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Comparative Thermal Analysis of Piston Crown Using Ansys

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Abstract-: In engines pistons are very important parts to produce power. Piston fail mainly due to mechanical stresses and thermal stresses. An analysis of thermal stress and damages due to application of temperature is presented and analysed in this work. Aluminium alloy have been selected for thermal analysis of piston. Results are shown and a comparison is made to find the most suited design Analysis of piston crown is done with boundary conditions, which includes pressure on piston head during working condition and uneven temperature distribution from piston head to skirt. There are four types of piston crown that has been analysed in this project. The CAD model is created using CATIA software. CAD model is then imported into ANSYS software for geometry and meshing purpose. Complete design is imported to ANSYS 15 software then analysis is performed.
Key words: Flat type, Recessed type, Chamfered type, Dome or convex type

I. INTRODUCTION

The modern trend is to develop IC Engine of increased power capacity. One of the design criteria is the endeavor to reduce the structures weight and thus to reduce fuel consumption. This has been made possible by improved engine design. These improvements include increased use of lightweight materials, such as advanced ultra-high tensile strength steels, aluminum and magnesium alloys, polymers, and carbon-fiber reinforced composite materials. The integration of lighter weight materials is especially important if more complex parts can be manufactured as a single unit. In the next 10–20 years, an additional 20–40% reduction in overall weight, without sacrificing safety, seems to be possible. Withstand loads tending to elongate. In other words, compressive strength resists compression. Compressive strength is often measured by universal testing machine. In this work Eutectic Al Alloy (Si 11-13%) was taken as piston material. Initially thermal and structural analysis was performed on Al Alloy piston without silicon nitride crown and then with silicon nitride crown using the software ANSYS. Then the results obtained are compared. The comparison of results indicated that the piston which is arranged by silicon nitride crown is better to withstand high thermal and structural stresses than the piston which is not arranged by silicon nitride crown. The present work has been undertaken with the following objective, To design an IC engine (piston and piston ring) by using CATIA V5 R20 software, To perform the thermal analysis (of piston and piston ring) using ANSYS 15 software. Engine pistons are one of the most complex components among all automotive and other industry field components. The engine can be called the heart of a vehicle and the piston may be considered the most important part of an engine. There are lots of research works proposing, for engine pistons, new geometries, materials and manufacturing techniques, and this evolution has undergone with a continuous improvement over the last decades and required thorough examination of the smallest details. Notwithstanding all these studies, there are a huge number of damaged pistons. In this analysis project we have analysed various types of piston heads which are normally used. They are namely Flat, Recessed, Concave, Convex, Chamfered types of piston head. And Temperature, stress and pressure properties of piston have been analysed in the project work that have been taken. This analysis could be useful for design engineer for modification of piston at the time of design. In this project we determine the various stress calculation by using pressure analysis, thermal analysis and thermo-mechanical analysis form that we can find out the various zones or region where chances of damage of piston are possible. The first is used to evaluate the temperature distribution through the piston volume, and the second is used to evaluate the thermal stress distribution due to heat gradient and different materials.

II. LITERATURE SURVEY

A. vaishali R.Nimbarte and et.al [1].describe that, The analysis predicts that due to temperature whether the top surface of the piston may be damaged or broken during the operating conditions, because damaged or broken parts are so expensive to replace and

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generally are not easily available.

B. Dilip Kumar Sonar, and et.al [2]. Describe that, Damage mechanisms have different origins and are mainly wear, temperature, and fatigue related. Among the fatigue damages, thermal fatigue and mechanical fatigue, either at room or at high temperature, play a prominent role. In this present work a piston is designed using CATIA V5R20 software. Complete design is imported to ANSYS 14.5 software then analysis is performed.

C. Dr.I.Satyanarayana, and et.al [3]. Describe that, We applied temperature and convection as and we determining total temperature on the body, total heat flux, heat flux in x,y,z directions respectively And this piston also having less stress(173.82 MPa) and good safety factor 1.6102. And the thermal heat flux also less other material cast iron and cast steel.

D. G.Siva Prasad and et.al [4]. Describe that, the analysis becomes completed on the different parameters (temperature, stress, deformation) and easily analysis the result. The different material Al alloy 4032, AISI4340 Alloy Steel & Titanium Ti-6A1-4V.

E. M.Srinadh, K. Rajasekhara Babu [5]. Describe that, the thermal flux, thermal temperature distribution is analyzed by applying temperatures on the piston surface in Thermal analysis. The structural and thermal analysis were also done on the piston and piston rings model using Cast iron, Aluminum Alloy A360 and Zamak.

