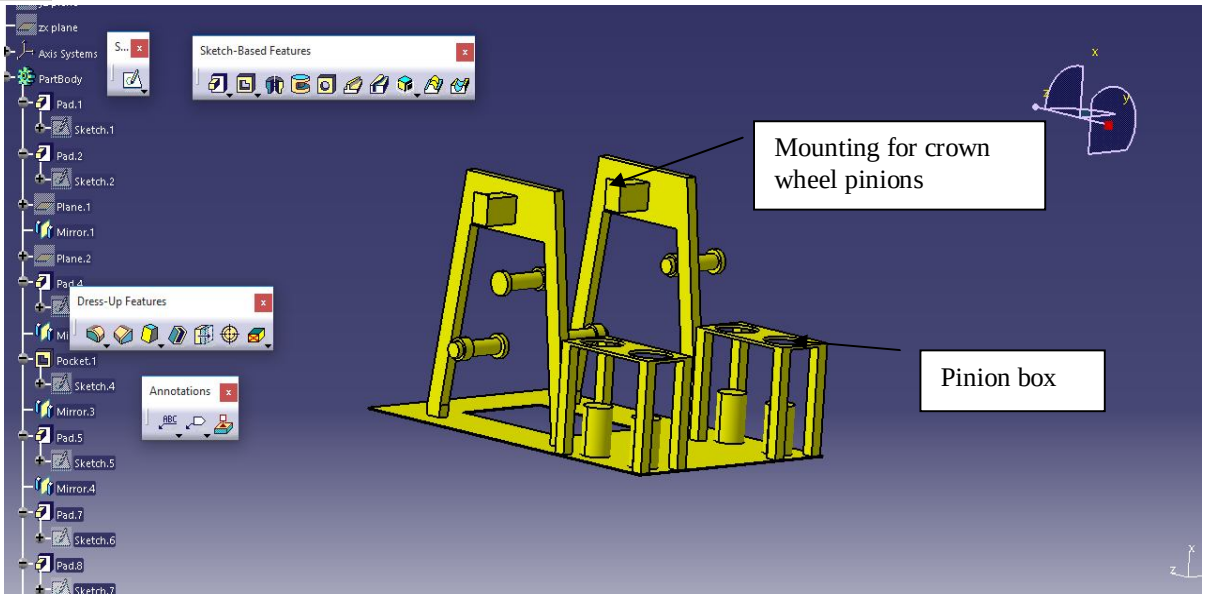

Fig. 2 New Trolley Design in Catia Software

For older version of the pallet, capacity in one time was two sets of crown wheel and pinion i.e. (2 crown wheels and 2 pinions) for washing. The time required for washing two sets was about 3 mins and 30 secs. In newly designed pallet, capacity gets doubled that the previous one i.e. (4 crown wheels and 4 pinions). But the cycle time for both the pallets remains same. Thus in new pallet 4 sets can be washed at a time within the same time span.

V. DESIGN PROCEDURE

A. Selection of base plate

Base plate selection is the first step in designing the newer version of the pallet. Entire structure is then welded on this plate, so plate has to sustain with the weight of the components as well. Older version of the pallet has dimensions (base plate- 660×440mm), thickness of 23mm and material used was S.S(Stainless Steel). As we were not allowed to change the dimensions of the base plate, we selected the plate having same dimensions as of older one. (base plate- 660×440mm), thickness we have increased to 25mm since material available with us was M.S(Mild Steel) which is not as stronger as S.S(Stainless Steel)

Base plate specifications/dimensions of new trolley- 660×440mm
25mm thickness
Material- M.S

B. Frame design

Frame design is the second step in designing the new trolley. Flat plate of stainless steel material used earlier in the old pallet for frame of inverted U shape. It was occupying more space as flat plate was used. Also it was having one way or one sided arrangement for mounting crown wheels on it. In the new pallet we selected the square bars of side 25mm for frame manufacturing. Square bars occupied less space and given us a bit compact structure. We made an arrangement in the new pallet such that, two sided or two way mounting of crown wheels is now possible. It is also called as cross arrangement, as one crown wheel is in cross direction with other one. Hence we have enhanced the capacity.

C. Pinion box design

Third step in the designing is the design of pinion box. Simple manufacturing is involved in the pinion box making. In old design two holes were there having different diameters(one for smaller pinion and another for larger pinion). We made an arrangement such that, two holes on the pinion box must have same diameters Ø70mm, we design this for largest pinion used on the machine. This results in ease of handling, operation and human comfort. Also we have added a thin rubber sheet on the pinion box to avoid wear and tear as well as friction. Because of the modification done in the pinion box, two pinions having largest diameters(Ø65mm) are comfortably placed on the pinion box.

D. Pinion box stoppers

According to the dimensions we have collected, the height of the pinion box is slightly greater than the height of the largest pinion used, for which we have designed the pinion box. Therefore to avoid misalignment and false between the successive pinions we used stoppers. Stoppers gave pinions a stability so that they will not move from their position during entire washing process.

