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Enhancement of Force Convection Heat Transfer in Pipe using Different Inserts

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Abstract: ***Heat transfer enhancement has been always a significantly interesting topic in order to develop high efficient, low cost, light weight, and small heat exchangers. The energy cost and environmental issue are also encouraging researchers to achieve better performance than the existing designs. Two of the most effective ways to achieve higher heat transfer rate in heat exchangers are using different kinds of inserts and modifying the heat exchanger tubes. There are different kinds of inserts employed in the heat exchanger tubes such as coiled wires, baffles. This paper presents an overview about the early studies on the improvement of the performance of thermal systems by using different kinds of inserts. Wire coil insert had better function in backward flow compared to forward one. Modifying the shape of twisted tapes led to a higher efficiency. Combination of various inserts and tube with artificial roughness provided promising results. In case of using various propeller types, heat transfer enhancement was dependent on higher number of blades and blade angle and lower pitch ratio.***

Keywords: Heat transfer coefficient, wire coil insert and baffle plate insert, laminar flow, turbulent flow, nusselt number, Reynolds's number.

I. INTRODUCTION

Heat exchangers are devices that facility at the exchange of heats between two fluids those area t different temperatures while keeping them from mixing with each other. Heat exchangers are extensively used in a variety of industrial processes for heating and cooling applications .The most important on front in designing a heat exchanger is to make the tools compact t and achieve elevated heat transporters at using minimum pumping power. The heat transfer rate can be improved by introducing a disturbance in the fluid flow there by breaking him viscous and thermal boundary layer.

Heat transfer processes in industrial, Automotive and domestic application involves the conversion, transfer and utilization of energy. The Enhancement of heat transfer in such several application can significantly improve the thermal performance of heat based equipment's (for instance, heat exchanger) are called as heat augmentation techniques. Heat augmentation techniques, used to increase the convective heat transfer coefficient by increasing the turbulence of the fluid.

II. LITERATURE REVIEW

A. Paisarn Nephon et.al. [2006] Have studied the heat transfer characteristics and the pressure drop of the horizontal double pipe with coil-wire inserts in April 2006 .Finally concluded that the heat transfer rate and heat transfer coefficient depend directly on the mass flow rates and effect of coil-wire insert on heat transfer tends to decrease as Reynolds number increase.

B. Alberto Garcia ET. al. [2007] studied on three wire coils of different pitch inserted in a smooth tube in laminar and transition regimes in March 2006, the heat transfer Enhancement obtained with the wire coils will be quite higher than the one obtained with the twisted tapes.

C. Jung-Yang San ET. al. [2015] has performed experiment on heat transfer and fluid friction correlations for circular tubes with coiled-wire inserts. The wire diameter-to tube inner diameter ratio (e/d) and coil pitch-to-tube inner diameter ratio (p/d) are in the ranges of 0.0725 to 0.134 and 1.304 to 2.319respectively. It is found that the Nusselt number (Nu) increases with the e/d value, where as it increases with a decrease of the p/d value. Alberto Garci et.al., [2005] Performed an experiment on heat transfer enhancement with wire coil inserts in laminar-transition –turbulent regimes at different prandtl numbers in which researchers used helical wire coils fitted inside round tubes. Researchers studied their thermo hydraulic behaviour in laminar, transition and turbulent flow. Researchers used Reynolds numbers from 80,000 to 90,000 and prandtl number from 2.8 to 150, in which six wire coils were tested within a geometrical range of helical pitch.

D. Hsieh and Huang -conducted experimental studies for heat transfer and pressure drop of laminar flow in horizontal tubes with/without longitudinal inserts. They reported that enhancement of heat transfer as compared to a conventional bare tube at the same Reynolds number to be a factor of 16 at Re >10000, while a friction factor rise of only 4.5. A new method was

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postulated by to predict heat transfer coefficients with twisted tape inserts in a tube in which the wall shear and the temperature gradients were properly modified through friction coefficient correlation leading to heat transfer augmentation from the tube wall. It was found that the performance evaluation criteria was about 1.32–1.39 times compared to plain tube.

E. Sujoy Kumar Saha.[13] perform an experiment investigation to study on Thermal and friction characteristics of laminar flow through rectangular and square ducts with transverse ribs and wire coil inserts in July 2009. The heat transfer and the pressure drop characteristics of laminar flow of viscous oil (195 <Pr< 525)through rectangular and square ducts with internal transverse rib turbulators on two opposite surfaces of the ducts and with wire coil inserts have been studied experimentally.

