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Bird Strike Analysis on Aircraft Wing

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Abstract: Bird strike, also known as avian ingestion, is the collision between a bird and an aircraft. Bird strikes have always been a cause of worry in the aeronautical industry: Aircraft both old and new have suffered from bird strikes. Aircraft ingestion occurs when the bird hits an aircraft wing and gets sucked in. Given that the Aircraft Wings moves at a high Speed, bird strike on a Wing causes its displacement into the wing. This leads to a cascading failure, wherein the entire system fails, thereby resulting in a lot of damage. In this article, we intend to investigate the impact of bird on wing and eventually strengthen its' resistance to bird strikes.

I. INTRODUCTION

Birds were involved in 97% of the reported strikes since the early days of flight. Every bird strike incident results in a loss of flying hours, and costs per incident. Based on the bird Strike cases reported, most damages occur at the wing and engines. The collisions between a bird and an aircraft wing are known as bird-strike events. With modern computer simulations capabilities, we can try to simulate bird-strike events and predict the damage to aircraft components with the Lagrangian method because it is easy to model. The aim of this research work was to define a computational testing methodology of bird-strike analysis of an aircraft wing with the use of ANSYS workbench 18.0 using Autodyn as solver tool. The geometry of the wing section, the meshing, connections and material properties are modelled and defined in Ansys 18.0. The bird is modelled in Autodyn using SPH technique with gap size of 0.5 mm. Then the validation of bird model is carried out by impacting the bird at velocity of on selected wing section and the simulation results are analysed.

II. OBJECTIVES

A. To analyze bird strike impact on Aircraft wings with various bird models using Ansys Autodyn.
B. To analyze bird strike impact on Aircraft wings with various bird impact velocities using Ansys Autodyn.

III. PROBLEM STATEMENT

Bird strikes have been a major cause of worry for aircraft designers ever since the inception of aviation. According to various surveys conducted in the past, it has been observed that quieter aircrafts are more susceptible to avian ingestion, specifically due their lack of warning. We can improve the aircrafts' wings themselves by making them more resistant to bird strikes.
In order to reach this goal, the impact of a bird strike on an Aircraft wings can be analyzed and emphasized not on just the bird model, Stress and deformation patterns will also be investigated to suggest more robust fan designs to lessen bird strike impact.

IV. METHODOLOGY

A. The blade and the bird are initially modeled in Ansys.
B. AUTODYN-3D is used for the collision simulation.
C. The bird was modeled as a cylinder with hemispherical ends.
D. To replicate the behavior of the actual bird during strike, rubber (density =1000 kg/m3) is selected as the bird material.
E. The bird was given a translational velocity range and the wing moves at aircraft speed.
F. The resultant stress and deformation patterns of the blade and bird were obtained.

V. GEOMETRY OF AIRCRAFT WING

Statistics	
Nodes	3580
Elements	4070

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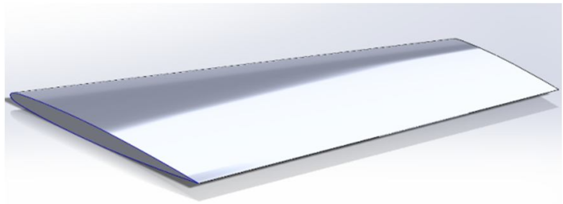
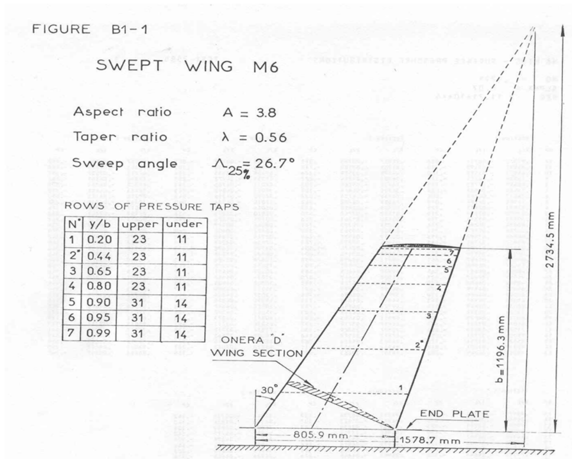




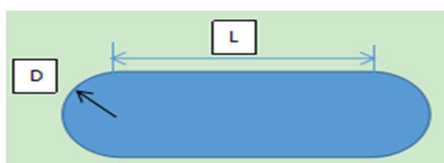
VI. GEOMETRY OF BIRD

A. Bird - 1

1) Length L = 28.7 mm
2) Diameter D = 9.8 mm

B. Bird - 2

1) Length L = 21.525 mm
2) Diameter D = 7.35 mm



VII. MATERIAL PROPERTIES

A. Aluminum AL-6061 T6

Wing	AL 6061-T6	
Max. Yield Strength	680	MPa
Shear Modulus	27600	MPa
Density	2703	Kg/m^3
Factor of Safety	4	