The figure no 2 indicate the new trolley design in catia software. This drawing are suggested for four sets of crown wheel and its pinion.

Process involved in manufacturing of the new pallet

1) *Marking on the base plate:* Marking on the plate is done with the dimensions taken to cut the plate in required size. Plate dimensions - 660×440mm. Plate is then cut with the help of gas cutter in required size and shape.

Fig No 3 Marking on the plate

2) *Frame welding on the base plate:* Inverted U shape frame with cross arrangement for mounting of crown wheels is now properly welded with high safety and precision on the base plate.

Fig No 4 Frame welding

3) *Pinion box welding on the plate:* Pinion box contains 4 base pillars as square bars of side 25mm and on these pillars a plate(240×120mm) is welded. At the end this entire assembly is now welded on the new trolley.

Fig No 5 Pinion box welding

4) *Fixation of the stoppers in the pinion box:* According to the dimensions we have collected, the height of the pinion box is slightly greater than the height of the largest pinion used, for which we have designed the pinion box. Therefore to avoid misalignment and false between the successive pinions we used stoppers. Stoppers gave pinions a stability so that they will not move from their position during entire washing process.

Fig No 6 Stoppers fixation

5) *Dimensions checking:* After welding the entire structure, we have mounted the 4 sets of crown wheels and pinions, to check the trueness, dimensional accuracy and cross alignment made in the frame.

Fig No 7 Dimensions checking

6) *Painting:* Painting of the trolley is done in painting shop. Entire painting is done with the help of spray painting as it gives uniformity and cleanliness and shining effect. It is done by a skilled labour. Main function of the painting process is to avoid corrosion and dust effects on the trolley. The life of the trolley is increased by painting operation.

Fig No 8 Painting

7) *Actual implementation:* Finally the pallet is mounted on the machine after competing all the necessary operations required for the manufacturing. Now we are all set for the first test of the pallet on the washing machine.

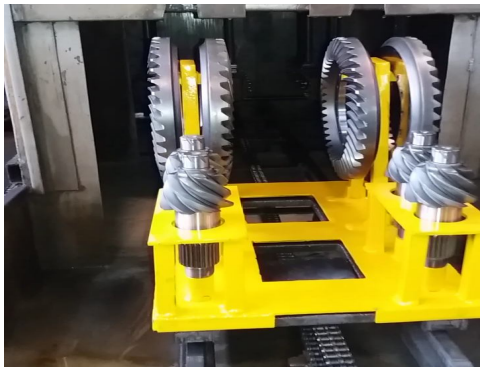

Fig No 9 Actual implementation

VI. RESULTS

1) Newly manufactured pallet is having arrangement for 4 sets of crown wheel and pinion.
2) Because of the increase in capacity of the pallet time saving is achieved as compared to the old design.
3) Overall energy required for machine per day using new pallet is lesser than using with older pallet.
4) Less human fatigue.
5) Convenient and user friendly design.
6) The daily targets is achieve in only A shift, therefore the shift B is not working on that machine.

VII.ENERGY and COST CALCULATIONS

A. For old pallet

Cycle Time =3.5mins.
In one hour =60 minute
Number of cycles in 1 hour =17.14 ~ 18 cycles.
1 cycle = 2 sets of crown wheel and pinion
18 cycle = 36 sets of crown wheel and pinion
In shift A- total working hours × sets of crown wheels
=7×36
=252 sets.
In shift B- total working hours × sets of crown wheels
=7×36

=252 sets.
In one day total number of sets = 504 sets,
In one month total number of sets =504×26
=13104 sets
In one year total number of sets = 157248 sets.

B. For New pallet
Cycle Time =3.5mins.
In one hour =60 minute
Number of cycles in 1 hour =17.14 ~ 18 cycles.
1 cycle = 4 sets of crown wheel and pinion
18 cycle = 72 sets of crown wheel and pinion
In shift A- total working hours × sets of crown wheels
=7×72
=504 sets of crown wheel and pinion.
In shift B- no working hours.
Note- The total working is 8 hours in a company but the some allowance are considered the working is 7 hours.
Allowances are as follows:

a) Break fast = 15 minute
b) Lunch = 30 minute
c) Tea break =15 minute

Hence the total working is = 7 hours/ day.

C. Energy Analysis
In 1hour = 15 units consume the machine
Cost of 1 unit = 11.5 Rs
If machine is working for 1hour the cost of electricity or bill is = 15×11.5
=Rs172.5
Therefore the total working hours in sift A= 7×172.5
=Rs.1207.5

The total working hours in sift A= 7×172.5
=Rs.1207.5

D. For old pallet
In one day produce in shift A 252 sets and shift B 252 sets of crown wheel and pinion. Therefore electricity consume in shift A = 105 units
electricity consume in shift B = 105 units
Total units = 210
In 1 month = 26 days machine is working
Therefore, number of days × units consume per day
=26×210
=5460 units consume the machine/ month
Hence the amount of energy bill is,
Units consume per month ×rate of charge
=5460×11.5
=62790 electricity bill / month.

