iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** VIII **Month of publication:** August 2018

DOI:

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue VIII, August 2018- Available at www.ijraset.com

Maximization of Airflow Velocity over the Static Blades of Air Conditioner and Reduction in Power Consumption

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Abstract: Airfoils or Aerofoils are primarily used for the lift generation purposes in Aerospace domain. This lift is generated by the pressure difference created across the upper and lower surfaces of the Airfoil and this pressure difference comes due to the difference in velocity of the fluid, flowing over the Airfoil. For the Airfoils having positive camber, the velocity above the surface of the Airfoil is greater than what it is below the surface of the Airfoil. This design feature of the Airfoil can be used to regulate the flow velocity of air over and ahead of the Airfoil. This characteristic of the Airfoil was used to design the static blade of Air Conditioner and increase the air flow, hence a decrease in power consumption of the Air Conditioners.
Keywords: Flow optimization of Air Conditioners, a power reduction of Air conditioners, Air conditioner, blades of Air conditioners, Flow Optimization.

I. INTRODUCTION

Airfoils have the unique characteristics of lift generation. During the generation of lift, some velocity and pressure difference is created between the upper and lower surface of the Airfoil. Most foil shapes require a positive angle of attack to generate lift, but cambered airfoils can generate lift at zero angles of attack. This "turning" of the air in the vicinity of the airfoil creates curved streamlines, resulting in lower pressure on one side and higher pressure on the other. This pressure difference is accompanied by a velocity difference, via Bernoulli's principle, so the resulting flow field about the airfoil has a higher average velocity on the upper surface than on the lower surface. The lift force can be related directly to the average top/bottom velocity difference without computing the pressure by using the concept of circulation and the Kutta-Joukowski theorem. The increment in velocity is used as an important application of Airfoil in various fluid-interactive aspects. Seeing the vast application of Airfoil and its unique characteristics, I applied this property on the static blades of an Air conditioner. Static blades are used to direct the air flow coming out of the Air conditioner. The Air flows above and below these blades with a velocity of the range 3 m/s to 7 m/s. The air blower operates and consumes a significant amount of power to blow the air. This power consumption can be reduced if the flow velocity can be increased without any increase in power consumption. This feat can be achieved if the static blades are designed in an airfoil shape and produce or generate increment in velocity of air flowing above it.

A. Thin Airfoil Theory

Thin airfoil theory is a simple theory of airfoils that relates angle of attack to lift for incompressible, inviscid flows. It was devised by German-American mathematician Max Munk and further refined by British aerodynamicist Hermann Glauert and others in the 1920s. The theory idealizes the flow around an airfoil as two-dimensional flow around a thin airfoil. It can be imagined as addressing an airfoil of zero thickness and infinite wingspan. Thin airfoil theory was particularly notable in its day because it provided a sound theoretical basis for the following important properties of airfoils in two-dimensional flow:

1) On a symmetric airfoil, the center of pressure and aerodynamic center lies exactly one quarter of the chord behind the leading edge.
2) On a cambered airfoil, the aerodynamic center lies exactly one quarter of the chord behind the leading edge.
3) The slope of the lift coefficient versus angle of attack line is 2π units per radian.

As a consequence, the section lift coefficient of a symmetric airfoil of infinite wingspan is:

$Cl = 2*\pi*\alpha$ where,

Cl is the section lift coefficient

α is the angle of attack in radians, measured relative to the chord line.

II. METHODOLOGY

For the experimentation or the analysis of the given idea, a computer-based approach was used. For the 2-D modelling of the airfoil shapes as the design of the static blades, CATIA V5 was used. 2D modelling was chosen because the only result I wanted was regarding the flow velocity and 2D modelling is perfect for the same and it takes less time for the analysis part. The different airfoils were taken from NACA airfoil database and exported via macros to CATIA. Then the analysis of the airfoil was done using the ANSYS Workbench 14 and the different results for different airfoils were analyzed.