III. EXPERIMENTAL APPARATUS AND METHOD

The schematic experimental apparatus that will be used to enhance heat transfer is as shown in Fig. Which consist of voltmeter, ammeter, pressure gauge orifice, blower switch, main power switch, data acquisition system (DAS) with computer, thermocouples, data logger, heater input etc. fig shows an cross sectional view of helical wire fitted inside smooth tube, where p stands for helical pitch, e for wire diameter and d for inner diameter of tube. The main function of different apparatus is as follows:-

A. Heat exchanger is made up of metal pipe which is thermally insulated outside to prevent heat transfer losses to atmosphere.
B. Heat regulator is used to supply regulated power input to heater.
C. Data logger is used to measure the temperature, voltmeter, current and air flow rate.
D. Thermocouples are used at suitable position to measure necessary temperature.
E. Blower unit used to blow the air through heat exchanger with orifice meter and control valves are used to control air flow rate.

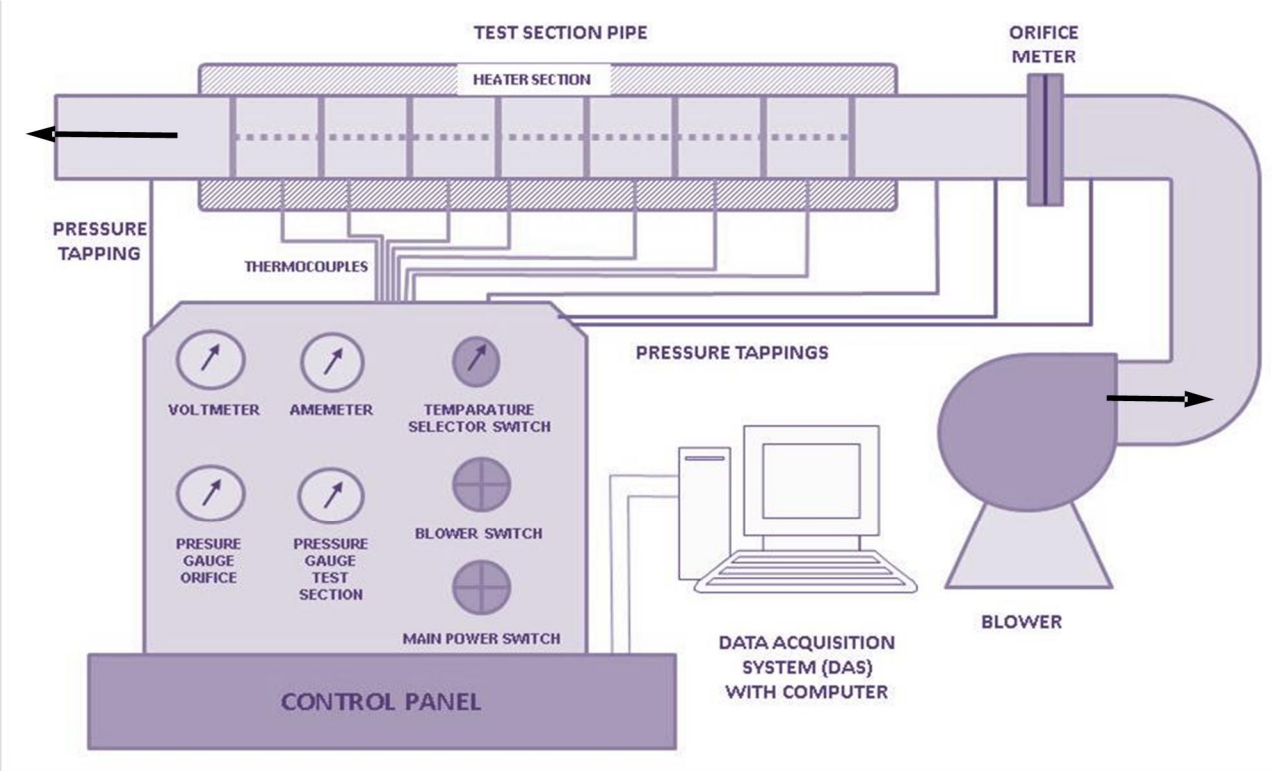


Fig 3.1: Enhancement of force convection heat transfer in pipe using different inserts.