E. For new pallet
In shift A produce 504 sets of crown and pinion.

In A shift = Number of working hours × Units consume per day
=7×15
A shift=105 units
Electricity bill = 105×11.5
= Rs1207.5 /day
In 1 month = 26 days working
= working day × units consume per day
=26×105
=2730 unit consume machine / month
Therefore cost of energy is = number of units consume ×rate charge
=2730×11.5
Electricity bill = Rs.31395 / month .

The shift B is closed because of daily target is achieved in shift A only. Therefore the shift B is not working. i.e. it is closed permanently. The main advantage of this technique is, the machine is require 2 operator at both shift. But the target is achieved in shift A. Therefore 2^nd operator on that machine is not require. Those operator are working at a different machine. Therefore the salary of that operator is also used in different ways.

VIII. CONCLUSION

By suggesting new changes in the pallet we have successfully increased the production rate of the gear washing machine. By increasing the production rate, saving of electricity and ultimately the cost reduction is achieved. The first trial on the newly manufactured pallet was extremely successful.

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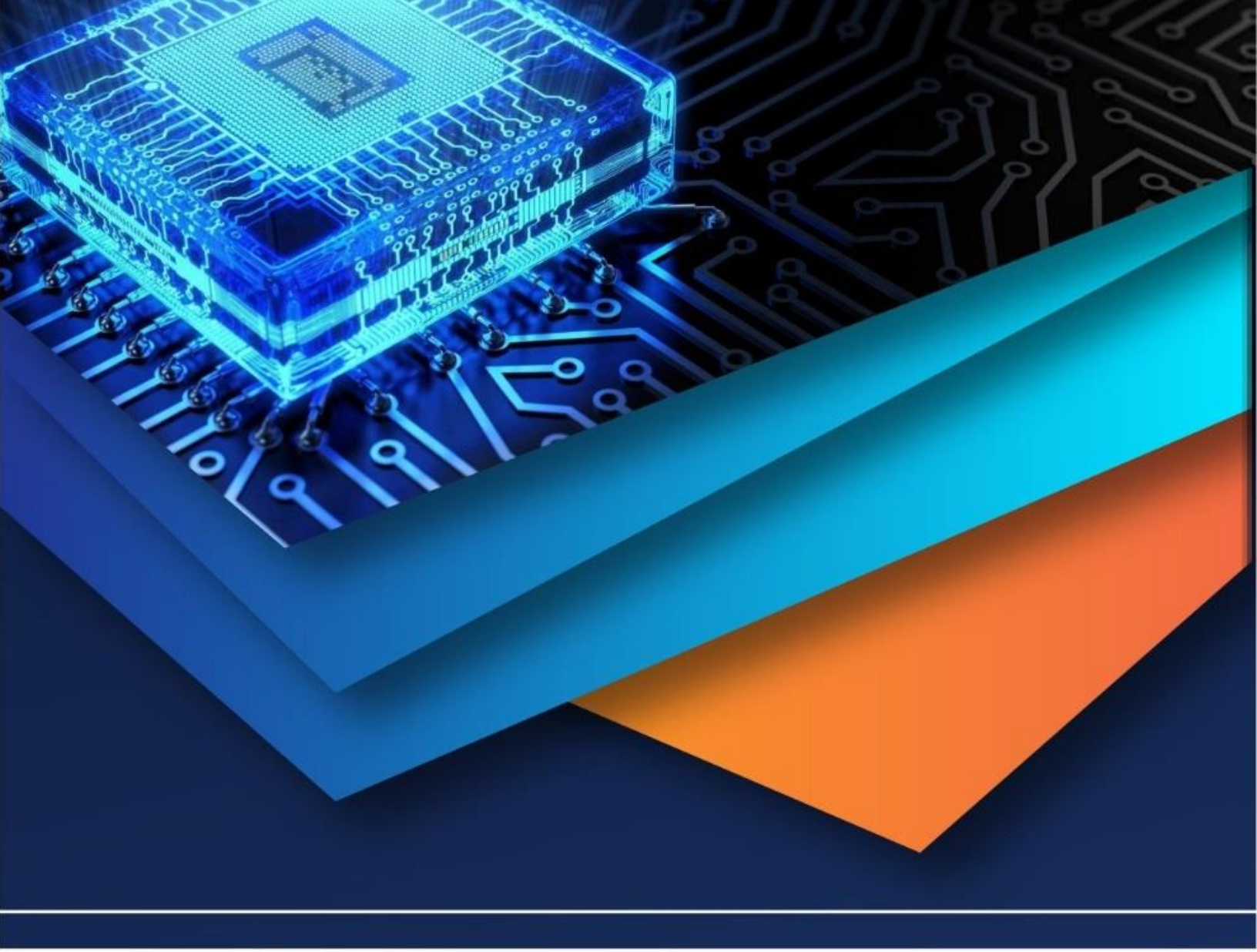

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