B. E Glass Epoxy

Wing	E-glass epoxy composite	
Max. Yield Strength	80	MPa
Shear Modulus	20000	MPa
Density	1850	Kg/m^3
Factor of Safety	4	

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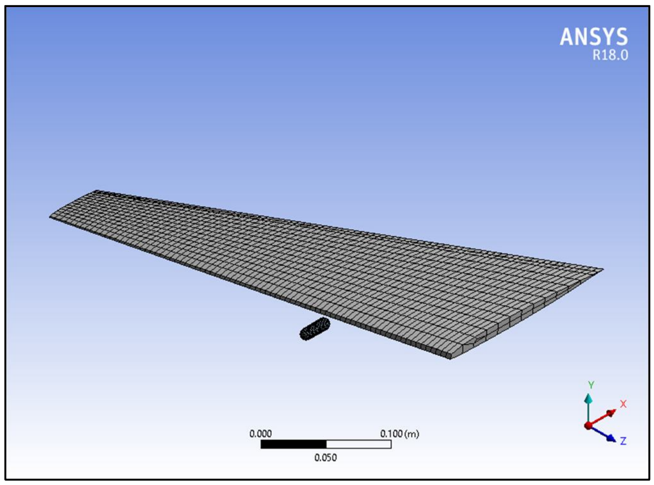
VIII. BOUNDARY CONDITION

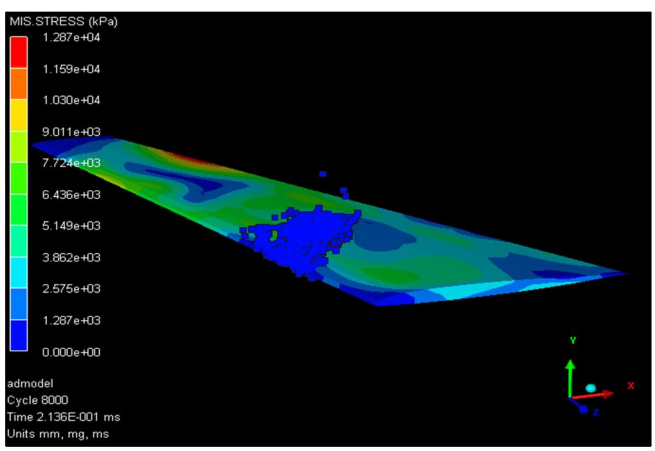
A. Case 1 Bird 1 @ velocity 262.22 m/s
B. Case 2 Bird 1 @ velocity 393.33 m/s
C. Case 3 Bird 1 @ velocity 219.165 m/s
D. Case 4 Bird 1 @ velocity 438.33 m/s
E. Case 5 Bird 2 @ velocity 262.22 m/s
F. Case 6 Bird 2 @ velocity 393.33 m/s
G. Case 7 Bird 2 @ velocity 219.165 m/s
H. Case 8 Bird 2 @ velocity 438.33 m/s

