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# Evaluation of Thermal Characteristics of Turbine Vane End Wall by varying Orientation and Position of the Combustor using CFD Analysis

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***Abstract - This paper aims to investigate the effects of orientation of the combustor - turbine interface on the cooling of a vane end wall by changing its orientation angles of $75^0$ and $60^0$ for different fluids Hydrogen and Helium. The CFD Analysis will be done to obtain fluid pressure, velocity, heat transfer coefficient, mass flow rate, Heat transfer rate for both hydrogen and helium fluids at Reynolds's numbers $2\times10^5$. The drawing part is done in Pro/Engineer and analysis is done in Ansys.***

***Key words: CFD Analysis, vane end wall, Hydrogen, Helium, pressure, velocity, heat transfer coefficient, mass flow rate, Heat transfer rate etc.***

## I. INTRODUCTION

Throughout the history of gas turbine development, thermal efficiencies have continuously been driven up by a desire to increase power output and lower fuel consumption. In the past decade the rising cost of fuel and an increasing worldwide effort to reduce environmental impact have only served to increase the demand for higher thermal efficiencies. Increasing engine thermal efficiency is directly achieved by increasing the turbine inlet temperature. Consequently, this places increased heat loads on turbine components that are already extensively cooled, particularly the first stage turbine vanes. Current cooling methods consist of full coverage film cooling through discrete holes on the surface of the vanes as well as the end walls. Although it is generally not considered as a part of the cooling design, leakage from the combustor turbine interface gap can also provide substantial cooling to the end walls.

## II. LITERATURE REVIEW

A. A. Thrift, K. A. Thole and S. Hada Have reviewed that Effects of Orientation and Position of the Combustor-Turbine Interface on the Cooling of a Vane Endwall, This paper reports on the effects of the position and orientation of a two-dimensional slot on the cooling performance of a nozzle guide vane endwall. In addition to surface thermal measurements, time-resolved, digital particle image velocimetry (TRDPIV) measurements were performed at the vane stagnation plane.

C. M. Mazzoni*B. Rosic† Osney have worked on Combustor Wall Axial Location Effects on First Vane Leading-Edge Cooling Because of the highest thermal load and the complex flow interactions, the cooling of the first vane leading edge is one of the most challenging problems in gas turbine aerothermal design. In industrial gas turbines with multiple can combustors around the annulus, depending on the clocking position between can combustors and downstream turbine, the first vane leading edges may also be exposed to large wake disturbances shed from the upstream combustor walls.

G. Barigozzi - P. Epis - A. Perdichizzi - S. Ravelli hav e focused that Aero-thermal investigation of end wall and showerhead cooling in a nozzle vane cascade The aerodynamic and thermal performance of a gas turbine cascade with slot platform and vane showerhead cooling was investigated. The cascade was tested at a high inlet turbulence intensity level (Tu1= 9%) and at variable cooling injection conditions of the upstream slot. Showerhead blowing ratio was maintained at the nominal value.

## III. CFD ANALYSIS

TABLE 1: FLUID PROERTIES USED IN CFD ANALYSIS

| Fluid Properties | Density(kg/m$^3$) | Thermal conductivity (w/m-k) | Viscosity(poise) | Specific heat(j/kg-k) |
|---|---|---|---|---|
| Helium | 0.16394 | 0.1494 | 0.000019 | 5193.1 |
| Hydrogen | 0.022 | 0.000013 | 0.01888 | 1804.4 |