F. Parthiban S and et.al [6]. Describe that, existing material of the piston ring material were considered and studied, a model corresponding to its dimensions were prepared and analysis were done on them in static conditions.

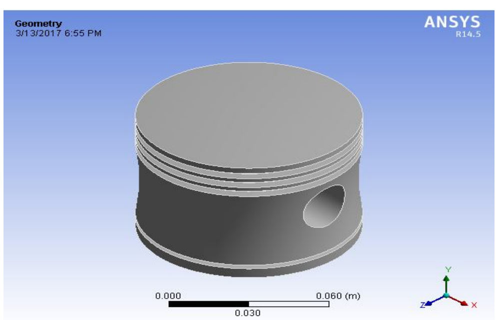
G. Sandeep Jain, and et.al [7]. Describe that, three different materials have been selected for structural and thermal analysis of piston. For piston ring two different materials are selected and structural and thermal analysis is performed using ANSYS 14.5 software.

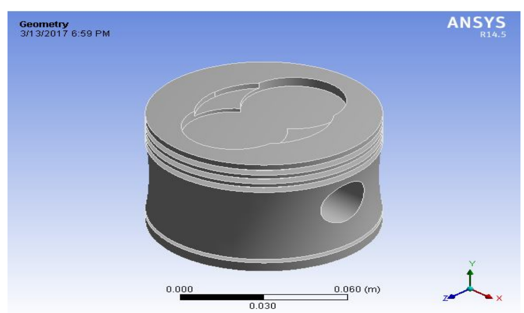
H. Saigowtham Ponnathi, and et.al [8]. Describe that, in this project the design of piston, piston rings and cylinder liners are modelled in CATIA V5. The design of the engine parts is complex and efficiency is related to the type of material. The material is taken as ALUMINIUM-FLYASH-ALUMINA composite.

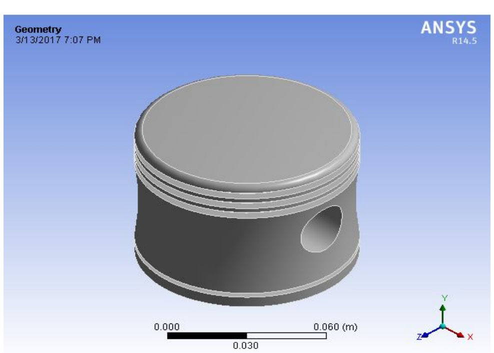
III. METHODOLOGY

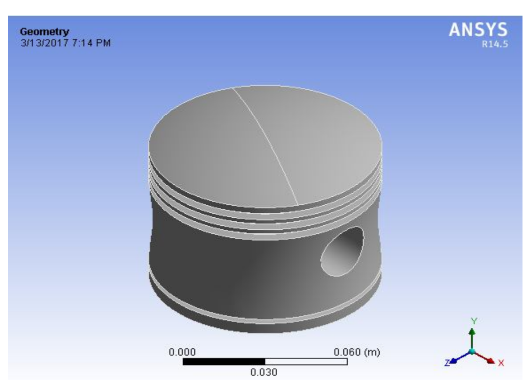
A. Importing Geometry From Catia V5 To Ansys 15