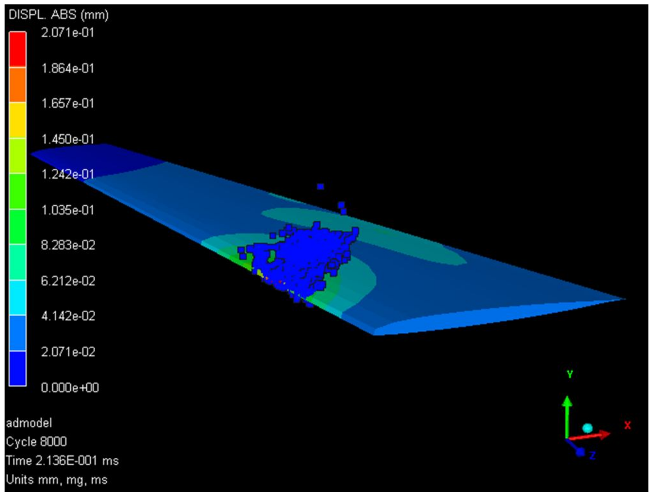
IX. MESH



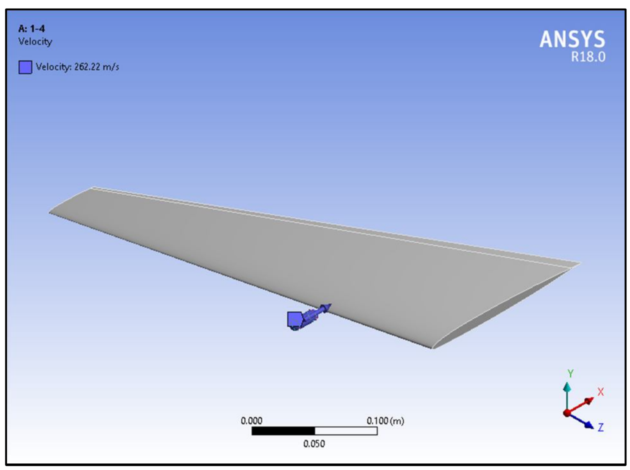
X. FEA SIMULATION

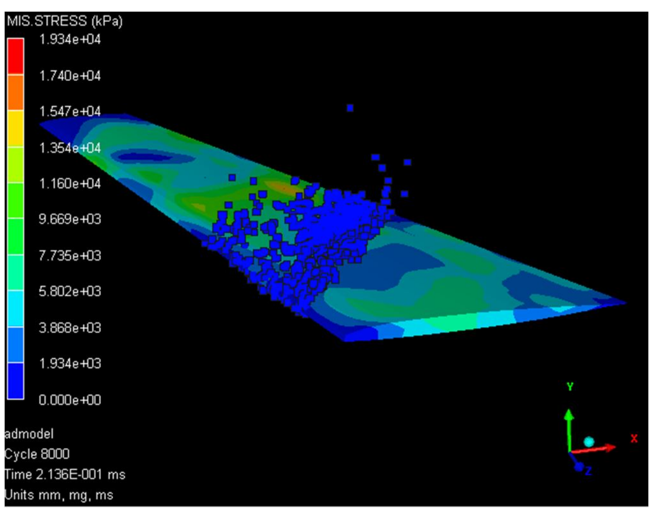
A. Case 1 Bird 1 @ velocity 262.22 m/s





B. Case 2 Bird 1 @ velocity 393.33 m/s





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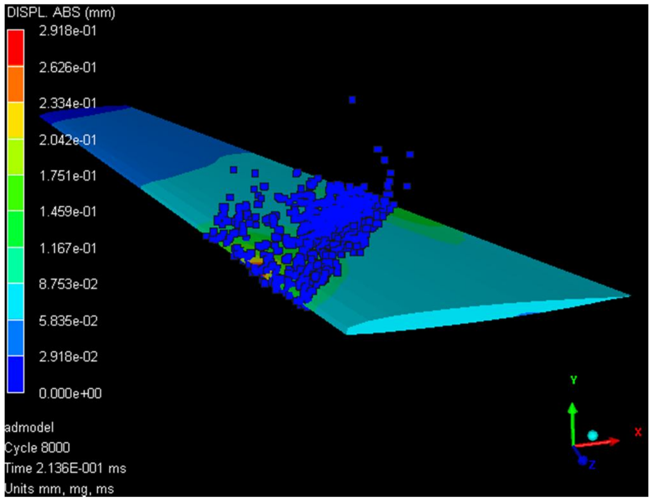
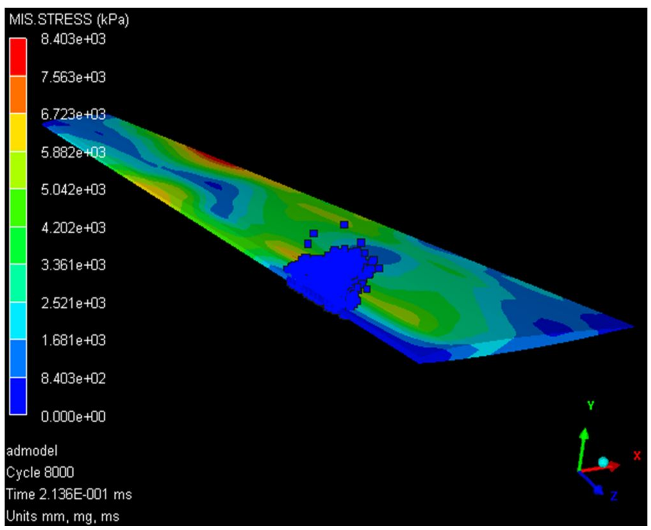
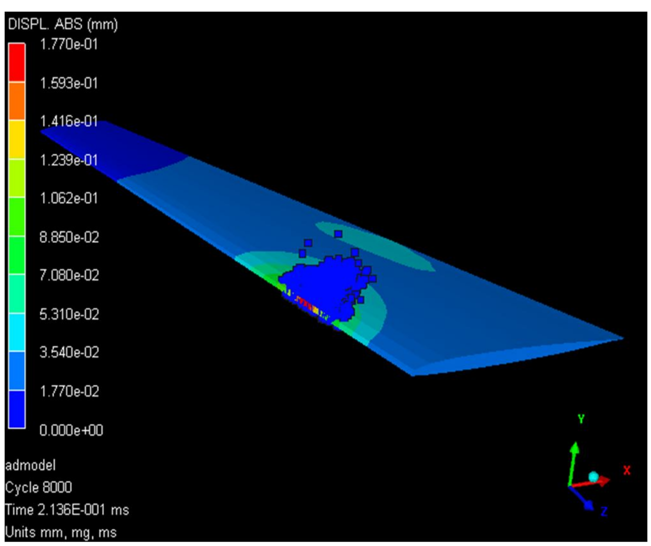
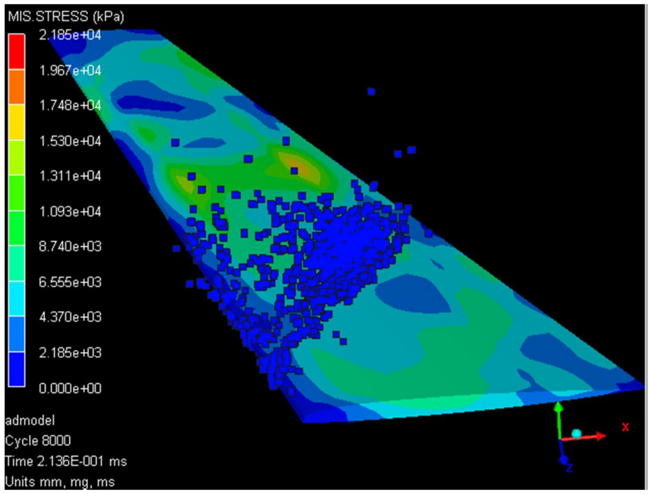