*A. Vane end wall orientation at $75^0$ using Hydrogen as fluid*

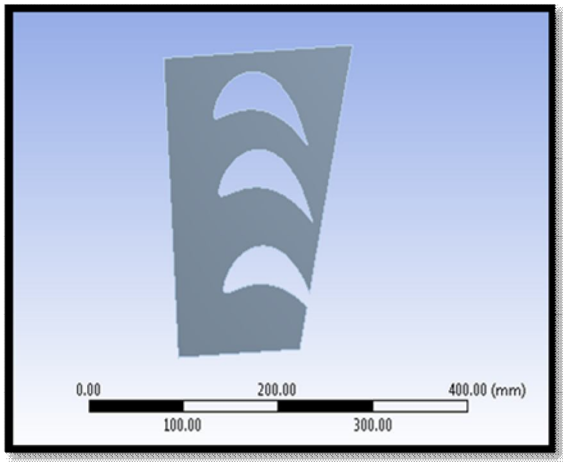


Fig 1: Imported model

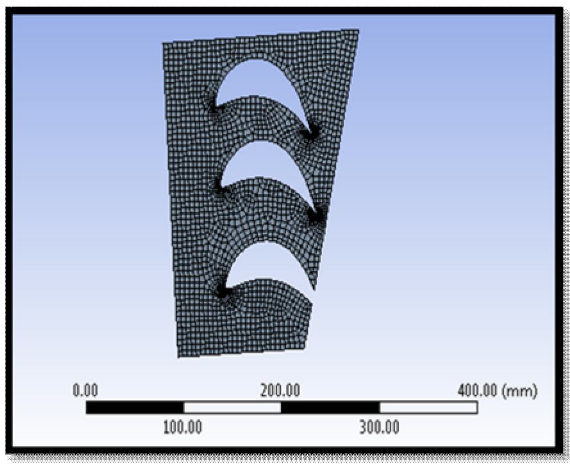


Fig 2: Meshed model

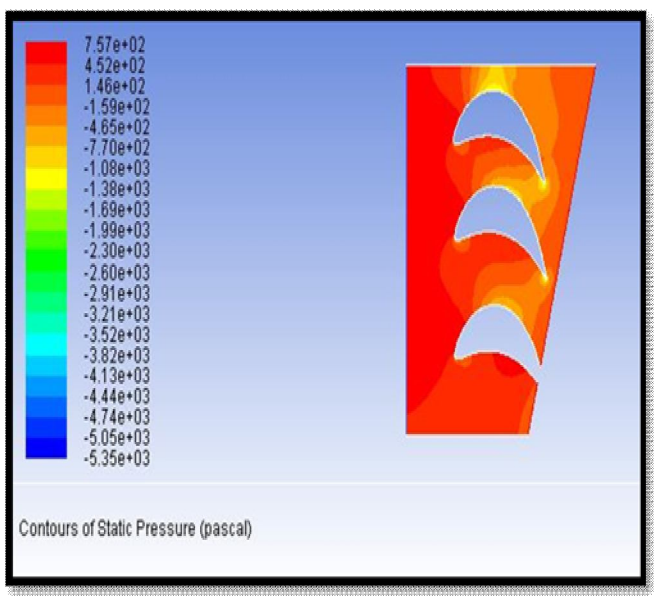


Fig 3: Pressure contours

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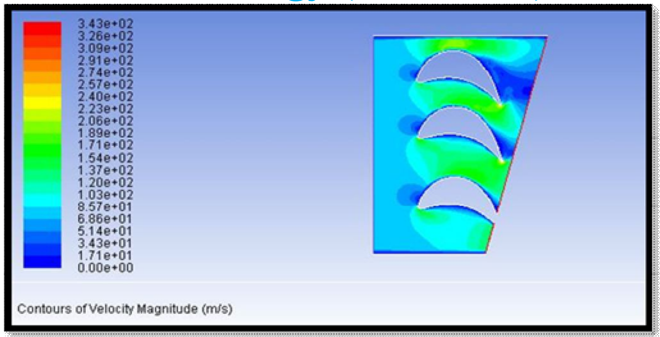


