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Conceptual Design, Analysis, and Fabrication of Subsonic Vertical Wind Tunnel

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Abstract: A vertical wind tunnel (VWT) is a wind tunnel which movements air up in a vertical column. In contrast to widespread wind tunnels which have taken a look at sections which can be oriented horizontally, as experienced in level flight, a vertical orientation enables gravity to be countered by drag in place of elevate, as experienced in an plane spin or by using a skydiver at terminal pace. Even though vertical wind tunnels had been constructed for aerodynamic research, the maximum excessive-profile are those used as recreational wind tunnels, regularly marketed as indoor skydiving or body flight, that have also grow to be a popular schooling device for skydivers. The aim of this project is to provide high quality flow characteristic and flow visualization over a body at reasonable initial and operational cost to lift up the body and analysis the properties of fluid like velocity and pressure of flow.
Keywords: Vertical Wind Tunnel (VWT), Design, Flow Analysis, Test Section Velocity, Test Section Pressure, Solid works, Ansys, eshing, Contour map, Streamline, Fabrication, ANSYS Software, CREO Software.

I. INTRODUCTION

The general public's urge for severe sports activities and thrill rides has been increasing over the last decade. Specially, skydiving has become pretty famous among the extra adventurous segments of our population. This recognition has sparked a growing demand for ground-based totally facilities wherein people can experience unfastened fall. For the general public, these centers decrease the actual or perceived risks of jumping from an airplane. Aggressive skydiving groups are able to use those centers to gain more "air time" for refining their maneuvering capabilities in a shorter time and at an awful lot less cost. In addition, America army airborne schooling has incorporated the usage of indoor skydiving wind tunnels, in addition to the special forces of the alternative army branches. Other forms of wind tunnels are completely depending on the external structures which keep the fans. The blowers/fan are able to be placed either on pinnacle or at the lowest of the flying chamber. In evaluation with the blowers or air Pusher, objects that discover ways to fly in a wall to wall environment seem to have greater difficulties whilst switching to different kind of wind tunnel configuration. By way of the usage of VWT, for analysing the properties like temperature, density, velocity, pressure of flow over the test piece in test section.

II. METHODOLOGY

A. Conceptual Design

Conceptual design is an early section of the layout system, wherein the huge outlines of function and shape of something are articulated. It consists of the design of interactions, studies, approaches, and strategies. It includes information of human being's desires - and a way to meet them with products, services, and techniques. Not unusual artifacts of conceptual layout are idea sketches and fashions.

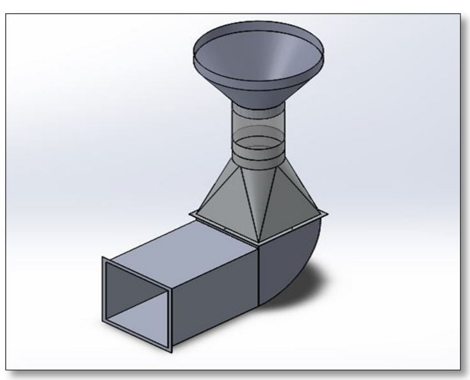

Fig 1: Design of VWT

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B. Applications
1) To replicate the physics of body flight experienced during freefall
2) Parachute testing
3) Helicopter blade testing
4) Aircraft spin testing
5) Effect of vertical gust on aircraft
6) Rocket nose testing

C. Theory Calculations

1) Cross-Sectional Area Of Test Section

$$a` = \frac{\pi d^2}{4}$$

Where;

a`= cross-sectional area of test section

d= diameter of cross section

2) Flow Rate Equation

$$Q = V * a`$$

Where;

Q= flow rate

V= velocity of test section

a`= cross-sectional area of test section

3) Speed of Sound

$$a = \sqrt{\gamma RT}$$

Where;

γ =Adiabatic constant

R= Gas constant

T:= Absolute temperature

a= speed of sound

4) Mach Number

$$Mtunnel = \frac{Vmax}{a}$$

Where;

