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IoT Based Pneumatic Sheet Metal Cutting Machine

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Abstract:** This paper introduces an advanced automatic sheet metal cutting system that seamlessly integrates Programmable Logic Controller (PLC) and Human-Machine Interface (HMI) technologies, revolutionizing manufacturing processes. The system's primary objectives include enhancing operational efficiency, accuracy, and safety standards. By utilizing precision sensors and responsive actuators, the system performs intricate metal cutting operations according to customer specifications. The HMI touch screen serves as the interface through which operators interact with the system, while the PLC processes data and dispatches instructions to the pneumatic cylinder, orchestrating the cutting operations. The HMI interface empowers operators with real-time oversight and control over the cutting process, enabling prompt adjustments based on feedback. Safety measures such as emergency stop buttons and interlocks further ensure operator well-being and prevent accidents. The integration of PLC and HMI technologies significantly reduces human errors, boosting productivity and ensuring precise cutting results. This innovation redefines industrial automation benchmarks, offering industries an efficient, accurate, and secure solution for high-speed cutting processes. Building effective industrial systems are now possible with the help of the Internet of Things abbreviated as IoT. In nowadays automatic systems are recommended over manual systems. IoT is the latest and rising internet technology. IoT is a developing network of everyday products, from industrial machinery to consumer goods which exchange information and carry out tasks while consumers are attending to other responsibilities. A machine tool is used to punch sheet metals to increase the static stability of the section of the sheet. The movement of the piston in the pneumatic punching machine is from the compressed air which generates high pressure on the piston. The focus of this project is on the development of an IoT- enabled sheet metal punching machine. The main objective of this project is to develop anIoT-based pneumatic punching machine that is capable of monitoring the production parameters of the pneumatic punching machine through an easily manageable web interface. Additionally this technology is innovative in that it allows the control of the punching machine through the Internet of Things as well as the tracking of production data or production values

I. INTRODUCTION

The IoT-Based Accident Avoiding Punching Machine is an advanced system designed to enhance safety in environments where punching machines are used. Traditional punching machines often pose risks of injury due to their moving parts and high-speed operations. Our project aims to mitigate these risks by integrating Internet of Things (IoT) technologies to monitor, detect, and respond to potential accidents in real-time The primary goal of this project is to develop a punching machine equipped with IoT sensors and intelligent algorithms that can prevent accidents and ensure user safety.

By leveraging real-time data collection and analysis, the system will provide immediate alerts and take corrective actions to minimize the risk of injuries. Sensors will continuously monitor the machine's operational status and the surrounding environment. Advanced algorithms will analyze sensor data to detect potentially hazardous conditions or anomalies. The system will automatically halt operations or trigger safety mechanisms in response to detected risks. Users and operators can monitor machine status and receive notifications through a connected IoT platform. The system will automatically adjust the machine's settings to prevent potential injuries. For instance, it can lower the intensity or halt operations if it detects a high-risk situation. The IoT-Based Accident Avoiding Punching Machine represents a significant advancement in industrial safety technology. By incorporating IoT capabilities, we aim to create a safer working environment and improve overall operational efficiency.

II. OBJECTIVES

1) Automation & Precision

- Automate the sheet metal cutting process using a pneumatic system.
- Ensure high precision and accuracy in cutting through IoT-enabled sensors and controls.
- Minimize human intervention to improve consistency and repeatability.

2) IoT Integration for Smart Monitoring & Control
   - Implement real-time remote monitoring using IoT sensors and cloud-based dashboards.
   - Enable remote control and scheduling via a mobile or web application.
   - Collect and analyze operational data for predictive maintenance and efficiency improvements.
3) Energy Efficiency & Cost Reduction
   - Optimize the pneumatic system to reduce air consumption and energy waste.
   - Reduce operational costs by automating manual tasks.
   - Use real-time analytics to improve machine utilization and minimize downtime.
4) Safety & Reliability
   - Implement emergency stop mechanisms and safety sensors to prevent accidents.
   - Monitor air pressure and cutting force to ensure safe operation.
   - Enable predictive maintenance alerts to prevent unexpected failures.
5) Scalability & Customization
   - Design the system to handle different metal thicknesses and cutting patterns.
   - Allow customization of cutting parameters based on material type.
   - Ensure the system is scalable for integration into industrial manufacturing environments.