Fig 4: Velocity magnitude

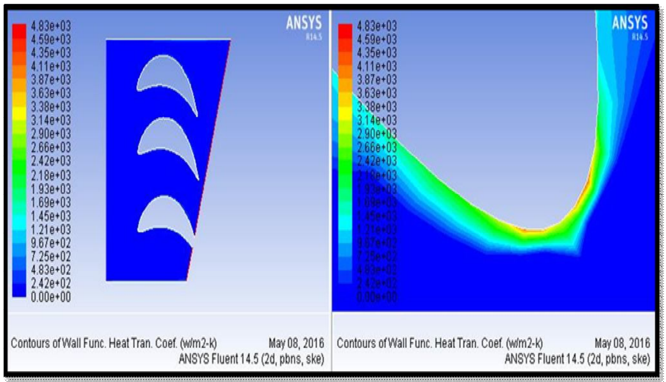


Fig 5: Heat transfer co-efficient

*B. Vane end wall orientation at $75^0$ using Helium as fluid*

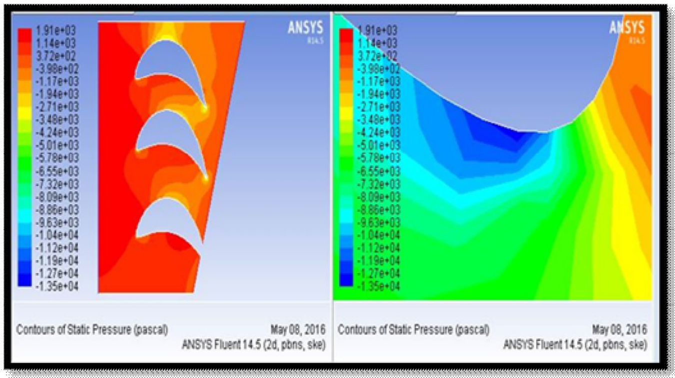


Fig 6: Pressure contours

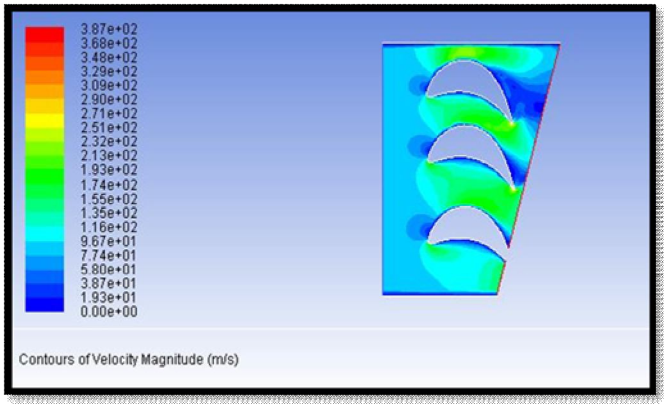


Fig 7: Velocity magnitude

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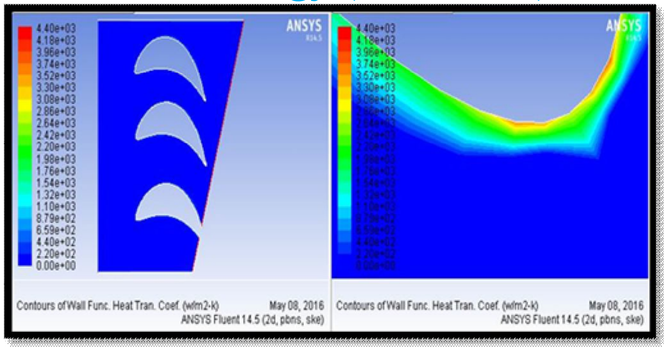