1) Flat typ
2) Recessed typ
3) Chamfered type
4) Dome or convex type









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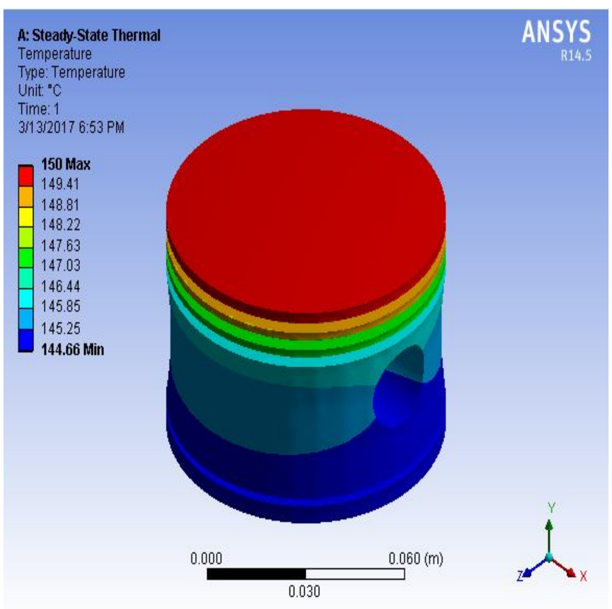
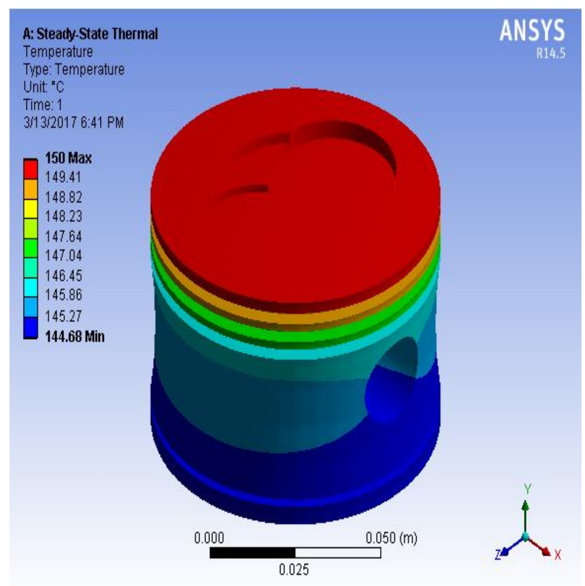
B. Mechanical properties of aluminium

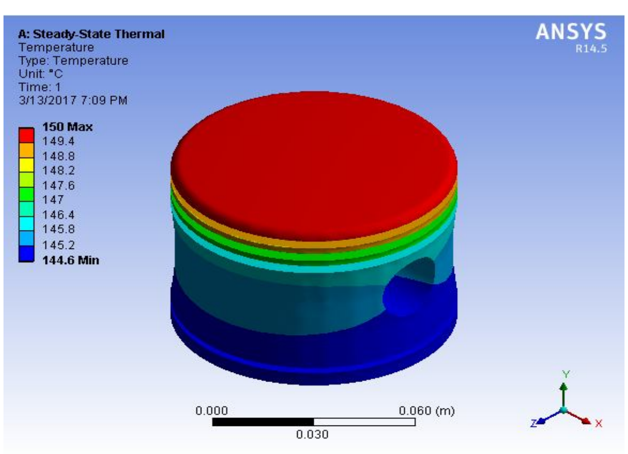
The materials considered for this work are A4032 and A2618 for an IC engine piston. The mechanical and physical properties of aluminum alloys are listed in the table.

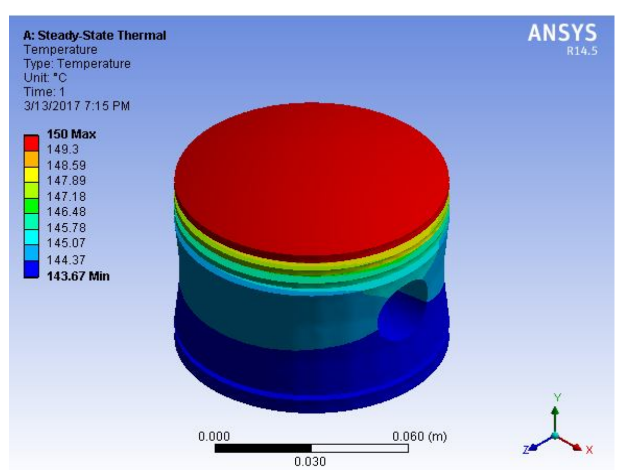
S.NO	PARAMETERS	A4032	A2618
1	Density(kg/m^3)	2684.95	2767.99
2	Poisson's ratio	0.33	0.33
3	Coefficient of thermal expansion(1/K)	79.2×10^{-6}	25.9×10^{-6}
4	Elastic modulus(Gpa)	79	73.7
5	Yield strength(Mpa)	315	420
6	Ultimate tensile strength(Mpa)	380	480
7	Thermal conductivity(W/m/0C)	154	147