IV. PROCEDURE

Put the dimmer stat to zero position and the switch on the main electric supply. Start the blower and adjust the air flow by means of valve to some desired difference in manometer level. (Preferably open control valve fully). Start the heating of the test section by adjusting desired heater input with dimmerstat. Take the readings of all 7 thermocouples at the interval of 10 minutes until the steady state is reached (last 2 readings should be same). Also note down the heater input (In terms of voltage and current). Repeat the procedure for different inserts. Calculate the heat transfer rate with the help of readings taken for with & without inserts.

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V. TYPES OF DIFFERENT INSERTS USED

A. *Louvered Strip Insert*

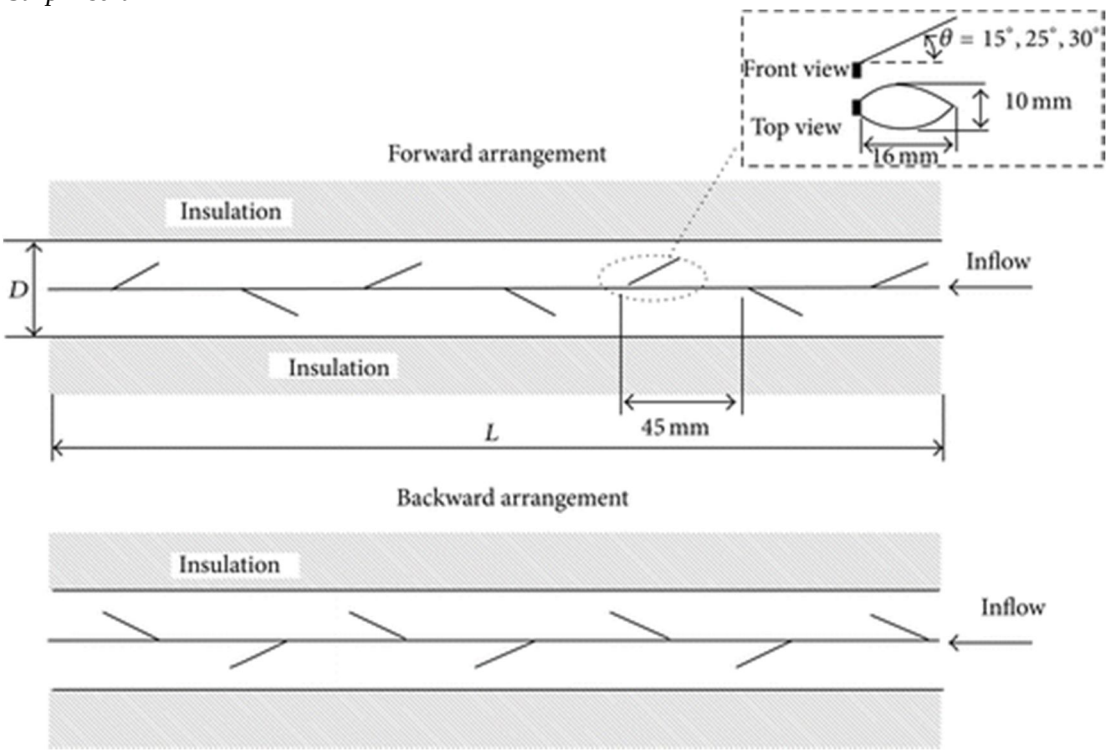


Fig 5.1: Louvered Strip Insert

B. *Wired Coil inserts*

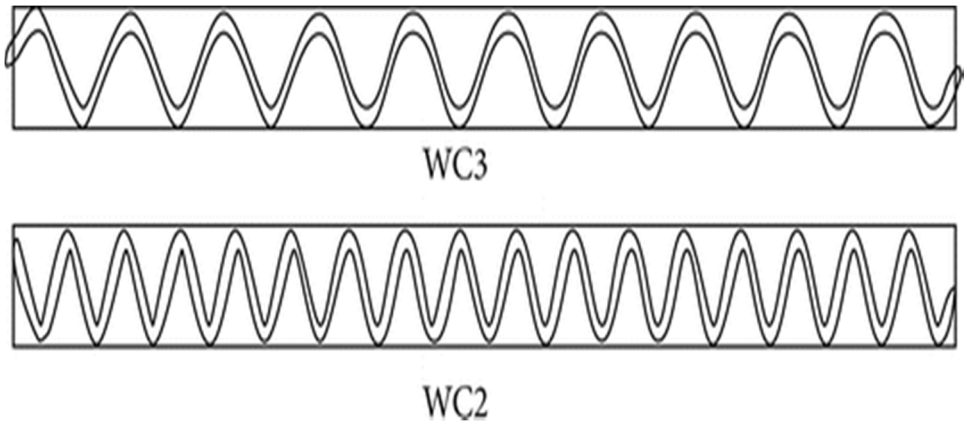


Fig 5.2: Wired Coil inserts

VI. SPECIFICATIONS

A. *For Helical Coil*

1) Pitch = 20mm.
2) Thickness of inserts, t = 3mm.
3) Length of tape, L = 500mm.

B. *For Baffle Type Insert*

1) Length of tape, L = 500mm.
2) Pitch=30mm.

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VII. SAMPLE CALCULATIONS

1) Bulk mean temperature of air: T mean = (T1+T7)/2

2) Properties of Air at T mean

ρ air = Density of air :-1.118 kg/m^3

CPA = Specific heat capacity of air=

3) Surface Temperature: T surface= (T2+T3+T4+T5+T6+T7)/6=74.99957143

4) Properties of Air at Film

μ = Dynamic viscosity of air (Ns/m2)

k =Thermal conductivity of air (W/mK)

5) Heat carried out

Qair = Qconv

In which

Qair=$\dot{m}$cp (dt) =82.9225781

Where, To & Ti Temperature at outer and inner wall of pipe

The convection heat transfer from the test duct can be written by

Qconv = hA (Ts-Tb) =54.02774083

Where,

Tb = (To + Ti) =43.26

Ts = average surface temperature h can be calculated. =31.74

i.e., h= Qair /A (Ts-Tb)