Fig 8: Heat transfer co-efficient

C. *Vane end wall orientation at $60^0$ using Hydrogen as fluid*

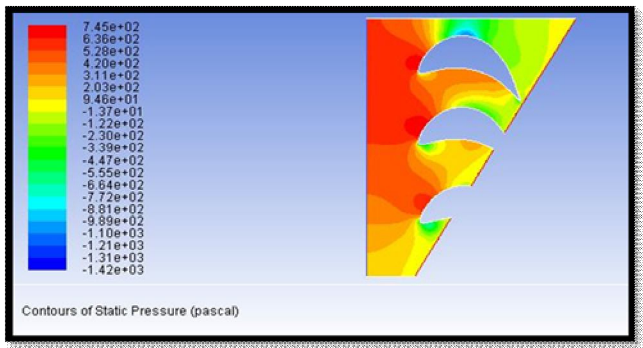


Fig 9: Pressure contours

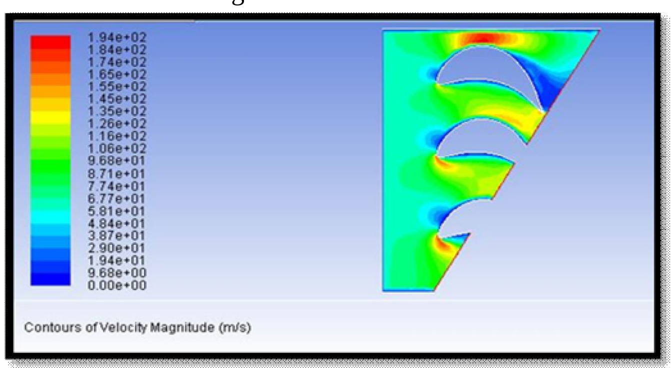


Fig 10: Velocity magnitude

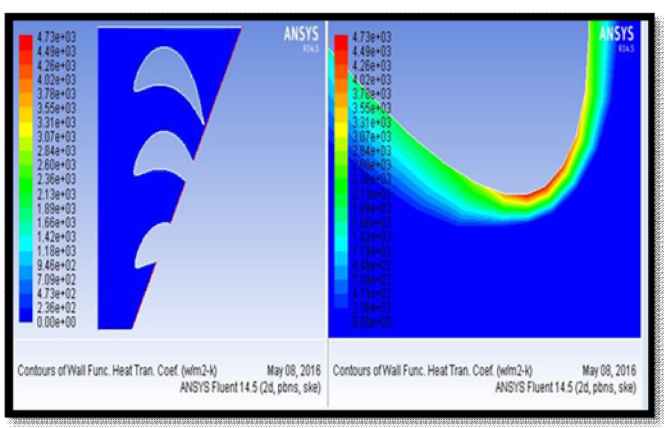


Fig 11: Heat transfer co-efficient

*D. Vane end wall orientation at $60^0$ using Helium as fluid*

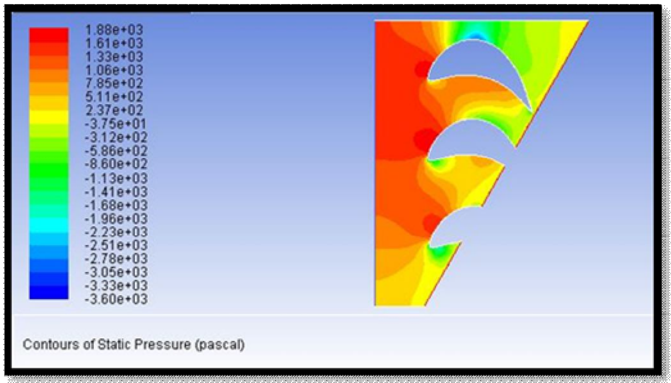


Fig 12: Pressure contours

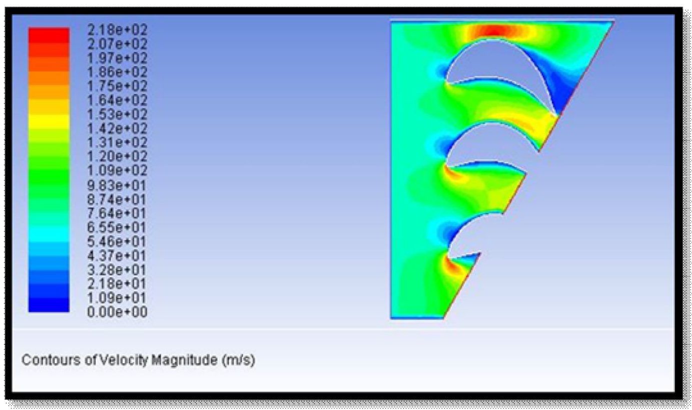


Fig 13: Velocity magnitude

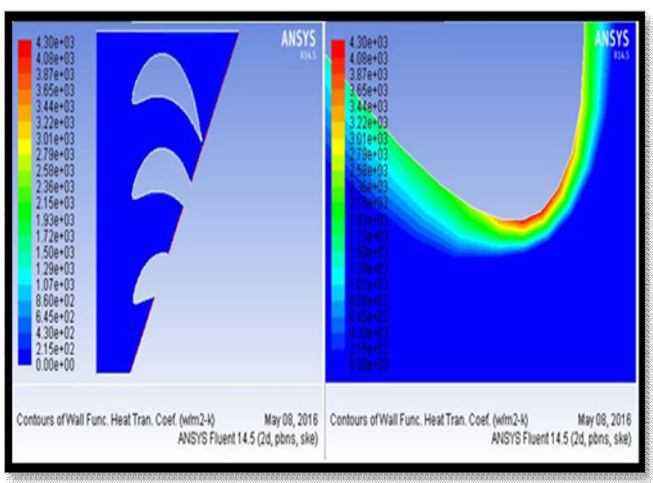


Fig 14: Heat transfer co-efficient

## IV. RESULTS AND DISCUSSIONS

Here we have done cfd analysis on turbine vane end wall by changing its orientation and positions are $75^0$ and $60^0$ by using hydrogen and helium are the fluid medium. After analysis we obtain results pressure, velocity, heat transfer coefficient, heat transfer rate, mass flow rate of both hydrogen and helium at angles of $75^0$ and $60^0$. The results are extracted from cfd analysis are neatly plotted blow table. The below produced graphs are shown that comparative analysis for both hydrogen and helium at different angles shown below figures