IV. RESULT AND DISCUSSION









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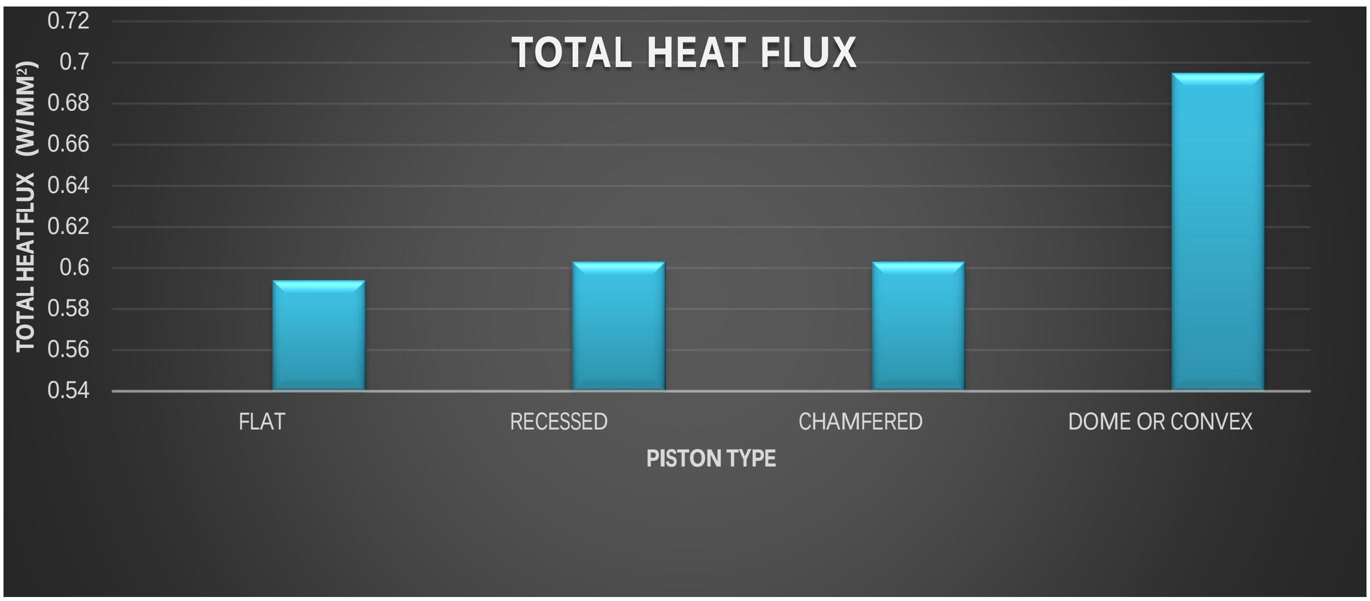
C. Total heat flux

TYPES	TOTAL HEAT FLUX (MINIMUM)	TOTAL HEAT FLUX (MAXIMUM)
FLAT TYPE	155.45 W/m²	59389 W/m²
RECESSED TYPE	4.9241e-006 W/m²	60288 W/m²
CHAMFERED TYPE	271.18 W/m²	60303 W/m²
DOME OR CONVEX TYPE	83.347 W/m²	69492 W/m²

D. Comparison of total heat flux



E. Directional heat flux

TYPES	DIRECTIONAL HEAT FLUX (MINIMUM)	DIRECTIONAL HEAT FLUX (MAXIMUM)
FLAT TYPE	-30418 W/m²	31554 W/m²
RECESSED TYPE	-31722 W/m²	30119 W/m²
CHAMFERED TYPE	-34405 W/m²	31691 W/m²
DOME OR CONVEX TYPE	-28660 W/m²	28389 W/m²

