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Review Paper on Agricultural Terrain Traversal Rocker Bogie Mechanism

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Abstract: This paper details the design and implementation of a terrain traversal system leveraging the rocker-bogie mechanism, specifically tailored for agricultural applications where uneven terrain presents significant challenges. The rocker-bogie suspension system, renowned for its application in planetary rovers, is innovatively adapted to navigate the complexities of agricultural fields. The primary objective of this research is to create a prototype that minimizes soil disturbance while effectively maneuvering over obstacles such as rocks, furrows, and varying soil conditions. Through this approach, the prototype aims to enhance operational efficiency in critical agricultural tasks, including planting, monitoring, and maintaining crops. The system's design incorporates advanced navigation capabilities, potentially integrating sensors for obstacle detection and GPS for precise positioning. This research addresses the pressing need for low-cost, scalable solutions in the realm of agricultural mechanization, ultimately contributing to improved productivity and reduced labor costs in farming operations. The findings from this study are anticipated to provide significant insights into the future of agricultural technology, paving the way for further innovations in automated systems that can adapt to the dynamic challenges of modern agriculture. The successful deployment of this prototype not only underscores the feasibility of the rocker-bogie mechanism in agricultural settings but also highlights its potential to revolutionize practices in the industry.

I. INTRODUCTION

Agriculture has long been a cornerstone of human civilization, providing essential resources and livelihoods for billions around the globe. As the global population continues to rise, the demand for increased agricultural productivity has intensified, placing unprecedented pressure on traditional farming methodologies. The challenge of efficiently managing and navigating agricultural landscapes characterized by uneven topography, rocky soils, and steep slopes has emerged as a significant barrier to optimizing farming operations. Conventional agricultural machinery, primarily designed for flat terrain, often struggles in these diverse environments, resulting in operational inefficiencies, increased equipment wear, and potential harm to both crops and soil health.

In light of these challenges, the development of innovative solutions capable of traversing complex terrains is imperative. This paper presents a novel terrain traversal system based on the rocker-bogie mechanism, engineered to enhance mobility in agricultural settings. By effectively addressing the difficulties posed by uneven and unpredictable landscapes, this system aims to improve operational efficiency, reduce soil disturbance, and facilitate a variety of agricultural tasks, ranging from seeding to crop monitoring. The integration of advanced technologies, including obstacle detection sensors and GPS navigation, further augments the system's capabilities, offering a scalable and cost-effective solution for modern farming practices. Through this research, we aspire to contribute to the mechanization of agriculture, enabling farmers to meet the escalating demands of food production sustainably and efficiently.

II. REVIEW

A. Amar, Faiz Ben, and Philippe Bidaud.

This study simulates off-road robots while considering the mechanical behaviour of the locomotion system and how it interacts with its surroundings. For various wheel soil contact behaviours, this interaction is investigated and explained. The study takes into account the slippage, soil compaction, soil shear deformation, and wheel elastic deformation phenomena. Analytical relationships that relate each the contact force components radial, longitudinal, and lateral forces to relative displacements radial displacement, longitudinal slip ratio, and side slip angle express models of wheel-soil contact. The behaviour of the entire system is then described by coupling these rules to the mechanical system's dynamic equations. These models are put into practise using a visual simulation system that offers a fundamental tool for mechanical system design, path planning, and the construction of control systems [1].

B. Bickler, Donald B.

The 'rocker-bogie,' often known as Rocky, is a novel form of vehicle design with a free rocking bogie in front of a master bogie. All vehicles of the Rocky design share the following characteristics: they have a single rigid body, very high ground clearance, all wheels can be turned, and the body is differentially connected between the left and right sides on a transverse axis. There are also no springs or elastic members other than those used with the tyres. It detailed how the design's foundation a linkage system that distributes weight across the wheels over a wide range of individual wheel elevations leads to greater capability for scaling obstacles and superior bump performance [2].

C. Choi, Dongkyu, Jongkyun Oh, and Jongwon Kim.

This work achieves an analytical approach to enable the rocker bogie mechanism to ascend a stair. Kinematic analysis and the rocker bogie's posture are established in order to assess whether or not the rocker-bogie might climb up the target stair at a certain length of the links and radii of the wheels. Three wheels coming into contact with the front of the stairway are analysed in the context of the rocker bogie's centre of mass trace. The stair climbs ability graph (SCG), which was determined by a stair's length and height, was produced using these two studies. For a rocker bogie with a specific size, the SCG displays the climbable stair group. 4 Two rocker bogie prototypes with various connection lengths were created and put to the test on two different staircases. The first prototype rocker bogie with a tiny rocker linkage achieves the same result as the SCG in that it can climb up one stair (length 450 mm, height 150 mm), but not the other (length 300 mm, height 175 mm). Both steps may be climbed using the second prototype rocker bogie with a massive rocker linkage [3]