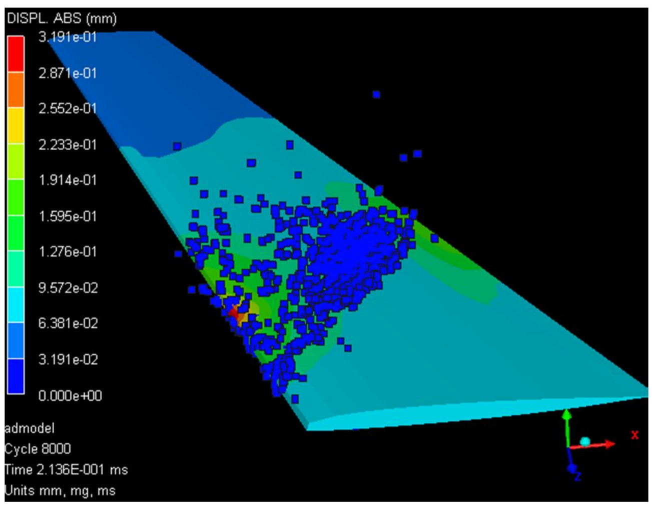
C. Case 3 Bird 1 @ velocity 219.165 m/s





D. Case 4 Bird 1 @ velocity 438.33 m/s





XI. RESULTS

For wing made up of AL-6061 T6 grade

Case No	Bird size	Velocity (m/s)	Equivalent Stress (MPa)	Absolute Deformation (mm)	Corresponding Cycle	Allowable stress limit (MPa)	Result
Case 1	L = 28.7 mm D = 9.8 mm	262.22	12.87	0.2071	8000	170	Pass
Case 2		393.33	19.34	0.2918	8000	170	Pass
Case 3		219.165	8.403	0.1770	8000	170	Pass
Case 4		438.33	21.85	0.3191	8000	170	Pass
Case 5	L = 21.525 mm D = 7.35 mm	262.22	8.222	0.1191	8000	170	Pass
Case 6		393.33	12.01	0.1696	8000	170	Pass
Case 7		219.165	5.877	0.1021	8000	170	Pass
Case 8		438.33	12.93	0.1879	8000	170	Pass

For wing made up of E-glass epoxy composite material

Case No	Bird size	Velocity (m/s)	Equivalent Stress (MPa)	Allowable stress limit (MPa)	Result
Case 1	L = 28.7 mm D = 9.8 mm	262.22	12.87	20	Pass
Case 2		393.33	19.34	20	Pass
Case 3		219.165	8.403	20	Pass
Case 4		438.33	21.85	20	Fail
Case 5	L = 21.525 mm D = 7.35 mm	262.22	8.222	20	Pass
Case 6		393.33	12.01	20	Pass
Case 7		219.165	5.877	20	Pass
Case 8		438.33	12.93	20	Pass