III. LITERATUREREVIEW

1) *KiranKumar, Akshata Fansekar,N Sandeep20237th International Conference on Computation System and Information Technology for Sustainable Solutions(CSITSS), 1-6, 2023*

This paper introduces an advanced automatic sheet metal cutting system that seamlessly integrates Programmable Logic Controller (PLC) and Human-Machine Interface (HMI) technologies, revolutionizing manufacturing processes. The system's primary objectives include enhancing operational efficiency, accuracy, and safety standards. By utilizing precision sensors and responsive actuators, the system performs intricate metal cutting operations according to customer specifications. The HMI touch screen serves as the interface through which operators interact with the system, while the PLC processes data and dispatches instructions to the pneumatic cylinder, orchestrating the cutting operations. The HMI interface empowers operators with real-time oversight andcontroloverthecuttingprocess,Safetymeasuressuchasemergencystopbuttons and interlocks further ensure operator well-being The integration of PLCand HMI technologies significantly reduces human errors, boosting productivity and ensuring precise cutting results. This innovation redefines industrial automation benchmarks, offering industries an efficient, accurate, and secure solution for high-speed cutting processes.

2) *VasuS, R Kumara, Nandeesha H Lb and Santhosh Hc1Department of Mechanical Engineering, MSRamaiah Instituteof Technology, Bangalore 560054Metals & Fuels70(2020).*

Building effective industrial systems are now possible with the help of the Internet of Things abbreviated as IoT. Innowadaysautomaticsystemsarerecommendedovermanualsystems.IoTisthelatestandrisinginternettechnology. IoT is a developing network of everyday products, from industrial machinery to consumer goods which exchange information and carry out taskswhileconsumersareattendingtootherresponsibilities.Amachinetoolisusedto punch sheet metals to increase the static stability of the section of the sheet. The movement of the piston in the pneumatic punching machine is from the compressed air which generates high pressure on the piston. The focus of this project is on the development of an IoT- enabled sheet metal punching machine.Themainobjectiveofthisprojectistodevelopan IoT-basedpneumaticpunching machine that is capable of monitoring the production parameters of thepneumaticpunchingmachinethroughaneasilymanageablewebinterface.Additionally, this technology is innovative in that it allows the control of the punching machine through the Internet of Things as well as the tracking of production data or production values.

3) *Kumar, R., and Nandeesha HL. "Development of IoT Based Pneumatic sheet metal cutting Machine. "Journal of Mines, Metals & Fuels 70 (2022).*

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section of the sheet. The movement of the piston in the pneumatic punching machine is from the compressed air which generates high pressure on the piston. The focus of this project is on the development of an IoT enabled sheet metal punching machine. The main objective of this project is to develop an IoT-based pneumatic punching machine that is capable of monitoring the production parameters of the pneumatic punching machine through an easily manageable interface.

4) *Dang, Khoa."Industry4.0-readyBuildingAutomationSystem: System design and commissioning for HAMK Sheet Metal Center building."(2017).*

This paper proposes the development of a novel system for automated industrialpunchingusingwirelesstechnologyandIoT-basedcontrol.Theproposedsetuputilizes an IR sensor-equipped pneumatic punch that is controlled via Wi-Fi, along with a roller feed system controlled by a mobile device. By incorporating the latest advancements in Industry 4.0 technology, the system aims to automate the industrialpunchingprocess.Theproposedsetupincorporateslong-distancewirelesscommunicationandIoT-based control, enabling remote observation and management of the punching process. The utilization of IR sensors ensures preciseandconsistentpunchingbyaccuratelydetectingthepunchingpositionwithreliability.Themobile-controlled roller feed system enhances the speed and precision of material feeding, leading to efficient and cost-effective manufacturing. Implementing thesuggestedapproachcansignificantlyincreaseproductivity,reliability, and the overall quality of industrial punching. The system offers a high level of automation and control, minimizing errors and reducing the need for user intervention. Furthermore, the combination of wireless connectivity and Industry 4.0technologyallowsforreal-time monitoring and management of the production process, providing valuable insights for process optimization and cost minimization. Overall, the suggested system represents a substantial advancement in the field of industrial automation and control, providing an effective and efficient solution for automated punching with wireless communication and IoT-based control

5) *Mandal, Akash, and Binayak Pattanayak. "Design and Fabrication of IoT-Based Pneumatic Punching Machine." International Conferenceon Recent Advances in Mechanical Engineering Research and Development. Singapore: Springer Nature Singapore, 2023.*