D. Farritor, Shane, Herve Hacot, and Steven Dubowsky.

A planetary rover has returned from Mars with crucial scientific data. Missions with greater scope are anticipated. We need new planning techniques that provide rovers with a high degree of autonomy while they investigate difficult terrain. The planning approach presented in this study is based on a physics-based model of the rover and its surroundings. Plans are created that let a rover carry out a task while expressly taking limitations like power, actuator, wheel slip, and vehicle stability restrictions into account. Results from thorough rover simulations are displayed [4].

E. Akhilesh Kumar Singh

This paper examines the investigation of the effect of increase in perforation diameter and angle of inclination on the natural convection heat transfer from rectangular fin array. In this paper, the natural convection heat transfer under steady state condition from the solid fin array and the perforated fin arrays with 4 mm fin spacing, fin perforation diameter (4,6 and 8 mm) & fin inclination angle (0, 30, 45, 60 and 90) were analyzed & compared.

Experimentation was carried out on configuration with 10 fins. Dimensions of fin and base plate made of aluminum material are taken as (75*27*2mm) and (76*75*2mm) respectively. Heat input was provided as 15 W, 25 W, 35 W, 45 W. Result implies that the enhancement in the heat transfer coefficient was achieved with the increase in the fin perforation diameter. With the variation in fin inclination angle from 0 to 90 also the heat transfer was enhanced. [5]

F. Basima S. Khalaf

In this paper, experiments were done to investigate the natural and forced convection of heat transfer along a flat surface equipped with various types of rectangular aluminum fins (solid and perforated). Selected rib with dimensions (30 mm high x 30 mm wide x 1 mm thick). Perforated ribs have different distributed holes (2mm for 9 holes, 4mm for 5 holes). Aluminum is used for the ribs and floor material. Natural convection modes of heat transfer along perforated and non-perforated fins were analyzed in steady state.

The effects of the number, size and arrangement of perforated lamellae were investigated. A higher heat transfer rate is observed with an increased number of circular holes, and efficiency is also improved due to the reduced weight of the fins. A numerical analysis was also performed to examine this temperature distribution and used in a simulation program (SOLDWORKS). Good agreement was found when comparing experimental and theoretical studies. Some observations from this study can be summarized as follows:

1) The temperature difference between the base and tip of the perforated fin was larger than that of the non-perforated fin.
2) The heat transfer coefficient of perforated fins depends on the dimensions of the holes and the width of the fins.
3) The heat transfer coefficient increased as the number of holes increased. [6]

G. Rashin Nath K.K

In this work, they numerically investigate the effect of different fin geometries on the overall heat transfer from an air-cooled fin assembly mounted on a cylindrical surface. In this paper, the heat transfer and heat transfer coefficient of three fin models (rectangular, wavy and zigzag) were studied. The structure was modeled with CATIA V5 software and thermally analyzed using ANSYS Fluent software. A cylinder with three ribs used for CFD analysis. The aluminum slat dimensions are assumed to be 220 x 150 x 1 mm. The outer diameter of the cylinder is 72mm. 70mm inner diameter, 1mm thickness. The length of the cylinder is 80mm.

Next, we compared the heat transfer coefficients of different geometries. At low speeds, flat fins were found to have higher heat transfer coefficients and heat transfer coefficients. The heat transfer coefficients of the zigzag and wave fins increased with increasing vehicle speed compared to the flat fins. The development of a curved zigzag shape can create vortices between the two fins, creating turbulence and increasing heat transfer. [7]

H. Ashok Tukaram Pise

Ashok Tukaram Pise conducted experiment for comparing the heat transfer coefficients of solid and permeable fins. The permeable ribs are formed by altering the solid rectangular ribs by drilling three holes per rib, inclined at half the rib length of the two-wheel cylinder block. Solid, permeable rib blocks were kept in an isolated chamber and the efficacy of each rib in these blocks was calculated.