III.MODELLING

Airfoil generation using MACROS

The airfoil generation was done using the conventional method i.e. MACROS

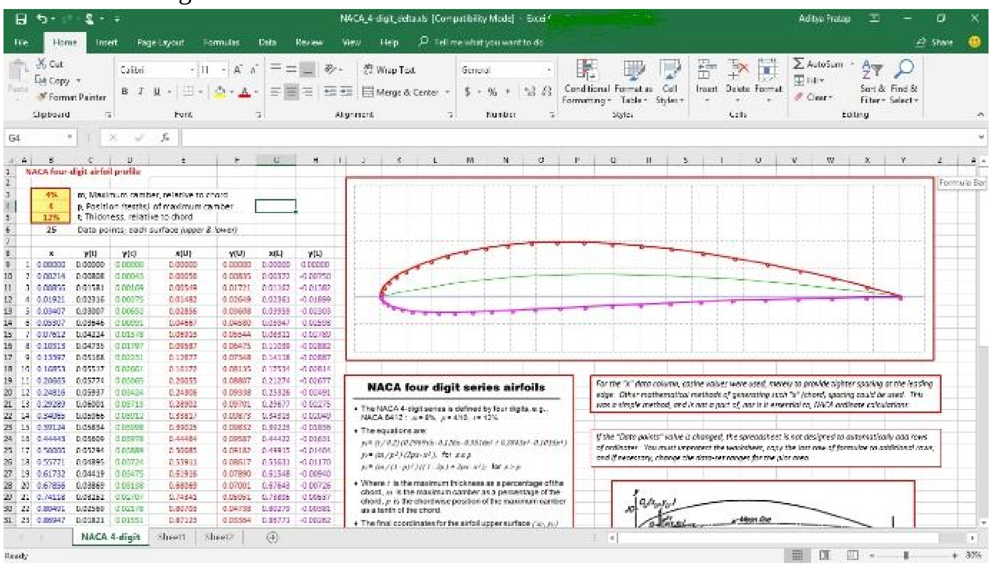


FIGURE 1

IV. 2-D MODELLING

CatiaV5 was used for modelling of Airfoil for the purpose of external flow analysis.

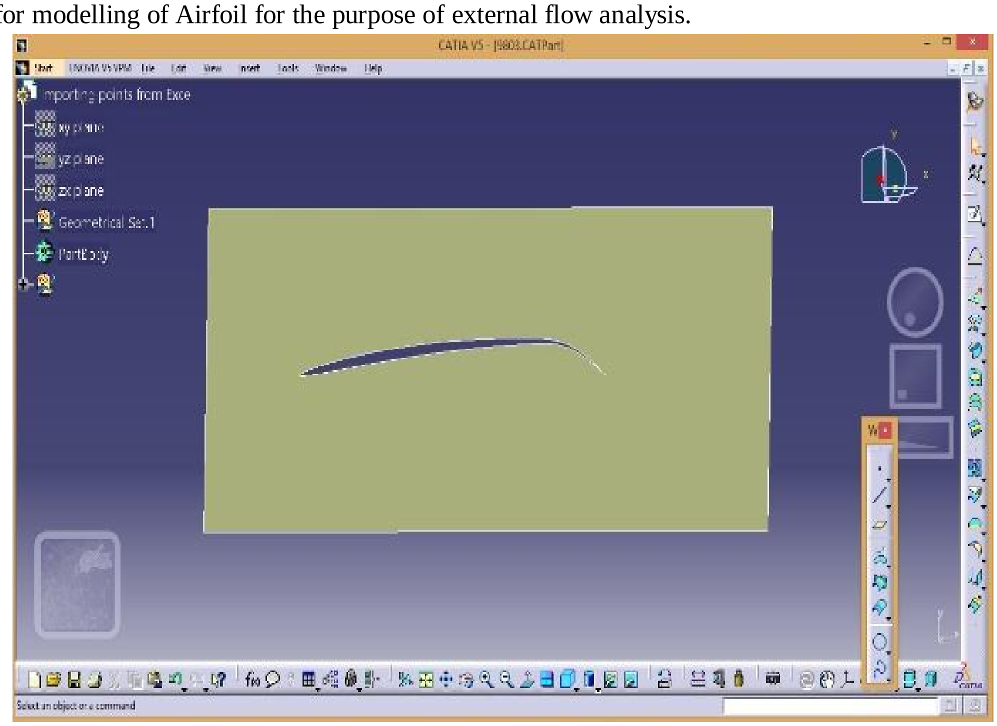
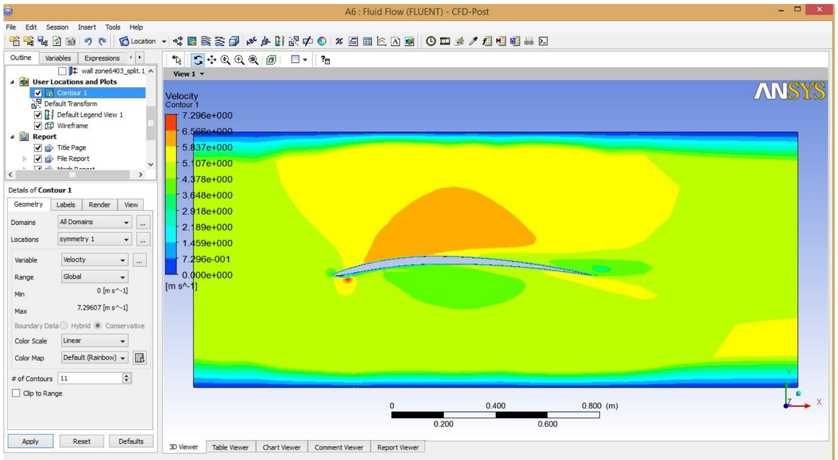