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TABLE 2: CFD ANALYSIS RESULTS

| Vane end wall angle | Fluids | Pressure (Pa) | Velocity (m/s) | Mass flow Rate (Kg/s) | Heat Transfer rate (W) |
|---|---|---|---|---|---|
| $75^0$ | Helium | 1.91e+03 | 3.87e+02 | 0.0020759106 | 51.757813 |
| | Hydrogen | 7.57e+02 | 3.43e+02 | 0.0018627644 | 129.32813 |
| $60^0$ | Helium | 1.88e+03 | 2.18e+02 | 0.0060584545 | 250.00 |
| | Hydrogen | 7.45e+02 | 1.94e+02 | 0.0027191639 | 307.91406 |

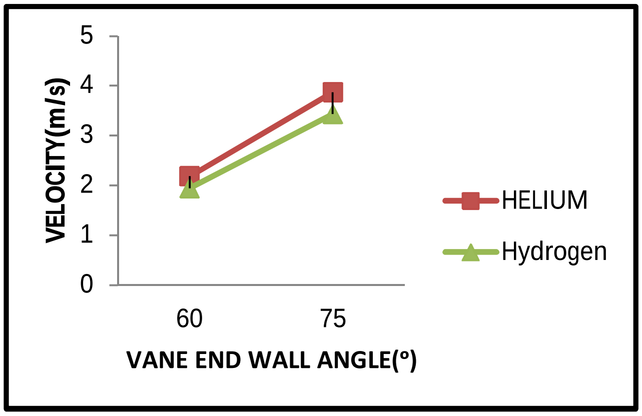


Fig 15: comparison of velocity values for different fluids and angles

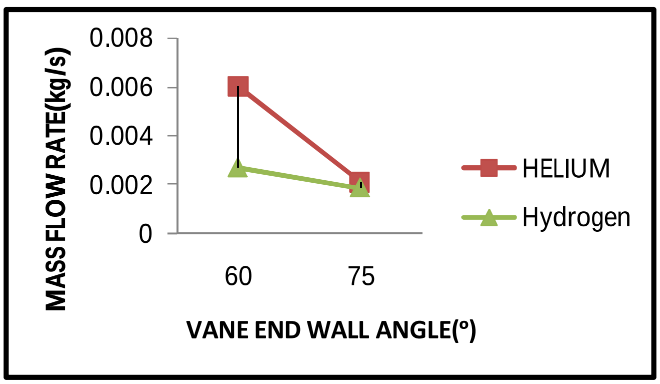


Fig 16: comparison of mass flow rate values for different fluids and angles

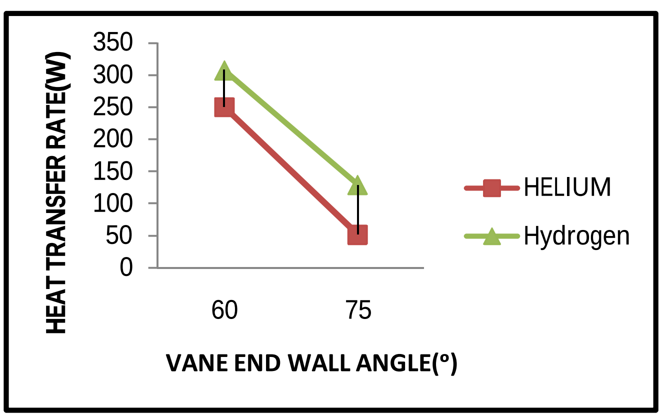


Fig 17: comparison of heat transfer rate values for different fluids and angles

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## V. CONCLUSION

The effects of orientation of the combustor - turbine interface on the cooling of a vane end wall by changing the orientation angles $75^0$ and $60^0$ for different fluids Hydrogen and Helium is determined by analyzing the heat transfer rates, pressures, velocity magnitude mass flow rate and heat transfer coefficient at Reynolds number is $2*10^5$ using CFD analysis.