Nu are estimated as follows,

Nu=hD/k=49.87176076

The Reynolds number is given by,

Re=ρUD/μ

Friction factor f can be written as,

f = ΔP / ($L\rho$v 2/ 2) =0.000001393201259v^2/2

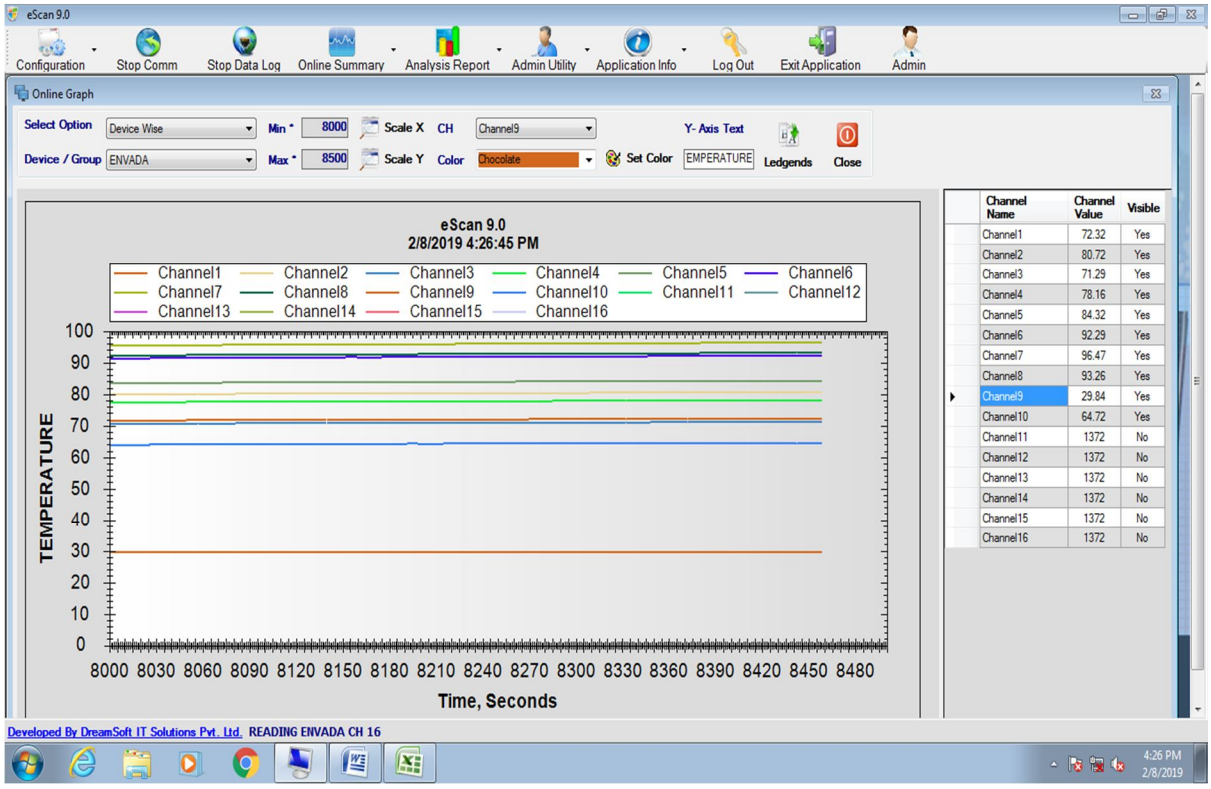


Fig 7.1: Online Graph (1)

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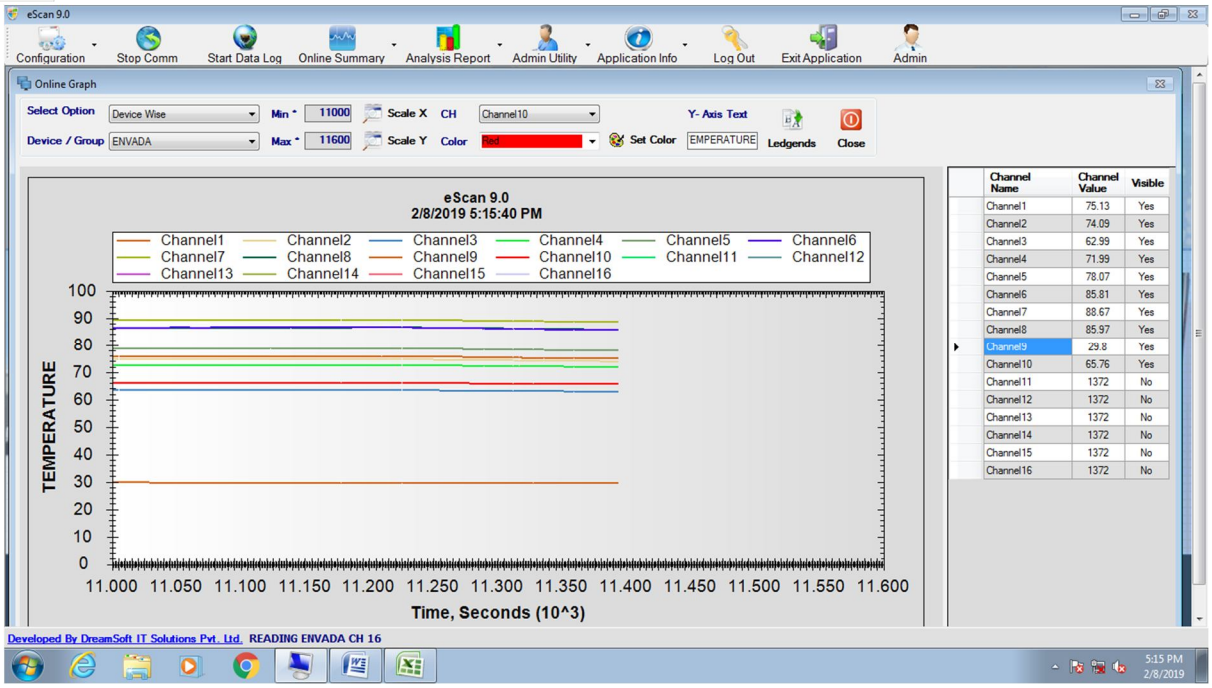


Fig 7.1: Online Graph (2)

VIII. CONCLUSION

Effect of coil wire insert on heat transfer enhancement: shows variation of Nussle number with Reynolds number for tube without and with coil wire inserts i.e. Aluminiumand Copper material. It seen that Nussle number for tube fitted with coil wire insert is higher than that of plain tube for given Reynolds number. This is because of coil wore insert interrupt the boundary layer of the fluid flow near the wall of test section hence it increases the fluid temperature in the radial direction .due to high contact surface area the heat transfer rate increases also it create turbulence and whirling motion inside the test section, this motion makes flow highly turbulent, which leads to improved convection heat transfer. The performance of system is evaluated for range of Re12000to15000 and for wattage input of 27.56W and 64.81W. Copper coil wire have greater PEC over Aluminium coil wire at lower watt input .Without insert PEC is one and with insert PEC is1.324.Thus through this project work the enhancement of heat transfer in pipe flows observed and recorded successful. This work can further be extended by changing the wire diameter, wire material and pitch of coil over wide range. The pitch has considerable effect over Number .There is ein Nunumberis observe 20 percent for Cu and for Al.