FIGURE 2

V. ANALYSIS

For the analysis part, FLUENT module via ANSYS Workbench 14 was used. Many airfoils were analyzed from the NACA database and the top four airfoils giving the best results were included in this paper. The method used was the pressure-based solver and time steady planar method. The model used was Sparlat-Allamaras(1eqn.). The fluid used was air and the material taken for the airfoil was Aluminum. The cell zone conditions were kept as default. Now regarding the Boundary conditions, the inlet was set as a velocity inlet type with the input value of 5 m/s. The outlet was set as a pressure outlet with the default values. The solution methods were- the simple scheme for pressure-velocity coupling. Least squares cell-based, Second order upwind momentum for the spatial discretization. Did run the iterations until the solution got converged. Then further steps were done using CFD post. Velocity contours were generated for the different airfoils and the results were observed and analyzed.



VI. RESULTS AND DISCUSSION

For the ease of understanding, the four Airfoils were named as A, B, C, D.

A. Airfoil A

The chord of the Airfoil is 999 mm. The maximum camber is 20% relative to the chord. The position of maximum camber is 0.5c or at the 50% chord. The maximum thickness is 2%
relative to the cord.
The result of the analysis is as follows:

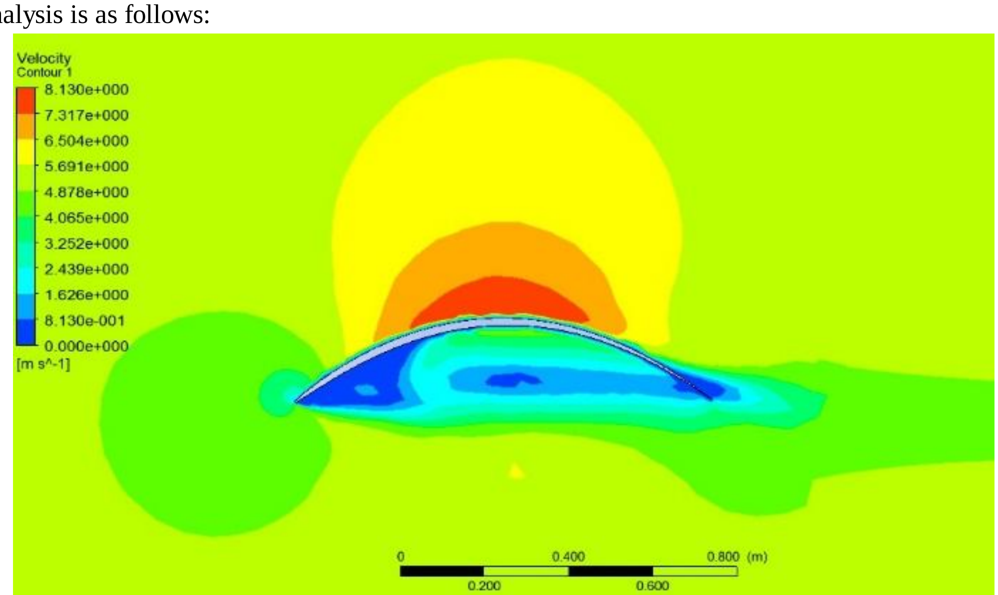


FIGURE 3

The maximum output velocity 8.13 m/s

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B. Airfoil B

The chord of the Airfoil is 999 mm. The maximum camber is 35% relative to the chord. The position of maximum camber is 0.5c or at the 50% chord. The maximum thickness is 5% relative to the cord.