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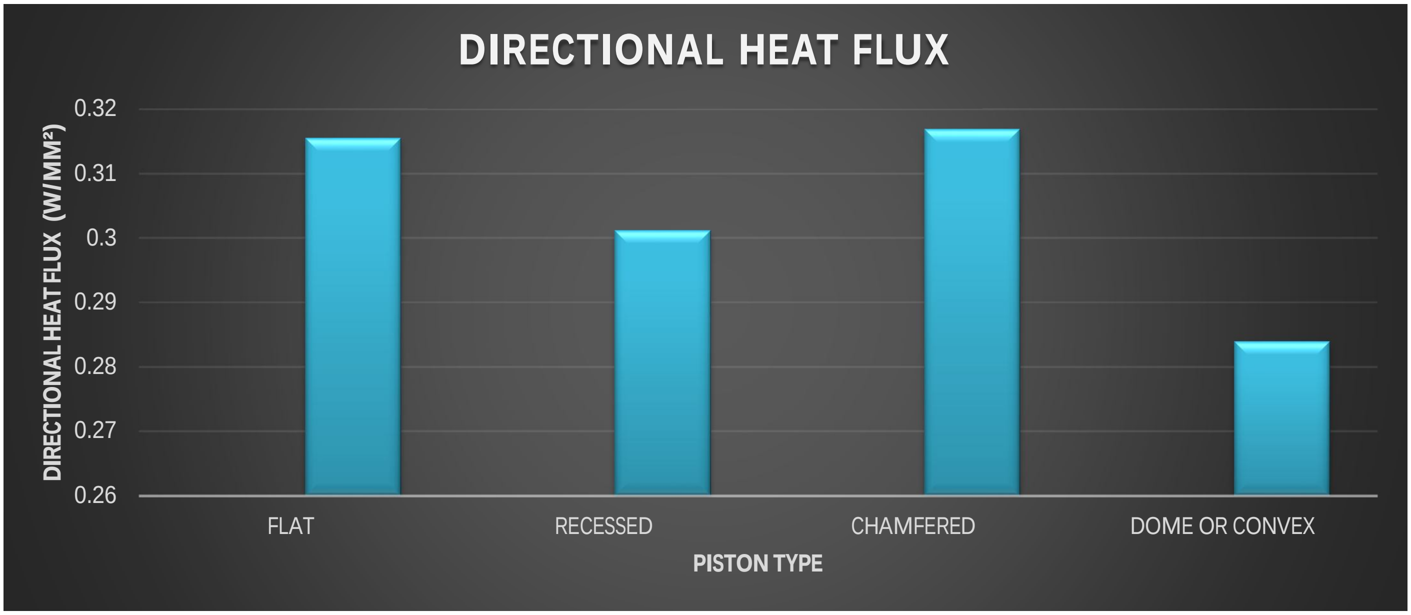
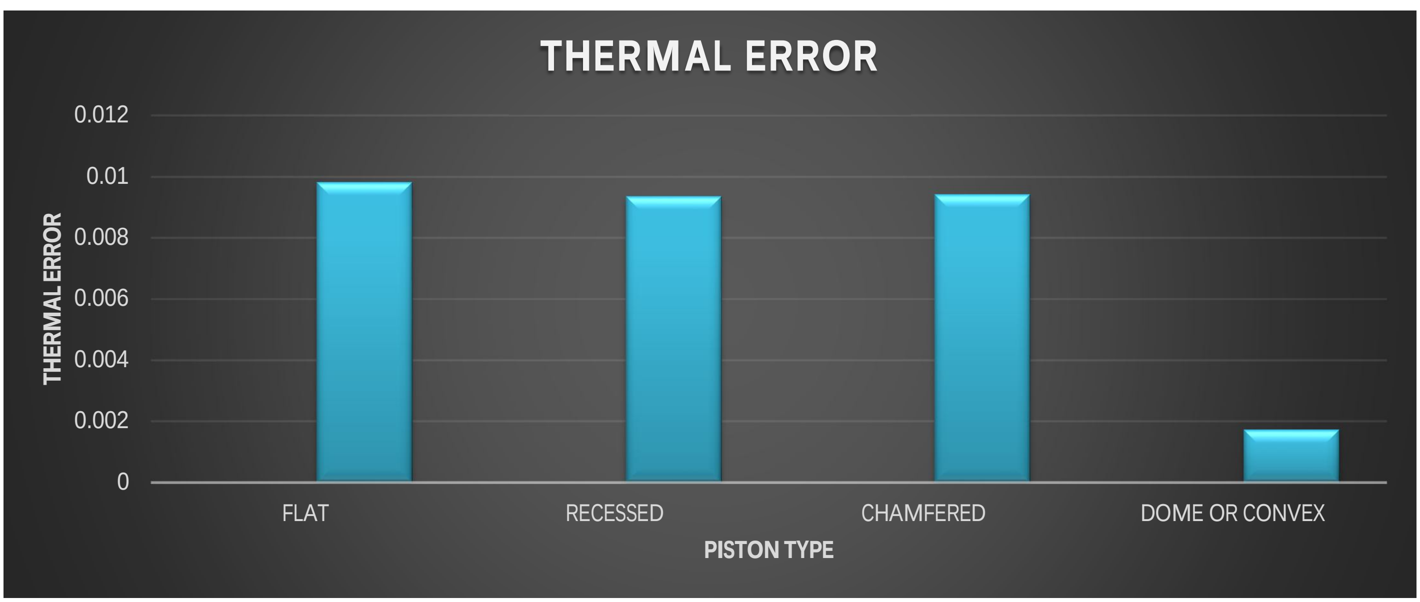
F. Comparison of directional heat flux



G. Thermal error

TYPES	THERMAL ERROR (MINIMUM)	THERMAL ERROR (MAXIMUM)
FLAT TYPE	1.2626e-014	9.8199e-003
RECESSED TYPE	4.8572e-019	9.3556e-003
CHAMFERED TYPE	1.3456e-014	9.4145e-003
DOME OR CONVEX TYPE	2.1887e-014	1.7123e-003

H. Comparison of thermal error



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V. CONCLUSION

We have concluded analysis of steady state thermal and done with the parameters of heat flux, directional heat flux and thermal error. By analyzing the above four types of piston crowns we found the minimum thermal error occurred in the type of DOME OR Convex Type by using ANSYS 15 software.