Mtunnel: Mach no. in wind tunnel

Vmax: Maximum velocity at test section

a: Speed of sound

Cross section area of test section	0.088 m^2
Flow rate equation	0.32352 m^3/s
Speed of sound	343 m/s
Mach number	0.011

Table 1: Calculation table

D. Designs and Dimensions

1) Inlet

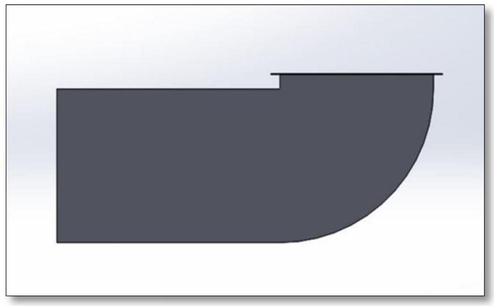

Fig 2: Inlet design

Inlet area	441 inch^2
Height	21 inch
Width	21 inch
Length	51.5 inch
Elbow radius	21 inch

Table 2: Inlet dimensions

2) Convergent Duct

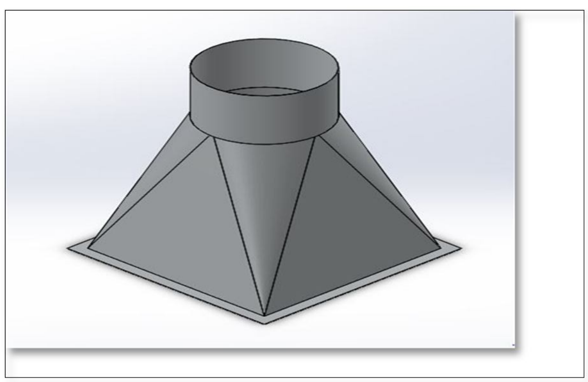

Fig 3: Convergent duct design

Convergent duct inlet area	441 inch^2
Convergent duct outlet area	112.7 inch^2
Convergent duct height	28 inch
Thickness	0.0276 inch
Inlet width	21 inch
Outlet diameter	12.5 inch
Length	21 inch

Table3: Convergent Duct dimensions

3) Test Section

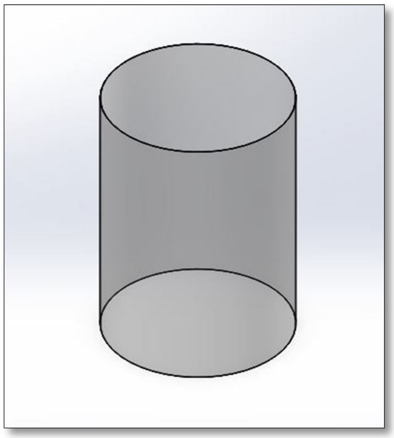

Fig 4: Test section design

Diameter	12.5 inch
Height	18.5 inch
Cross section area	112.7 $inch^2$
Flow rate	11.61 m^3/s

Table 4: Test section dimensions

4) Divergent Duct

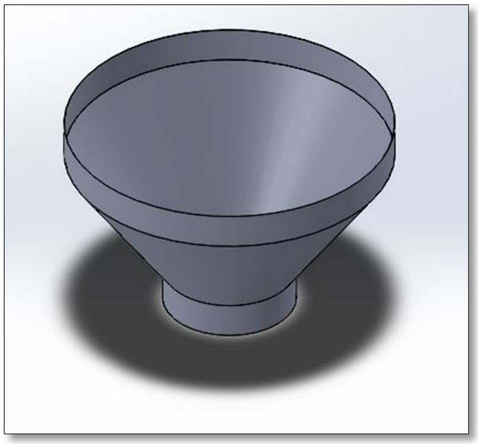

Fig 5: divergent duct design

Div. duct inlet area	441 $inch^2$
Div. duct height	20.5 inch
Thickness	0.0276 inch
Inlet diameter	12.5 inch
Outer diameter	31 inch
Outer area	754 $inch^2$