The result of the analysis is as follows:

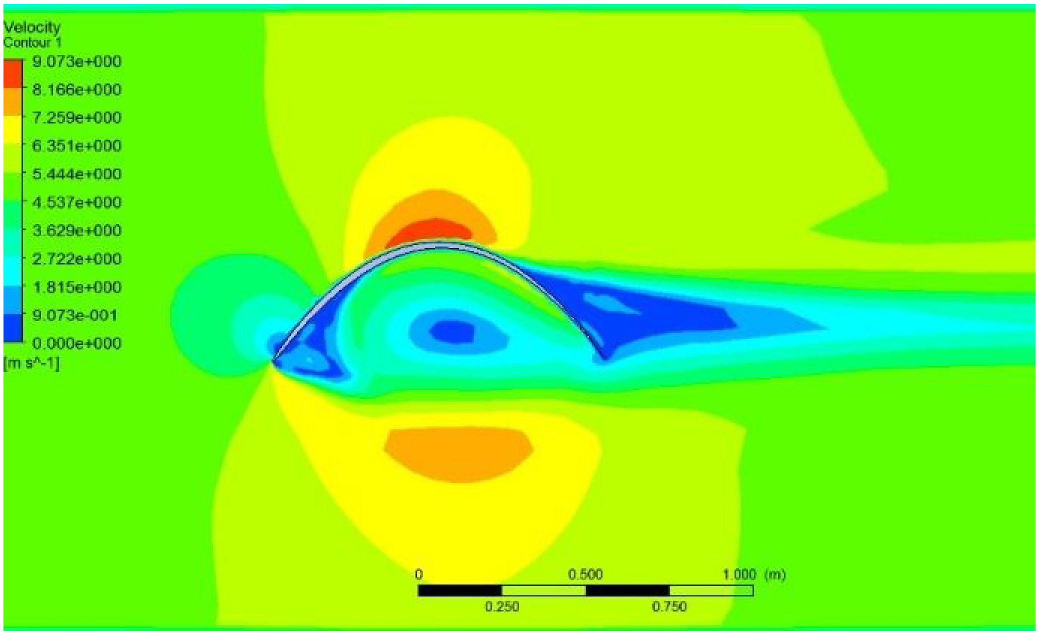

FIGURE 4

The maximum output velocity 9.07 m/s.

C. Airfoil C

The chord of the Airfoil is 999 mm. The maximum camber is 6% relative to the chord. The position of maximum camber is 0.4c or at the 40% chord. The maximum thickness is 3% relative to the cord.

The result of the analysis is as follows:

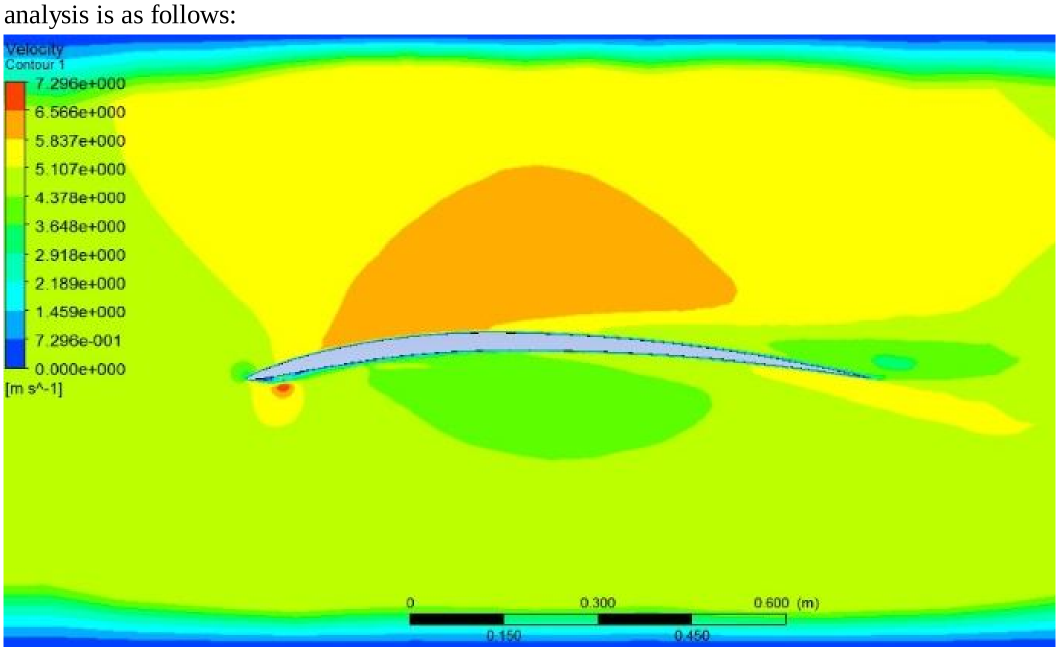

FIGURE 5

The maximum output velocity 7.29 m/s

D. Airfoil D

The chord of the Airfoil is 999 mm. The maximum camber is 9% relative to the chord. The position of maximum camber is 0.8c or at the 80% chord. The maximum thickness is 3% relative to the cord.

The result of the analysis is as follows:

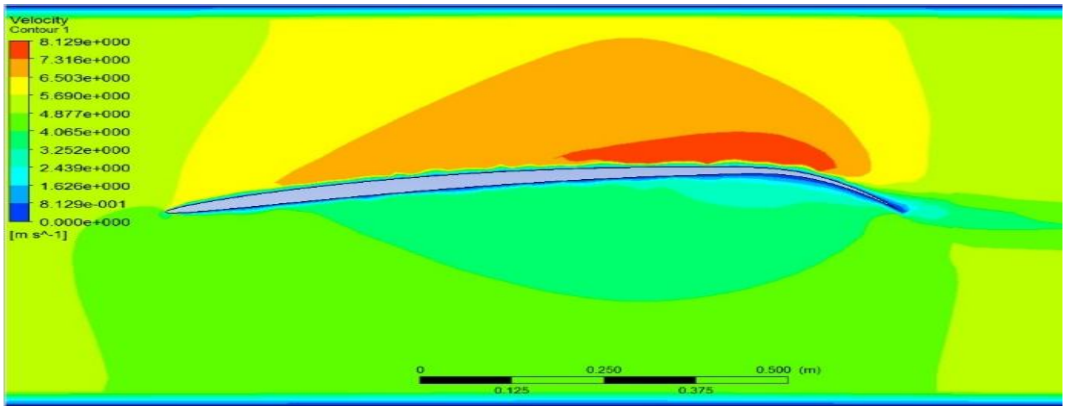

FIGURE 6

The maximum output velocity 8.12 m/s

This analysis clearly shows that if the static blades of an Air conditioner are designed in Airfoil shapes as shown above, then we can easily increase the output air velocity of Air conditioner. If the blades are designed as one of the above Airfoils, we can also reduce the power consumption by the Air conditioner. Since the Air output velocity can be significantly increased, the power required by the Air Conditioner to maintain the same airflow velocity will be decreased.

Heavy power consumption is a major con of Air conditioner which can be solved using the Airfoil design of the blades of Air conditioners.

Further comparison of the results produced by different Airfoils can be done using the Tally table, which is as follows:

Airfoil	Maximum Camber	Position of max. camber	Max. thickness	Input velocity	Output velocity
A	20%	0.5c	2%	5 m/s	**8.13 m/s**
B	35%	0.5c	5%	5 m/s	**9.07 m/s**
C	6%	0.4c	3%	5 m/s	**7.29 m/s**
D	9%	0.8c	3%	5 m/s	**8.12 m/s**

TABLE 1

VII. CONCLUSIONS

It is clear from the above table that the Airfoil B having maximum camber of 35%, position of maximum camber at 0.5c and maximum thickness of 5% produces the maximum velocity of all, i.e. 9.07 m/s after an input velocity of only 5 m/s. Hence, it is recommended to design the static blades of Air Conditioners as Airfoil B (Figure 2). This design enables the Air Conditioners to produce greater velocity and that too with less consumption of power. From the above results, we can conclude that approximately 70-80% of power consumed by the Air Conditioner for the Air flow velocity can be reduced.