By observing the analysis results pressure and heat transfer rate is more for hydrogen fluid at vane end wall angle is both $75^0$ and $60^0$ comparing to helium fluid. And we also observed that velocity and mass flow rate is more for helium fluid at vane end wall angle is both $75^0$ and $60^0$ comparing to hydrogen fluid.

By the results it's found that pressure and velocity is going to decreased for varying orientation of angles in both helium and hydrogen fluids and Mass flow rate and heat transfer rate are going to increased when we are decreasing the orientation of angle for both hydrogen and helium fluids.

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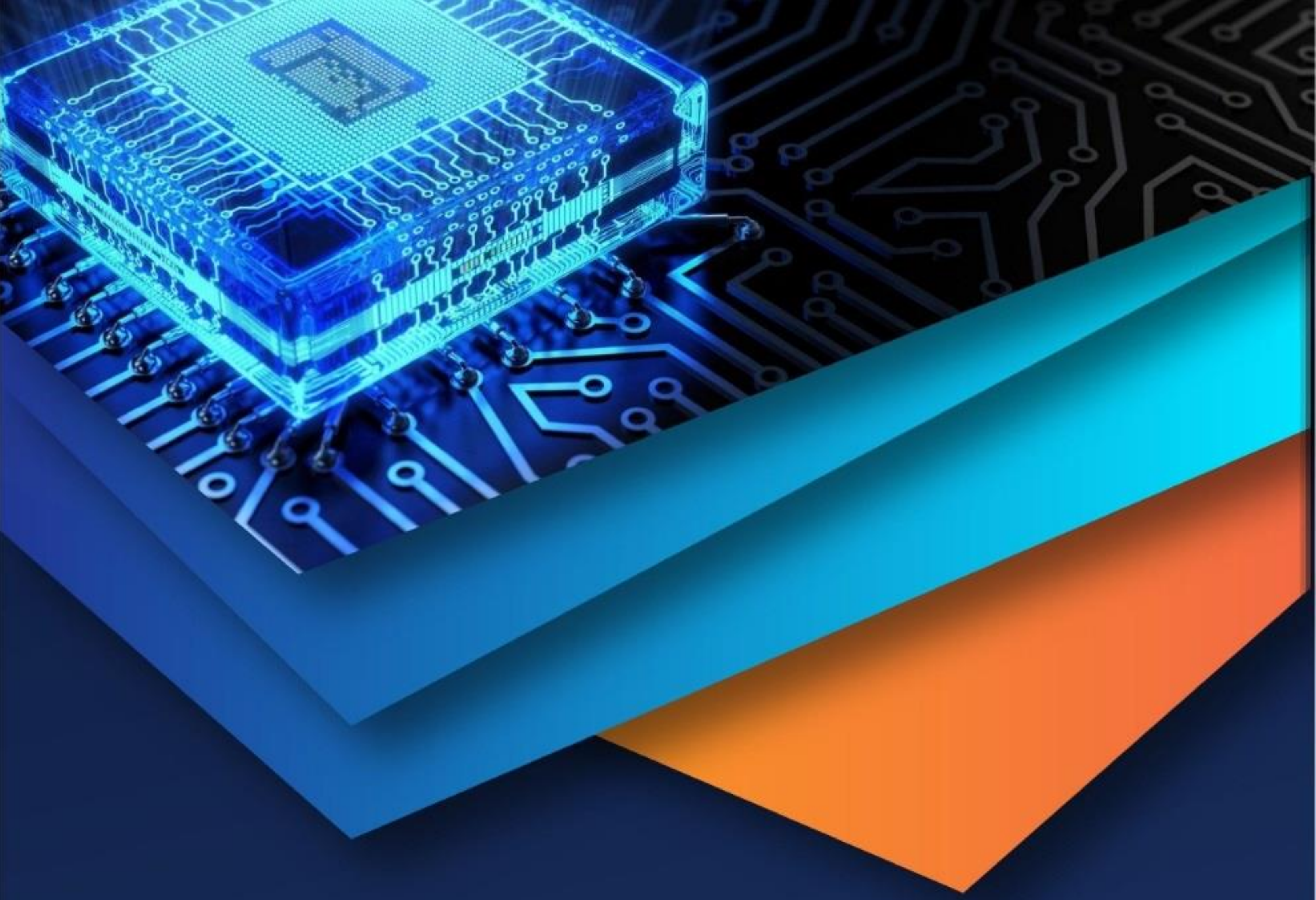


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