Table 5: Divergent duct dimensions

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III. FLOW ANALYSIS

Computational fluid dynamics (CFD) is a branch of fluid mechanics that uses numerical evaluation and records structures to analysis and clear up troubles that involve fluid flows. Computers are used to perform the calculations required to simulate the unfastened-movement glide of the fluid, and the interaction of the fluid (beverages and gases) with surfaces described by using boundary situations. With high-speed supercomputers, higher answers may be accomplished, and are often required to resolve the biggest and most complicated issues. Ongoing studies yields software that improves the accuracy and speed of complex simulation scenarios together with transonic or turbulent flows. Preliminary validation of such software program is generally performed the use of experimental apparatus which includes wind tunnels. Further, formerly achieved analytical or empirical analysis of a specific hassle may be used for evaluation. A very last validation is frequently finished the use of full-scale testing, consisting of flight checks.

CFD is carried out to a huge range of studies and engineering troubles in lots of fields of look at and industries, which includes aerodynamics and aerospace evaluation, climate simulation, natural science and environmental engineering, industrial machine design and analysis, organic engineering, fluid flows and heat transfer, and engine and combustion analysis

A. Meshing

The extent occupied by means of the fluid is split into discrete cells (the mesh). The mesh can be uniform or non-uniform, structured or unstructured, such as a combination of...

1) Hexahedral
2) Tetrahedral
3) Prismatic
4) Pyramidal
5) Polyhedral elements

In meshing we have done “UNIFORM STRUCTURED TETRAHEDRAL” meshing

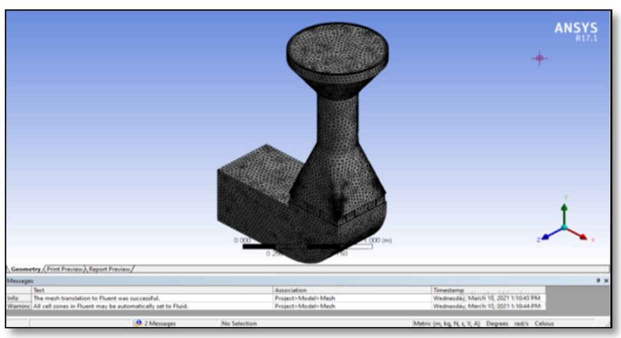

Fig 6: Uniform Structured Tetrahedral” meshing

B. Boundary Condition

1) For boundary conditions first we set viscous equation (standard wall function).
2) For material we defined solid as a “Galvanized Iron Sheet” and fluid as air.
3) For inlet we define the inlet velocity as 1m/s.
4) Inlet pressure is 1 atm.
5) Initial temperature is 297 K.

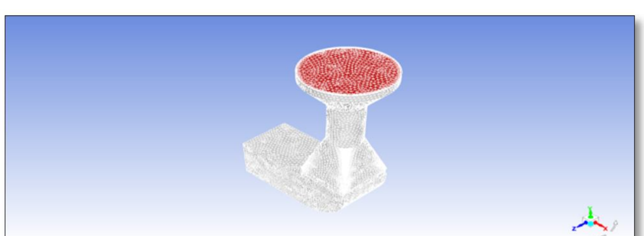

Fig 7: Boundary Condition

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C. Streamline

1) From streamline it shows that the flow becomes laminar in test section and we get max desired velocity at test section as shown in streamline contour.
2) From blue to red colour it shows the intensity of velocity where blue colour shows minimum velocity and red colour shows maximum velocity.