XII. CONCLUSION

A. Result show that wings made with Al-6061 T6 is safer than E-glass epoxy composite.
B. The results also indicated that the wing of composite improves strength to weight ratio as density of composite is less than that of al-6061 T6.
C. The wing of composite material fails at high speed of 438.33 m/s.
D. Although aluminum is best for wing but to achieve optimum benefit mix of both composite and aluminum is suggested.
E. For Explicit Analysis, Composite Material explicit data is required which not easy available in the open source. So its difficult to calculate the Deformation induced in the Wing Made of Composite Material.

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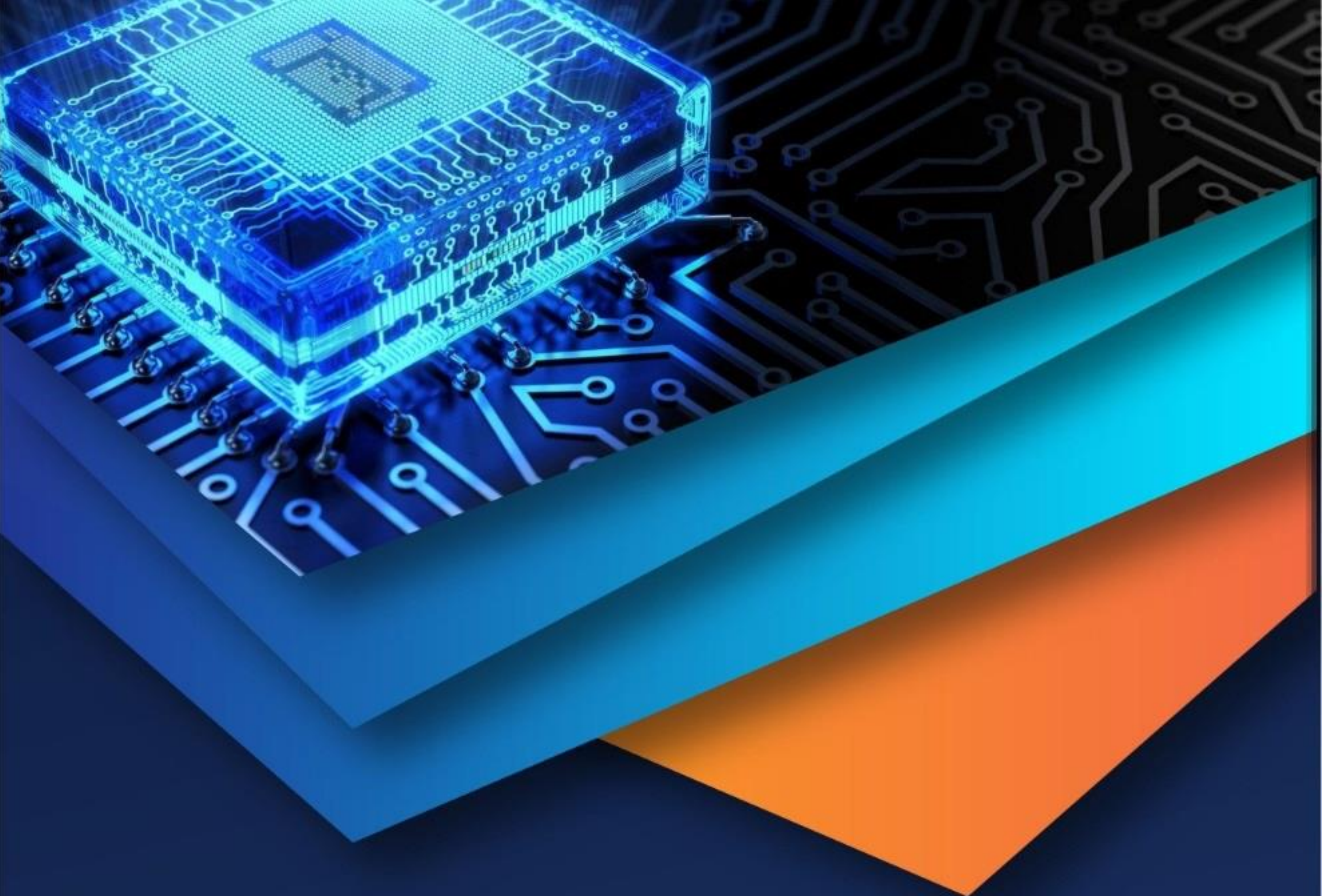

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