VIII. ACKNOWLEDGMENT

I wish to acknowledge my professors and mentors who always guided me and motivated me to do the research related activities.

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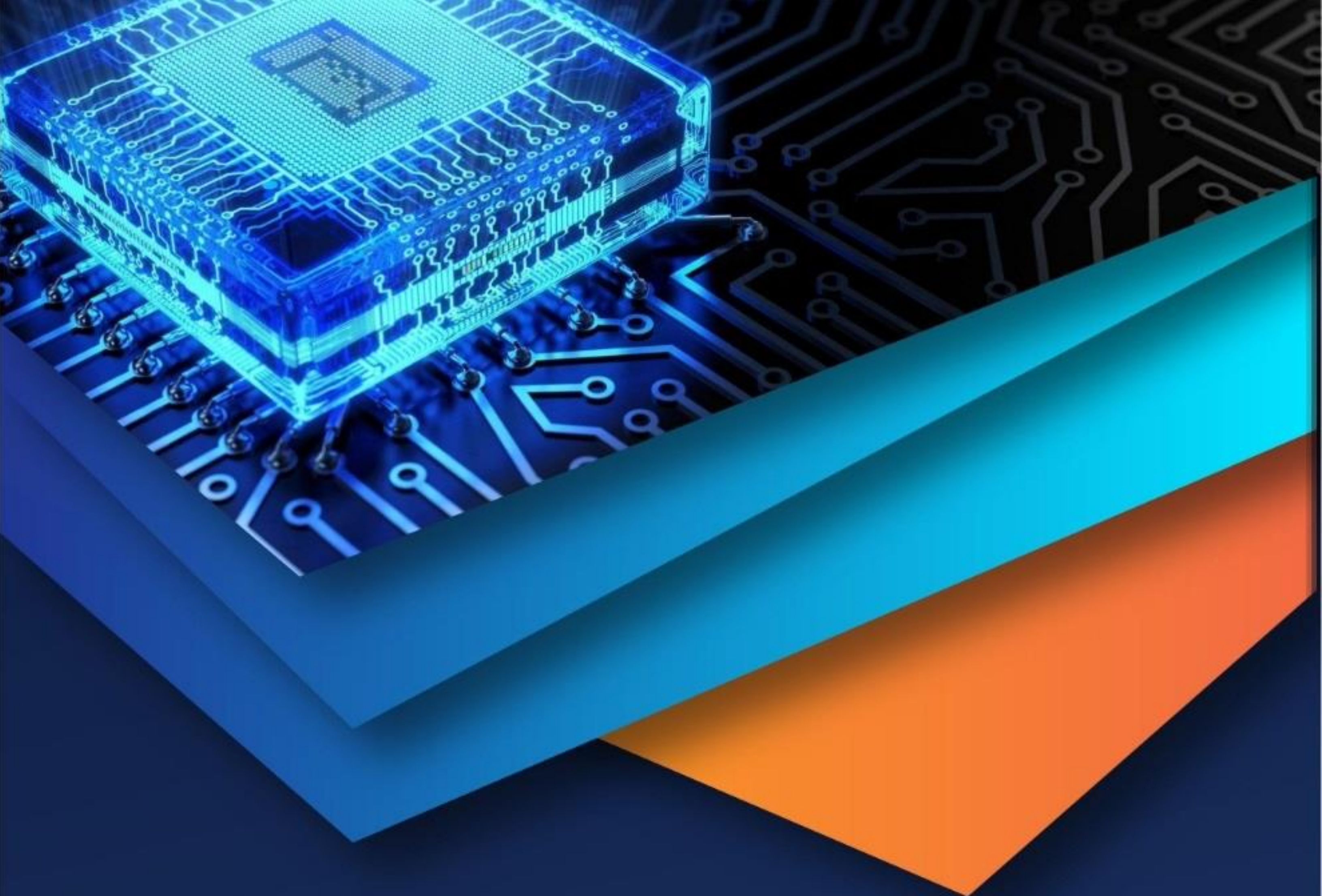

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