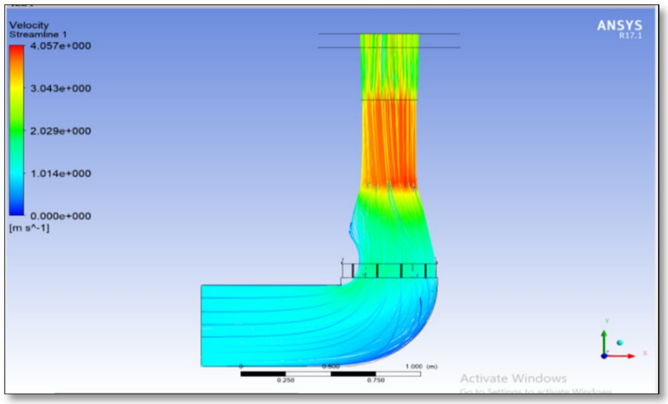

Fig 8: Streamline 1

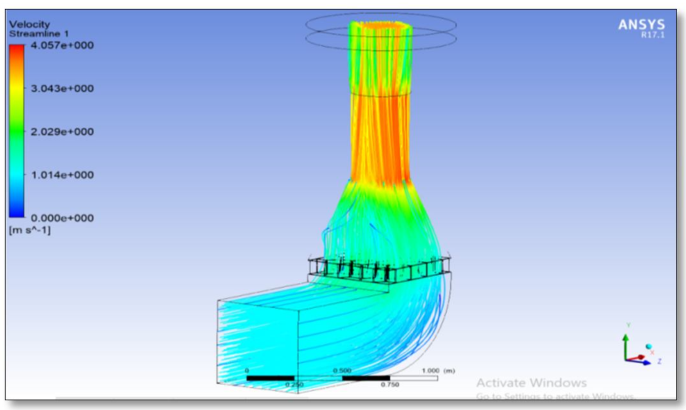

Fig 9: Streamline 2

D. Contour

1) *Velocity Contour*

a) We achieved desired velocity at test section which is shown in RED colour in velocity contour.
b) At inlet there is 1 m/s velocity which incresed to 4 m/s at test section.

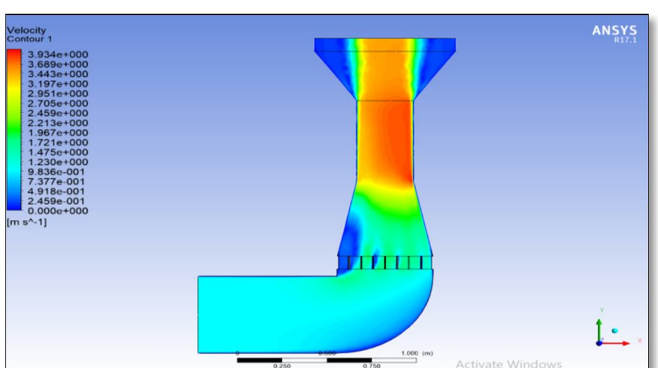

Fig 10: velocity contour

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2) *Pressure Contour:* From pressure contour it denoted that red colour shows max pressure at inlet and light blue colour shows low pressure at outlet

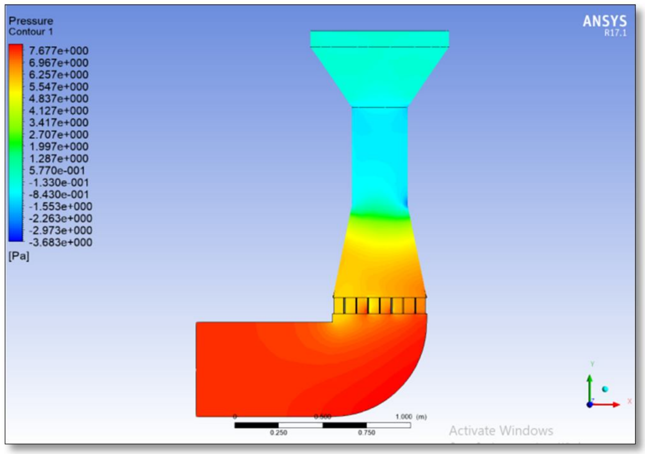

Fig 11: Pressure contour

IV. FABRICATION

A. Material

1) In Fabrication Galvanized Iron sheet of 24 Gauge is used in Convergent duct and Divergent duct.
2) Galvanized iron (GI) sheets are steel sheets which are basically coated with zinc and include a range of hot dip galvanized and electro-galvanized steel sheets