Thispaperproposesthedevelopmentofanovelsystemforautomatedindustrialpunching using wireless technology and IoT-based control. The proposed setup utilizesan IR sensor-equipped pneumatic punch that is controlled via Wi-Fi, along with a rollerfeed system controlled by a mobile device. By incorporating the latest advancements in Industry 4.0 technology, the system aims to automate the industrial punching process. The proposed setup incorporates long-distance wireless communication and IoT-based control, enabling remote observation and management of the punching process. The utilization of IR sensors ensures precise and consistentpunchingbyaccuratelydetectingthepunchingpositionwithreliability.Themobile-controlledrollerfeedsystem enhances the speed and precision of material feeding, leading to efficient and cost-effective manufacturing. Implementing the suggested approach can significantly increase productivity, reliability, and the overall quality of industrial punching. The system offers a high level of automation and control, minimizing errors and reducing the need for user intervention. Furthermore, the combination of wireless connectivity and Industry 4.0 technology allows for real-time monitoring and management of the production process, providingvaluableinsightsforprocessoptimizationandcostminimization.Overall,thesuggestedsystemrepresentsasubstantialadvancementinImplementingthesuggestedapproachcansignificantlyincreaseproductivity,reliability, and the overall quality of industrial punching. The system offers a high level of automation and control, minimizing errors and reducing the need for user intervention. Furthermore, the combination of wireless connectivity and Industry 4.0technologyallowsforreal-time monitoring and management of the production process, providing valuable insights for process optimization and cost minimization. Overall, the suggested system represents a substantial advancement in the field of industrial automation and control, providing an effective and efficient solution for automated punching with wireless communication and IoT- based control.

6) *Kiran Kumar, Akshata Fansekar, N Sandeep2023 7th International Conference on Computation System and Information Technology for Sustainable Solutions (CSITSS), 1-6, 2023*

Thispaperintroducesanadvancedautomaticsheetmetalcuttingsystemthatseamlessly integrates Programmable Logic Controller (PLC) and Human-Machine Interface (HMI) technologies, revolutionizing manufacturing processes. The system's primary objectives include enhancing operational efficiency, accuracy, and safety standards. By utilizing precision sensors and responsive actuators, the system performs intricate metal cutting operations according to customer specifications. The HMI touch screen serves as the interface through which operators interact with the system, while the PLC processes data and dispatches instructions to the pneumatic cylinder, orchestrating the cutting operations.

The HMI interface empowers operators with real-time oversight and control over the cutting process, enabling prompt adjustments based on feedback. Safety measures such as emergency stop buttons and interlocks further ensure operator well-being and prevent accidents. TheintegrationofPLCandHMItechnologiessignificantlyreduceshumanerrors, boosting productivity and ensuring precise cutting results. This innovation redefines industrial automation benchmarks, offering industries an efficient, accurate, and secure solution for high speed cutting processes the field of industrial automation and control, providing an effective and efficient solution for automated punching with wireless communication and IoT based control.

IV. PROBLEMIDENTIFICATION

The problem identification for an IoT-based pneumatic sheet metal cutting machine focuses on the challenges faced in traditional metal cutting processes. Manual cutting methods are labor-intensive, time-consuming, and prone to human errors, leading to inconsistencies in precision and quality. Conventional pneumatic cutting systems operate without real-time monitoring, making it difficult to track machine performance, predict maintenance needs, or optimize efficiency. Additionally, unexpected failures in pneumatic components, such as pressure drops or valve malfunctions, can cause production delays and increased operational costs. The lack of remote control and automation further limits scalability and productivity.

To address these issues, integrating IoT technology with a pneumatic cutting system enables real-time monitoring, predictive maintenance, automated control, and data-driven decision-making, ensuring higher accuracy, efficiency, and cost-effectiveness in metal cutting operations