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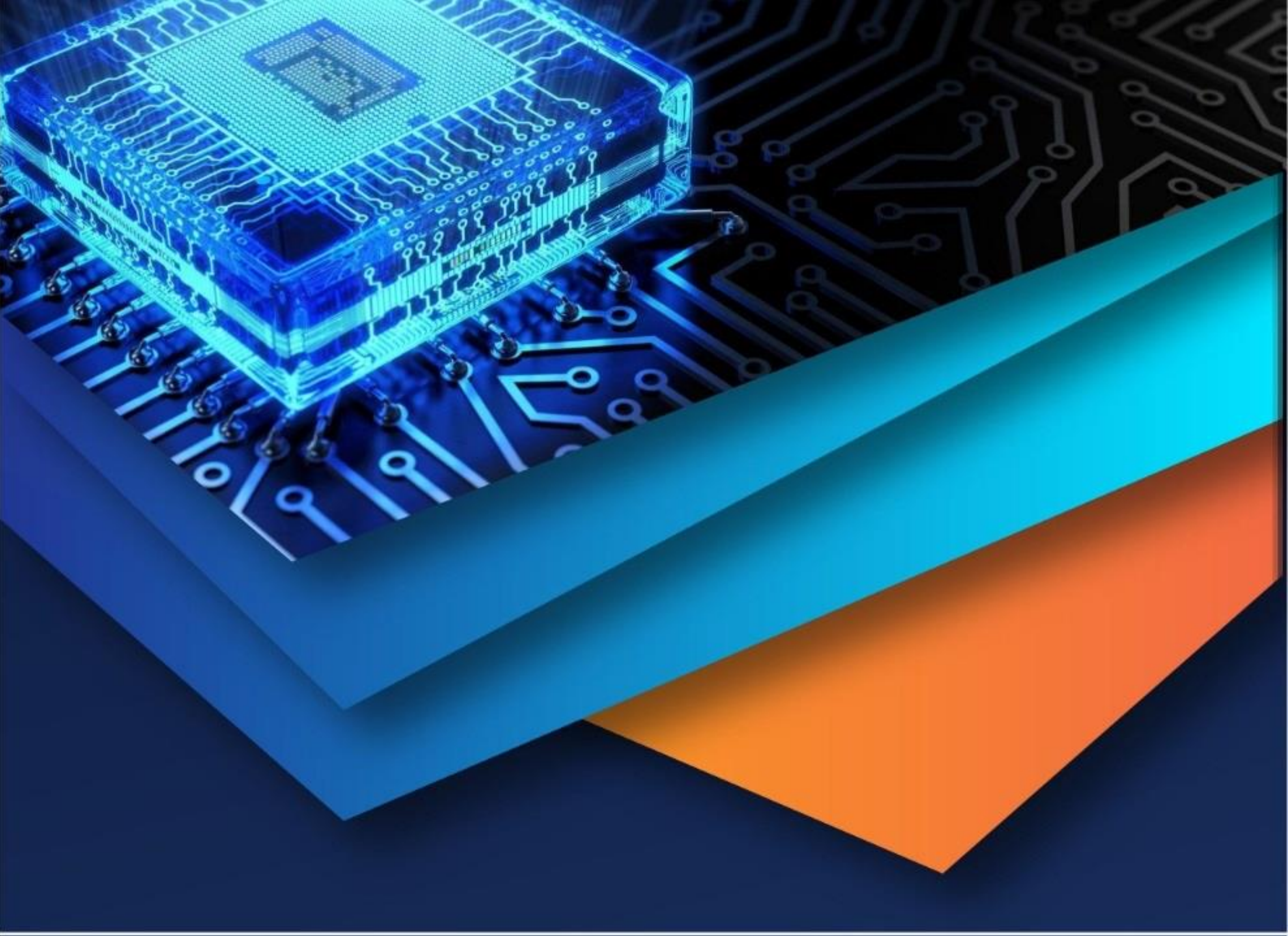

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