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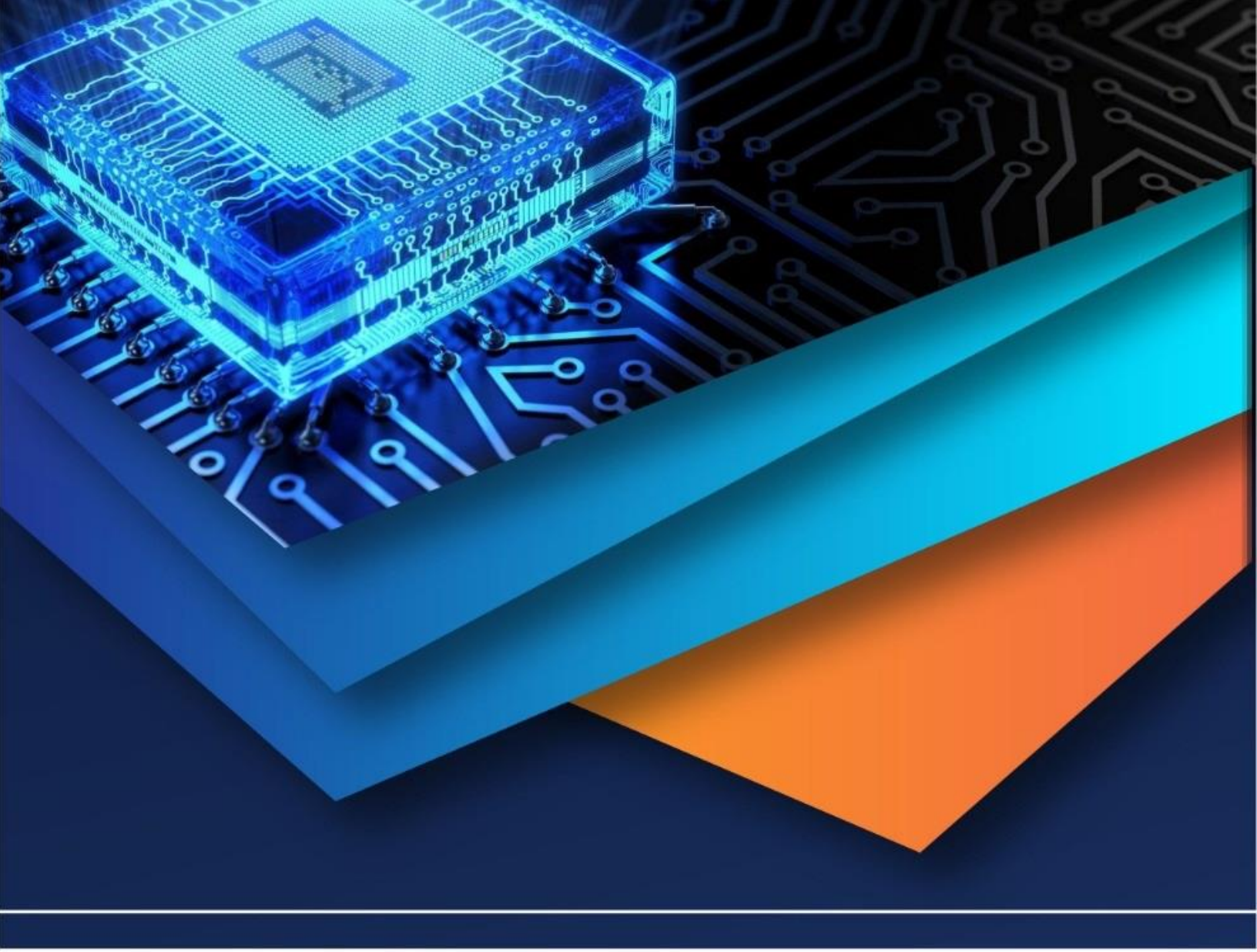
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