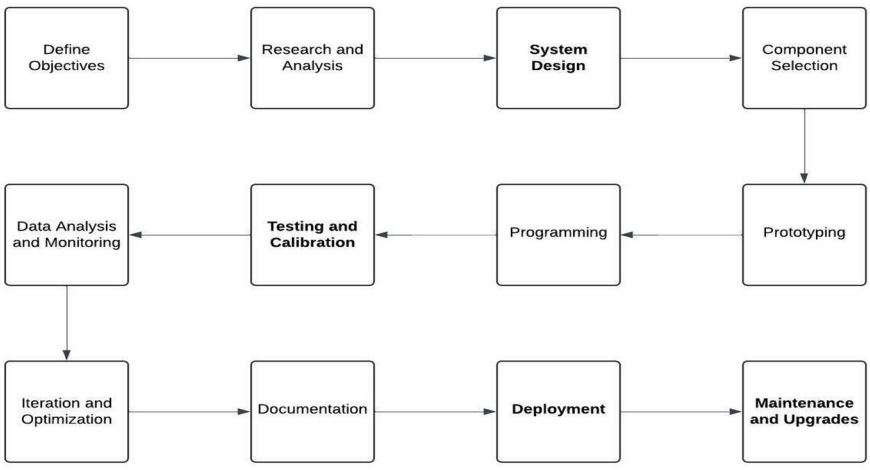
In the sheet metal industry, cutting operations play a crucial role in manufacturing, but traditional methods face several challenges. Manual cutting and conventional pneumatic systems often result in inconsistent accuracy, high labor dependency, and increased material wastage due to human errors. Operators must manually control the cutting process, leading to fatigue, inefficiency, and variations in quality.

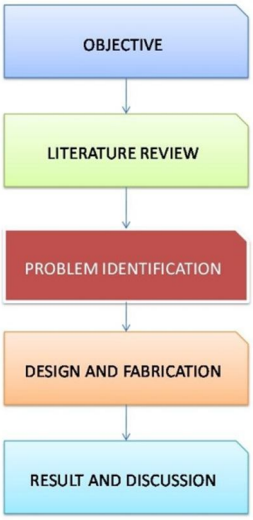
Furthermore, conventional pneumatic cutting machines lack real-time monitoring and predictive maintenance, making it difficult to detect issues such as air pressure drops, misalignment, or tool wear. Unexpected failures can result in downtime, production delays, and increased maintenance costs. Without an automated feedback system, operators cannot monitor performance, leading to inefficiencies in resource utilization.

Another major challenge is the inability to control and track machine operations remotely. In traditional setups, operators must be physically present to adjust settings, monitor operations, or shut down the system in case of emergencies. This limitation reduces productivity, especially in large-scale industrial applications where multiple machines operate simultaneously.

By integrating IoT technology into pneumatic sheet metal cutting machines, these issues can be addressed effectively. Real-time data monitoring, remote control access, and predictive maintenance capabilities will enhance precision, reduce downtime, and improve overall efficiency. IoT-enabled sensors can track air pressure, cutting force, and machine health, allowing operators to make informed decisions and optimize operations. Implementing this smart solution will not only increase automation and productivity but also reduce human intervention, making the manufacturing process more reliable, cost-effective, and efficient.

V. METHODOLOGY

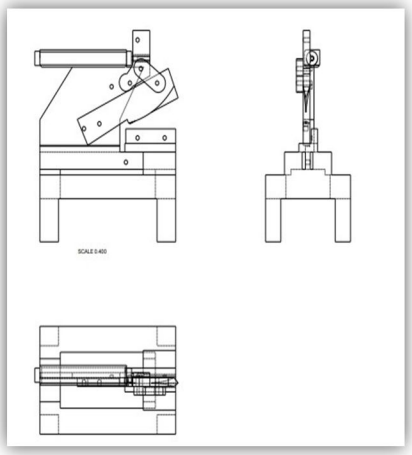




This project involves controlling accident or defecting due to machines. Here an object sensor is fixed on the machine where if anybody gets close contact with the machine then the relay circuit will trip off the machine and indicate through halarm. Hence accidents can be prevented which is caused due to carelessness. The main function of pneumatic is to cut thin and by pneumatic power. The compressed air from the compressor is used as the for cemedium for this operation. There are pneumatic double acting cylinders solenoid valves and the timer unit is used. The air enters to the solenoid valve. The function of solenoid valves all of air correct time interval. The5/2 solenoid valve is used. In one position air enters to the cylinder and pushes the piston so that the cutting stroke is obtained. The next position air enters to the other side of cylinder and pusses the piston return back, so that the releasing stroke is obtained.

A. Design and Fabrication

1) The design of an IoT-based pneumatic sheet metal cutting machine is a complex task that requires a multi disciplinary approach, combining mechanical engineering, electrical engineering, computer science, and materials science. The goal of this design is to create a cutting-edge system that integrates the benefits of IoT technology with the precision and efficiency of pneumatic sheet metal cutting machines. The pneumatic sheet metal cutting machine's mechanical design should ensure precision, accuracy, and reliability in cutting various types of sheet metal.