B. Properties (Galvanized Iron Sheet)

1) Extended Durability
2) Strength
3) Resist Corrosion
4) Protect Steel from Rust
5) Last for 70 years in many different environments
6) Scratch free finish

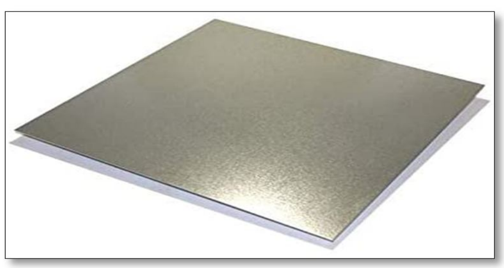

Fig 12: Galvanized Iron Sheet

C. Advantages

1) Lowest first cost
2) Less maintenance/Lowest long term cost
3) Long life
4) Reliability
5) Toughest coating
6) Automatic protection for damaged areas
7) Complete protection
8) Ease of inspection
9) Faster erection time

D. Acrylic Sheet

1) Acrylic sheets are lightweight alternative to glass.
2) Acrylic was selected as the material for the test section window because it is a low-cost option that provides excellent visibility.

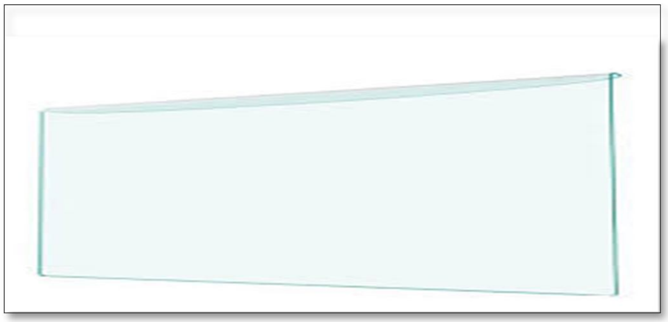

Fig 13: Acrylic sheet

E. Processes

1) Marking
2) Cutting
3) Bending
4) Layer forming
5) Drilling
6) Shearing
7) Assembling (threaded fasteners)

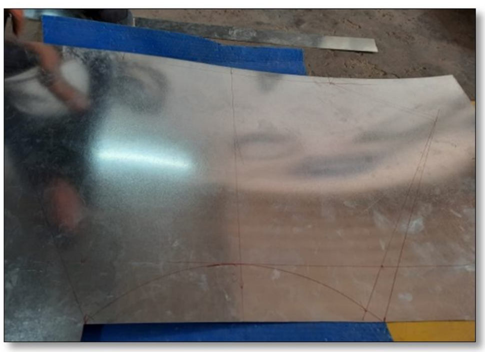

Fig 14: Marking

Fig 15: Cutting

Fig 16: Bending

F. Apparatus

1) Hammer
2) Grinder
3) Measure tape
4) Screw driver
5) Drill machine
6) Adjustable spanner
7) Nut and bolts

V. PARTS FABRICATION

A. Inlet

Fig 17: Inlet fabrication

B. Convergent Duct

Fig 18: Convergent duct fabrication

C. Divergent Duct

Fig 19: Divergent duct fabrication

VI. CONCLUSIONS

Flow analysis at test section is essential part of vertical wind tunnel and paper gives a perfect concept on how to achieve desired velocity at test section for flow analysis vertically and desired velocity comes out to be **4 m/s.**

A. Flow is uniform in test section.
B. We get High Velocity in Test Section.
C. We achieve desired high velocity compare to others designs.
D. From Analysis contour we achieved accurate results in every sections
E. Moreover every section has performed efficiently upto a certain limit on the basis of initial conditions**.**