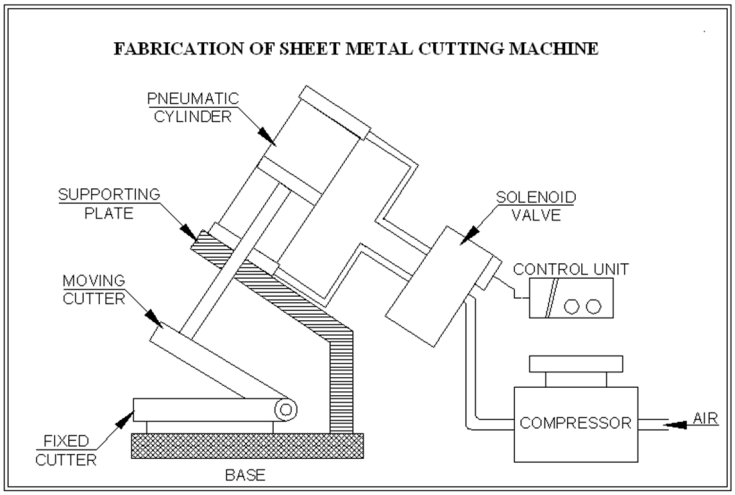


2) The IoT system should be seamlessly integrated with the machine, ensuring reliable data transmission and minimizing latency.

3) The design should prioritize operator safety and system security, protecting against cyber threats and ensuring compliance with industry standards.

4) The system should have an intuitive user interface, enabling operators to easily monitor and control the machine, as well as access data insights and analytic. A detailed mechanical design of the pneumatic sheet metal cutting machine. A specification for the IoT sensors and devices, including their placement and integration with the machine. A design for the microcontroller or IoT gateway, including its connectivity and data transmission protocols. A cloud-based platform architecture, including data analytics and visualization tools

Drawing For Fabrication of Sheet Metal Cutting Machine



B. *Synopsis*

The sheet metal cutting process is a main part of the all industries. Normally the sheet metal cutting machine is manually hand operated one for medium and small scale industries. Automation in the modern world is inevitable. Any automatic machine aimed at the economical use of man, machine, and material worth the most. In our project is solenoid valve and control timing unit is used for automation. The sheet metal cutting machine works with the help of pneumatic double acting cylinder. The piston is connected to the moving cutting tool. It is used to cut the small size of the sheet metal. The machine is portable in size, so easy transportable.

C. *Working Principle*

The compressed air from the compressor is used as the force medium for this operation. There are pneumatic double acting cylinders solenoid valves, flow control valve and the timer unit is used. The arm from the compressor enters to the flow control valve. The controlled air from the flow control valve enters to the solenoid valve. The function of solenoid valves all of air correct time interval. The 5/2 solenoid valve is used. In one position air enters to the cylinder and pushes the piston so that the cutting stroke is obtained. The next position air enters to the other side of cylinder and pusses the piston return back, so that the releasing stroke is obtained. The speed of the cutting and releasing stroke is varied by the timer control unit circuit.

D. Advantages

The pneumatic is more efficient in the technical field.
Quick response is achieved
Simple in construction
Easy maintenance and repair
Cost of unit is very less
No fire hazard problem due to overloading
Continuous operation is possible without stopping

E. Disadvantages

Silencer must be used while compressing the air
High torque can not be obtained
Load carrying capacity is low

F. Applications

This machine is very useful for small scale industries
These machines used to cut the roller sheet metal
All industrial application

VI. ACKNOWLEDGEMENT

First and foremost, I would like to thank the Almighty God for giving us the strength knowledge, ability and opportunity to undertake this project study and to persevere and complete it with satisfaction.
We would like to express our special gratitude and thanks to special al machines laboratory and technicians for giving us such attention time.
We would like to express our gratitude towards our parents for their tremendous contribution in helping us reach this stage in our life. This would not have been possible without their unwavering and unselfish love, cooperation and encouragement given to us at all times.