VII. ACKNOWLEDGEMENT

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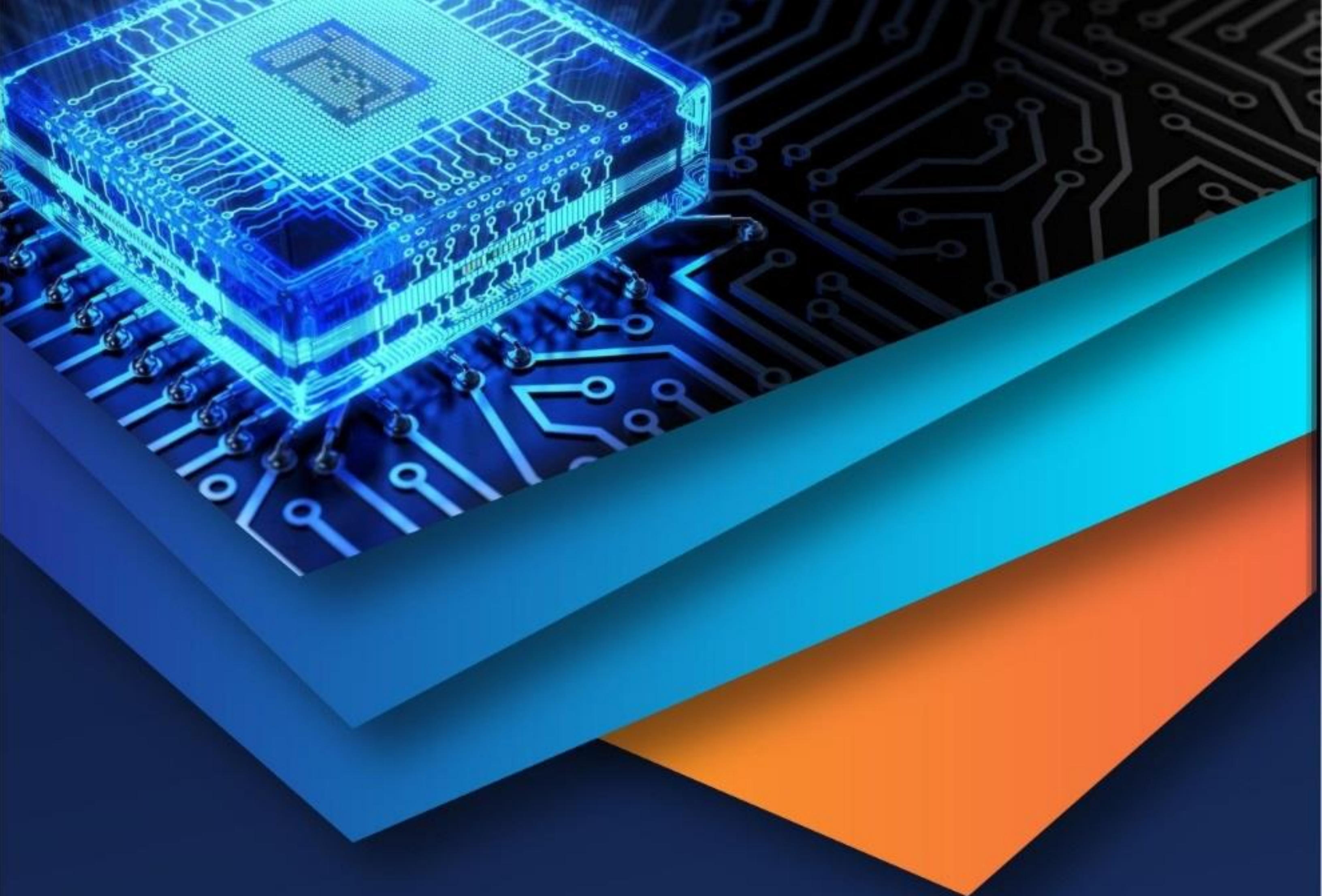

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