VII. CONCLUSION

1) Enhanced Automation: The integration of IoT with pneumatic sheet metal cutting machines reduces human intervention, ensuring precise and consistent cutting operations.
2) Real-Time Monitoring: IoT-enabled sensors allow continuous tracking of parameters such as air pressure, cutting force, and machine status, leading to improved operational efficiency.
3) Predictive Maintenance: The system can detect faults and schedule maintenance before failures occur, minimizing downtime and reducing repair costs.
4) Remote Access & Control: Operators can monitor via a cloud-based dashboard, increasing convenience and productivity.
5) Improved Safety: Automated control mechanisms and real-time alerts help prevent accidents, ensuring a safer working environment.
6) Energy & Cost Efficiency: Optimized pneumatic operations reduce energy consumption and material wastage, making the system more cost-effective.
7) Scalability & Industrial Integration: The system can be easily adapted for different industrial applications, supporting various sheet metal cutting needs.
8) Overall, an IoT-based pneumatic sheet metal cutting machine enhances precision, efficiency, and reliability, offering a smart, automated, and cost-effective solution for modern manufacturing industries.

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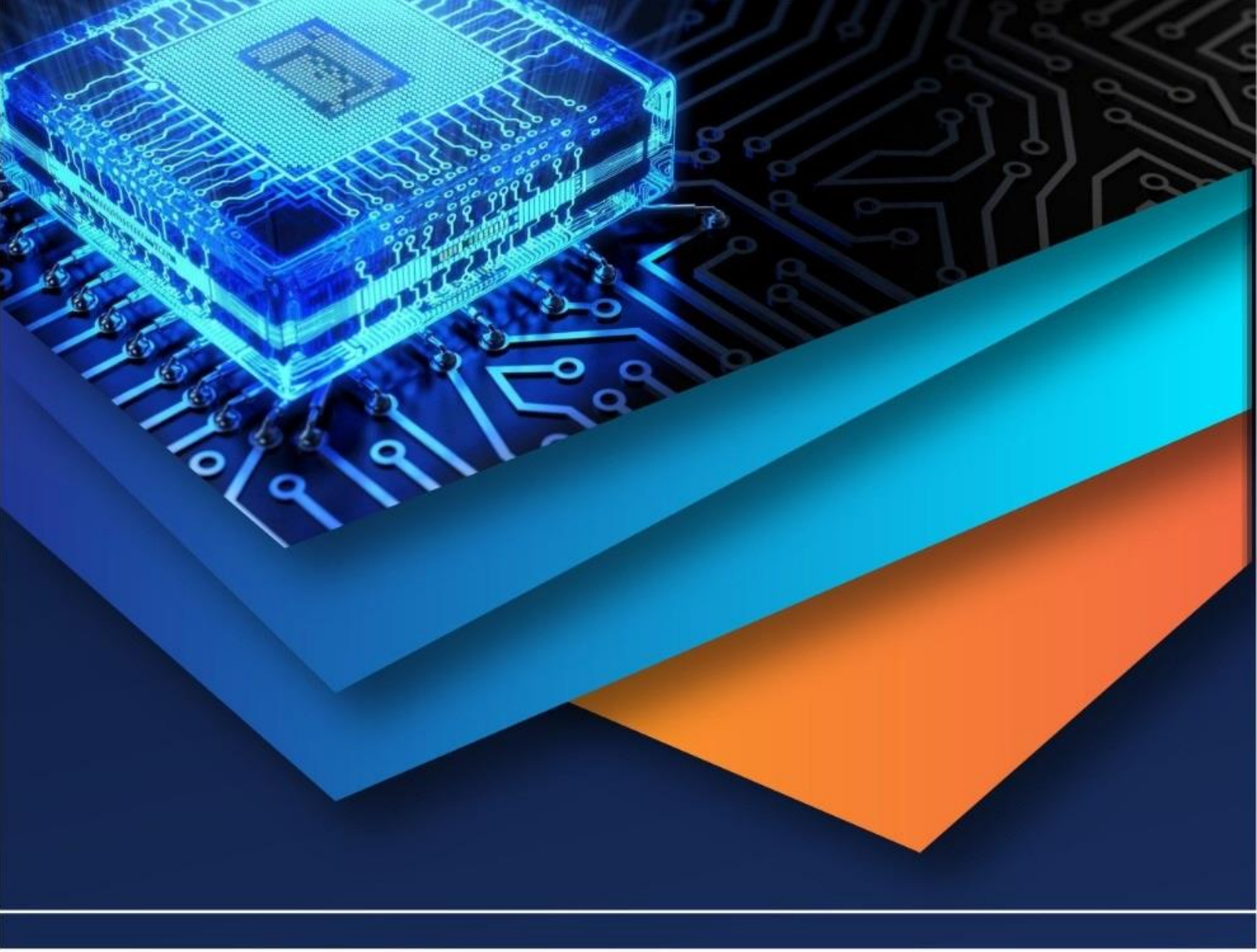

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