An engine cylinder block with solid permeable fins was tested at various power inputs (i.e. 75W, 60W, 45W, 30W, 15W). We found that the permeable fins improved the average heat transfer coefficient of the block by about 5.63%, increasing the average heat transfer coefficient by 42.3% compared to the solid fins, and reducing the material cost by 30%. [8]

I. Mahathir Mohammad

This experimental study was conducted to investigate the effect of extended surface perforation shape or geometry on forced convection heat transfer, finding the heat transfer properties of various perforated fins to reveal the optimal perforation geometry for planar heat sinks. Studies have shown that the temperature drop along perforated ribs was greater than without perforations. For the heatsink we used a solid aluminum block 190mm long, 120mm wide and 7mm thick. The rib was 120 mm long, 85 mm wide and 4 mm thick. Each fin is spaced 38mm apart for even heat distribution. To minimize heat loss from the baseplate and finplate, the finplate was placed 3mm inside the baseplate and was also soldered to the baseplate and fins to reduce heat loss. The parameters studied were temperature distribution and heat transfer coefficient. The average increase in convective heat transfer coefficient at 150W is 78.98% for triangles and fins without holes, which is greater than for rectangles (74.36%) and circles (41.42%). A similarity can be seen for 100W power consumption, with triangular perforated fins exhibiting the highest temperature difference at 54.59%, followed by rectangular at 38.0% and circular at 33.04%.

From this study it can be concluded that, Fin holes and hole geometry had a significant impact on the temperature distribution across the fin, which affects the fin's performance. A triangular perforated shape gives the best results, followed by rectangular and circular. [9]

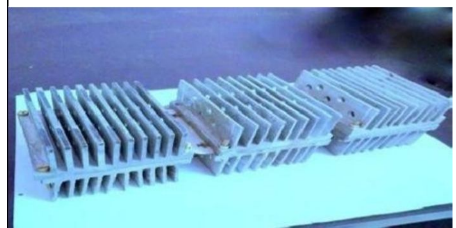
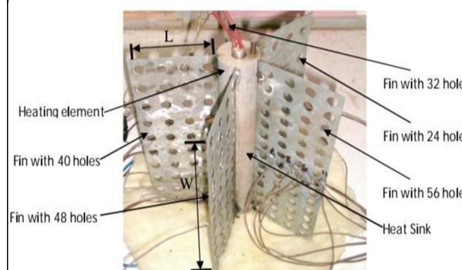
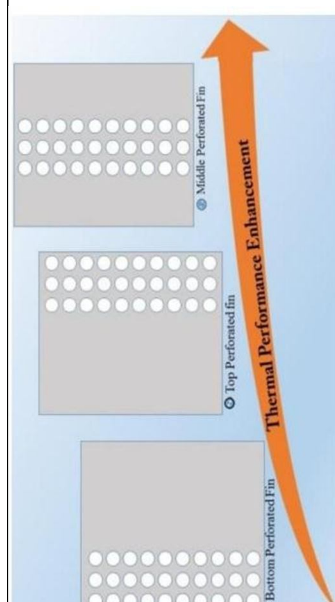
J. G. M. Sobamowo

In this study, investigation on the thermal responses of moving irregular porous fins with trapezoidal, concave, and convex profiles of copper, aluminum, silicon nitrides and stainless-steel materials were examined. The developed thermal model is solved using differential transform method (DTM).

In the parametric studies carried out, the effect of physical parameters such as convective-conductive, convective- radioactive term, internal heat generation, porosity, surface emissivity, power index of heat transfer coefficient, Peclet number and Darcy number on the thermal behavior of fins were examined and discussed. The comparative analysis carried out on the effect of materials on non-dimensional temperature distribution reveals that copper obtains the highest temperature while the stainless steel gets the lowest. More-so, the fins with concave geometry gives the highest volume adjusted efficiency with increase in Peclet number while that with convex profile has the least.

The conclusions made from the experimentations are clear that these result outputs are essential and would be useful in the future design of fins with optimum size reduction and high efficiency. [10]

TABLE -1: Comparison of Parameters

NAME OF AUTHOR	MODIFICATIONS	PARAMETERS STUDIED	ENHANCEMENT ACHIEVED	GEOMETRY
Pramod R. Dabhade [1]	Rectangular finswith Blind holes	Surface area offins	Heat transfer rate is maximum in perforated fins with Blind holes as compared to fins with complete holes.(i.e., heat transfer rate is depends upon the surface area of fins.	 Fin Array Block (Pramod R.Dabhade et all, 2019)
Wadhah Hussein [2]	Rectangular fins plate with circular perforations (complete holes)	No. of perforations - 24,32,40,48,56 Dia. of perforations - 12mm (i.e. variation in no. of perforations with constant diameter)	Temperature drop in perforated fins ishigher than non- perforated fins. Heat transfer rate increases with no. of holes increases.	 iew of the Heat Sink (WadhahHussein et all, 2011)
OsamahRaad [3]	Rectangular fins with perforations having perforated positions like bottom, middle, top.	Perforations diameter - 3,5,7 No. of perforations (holes) - 30 (i.e., variations india. of perforations with constant no. of holes) Perforations positions – (Top,Middle, Bottom) Fin dimensions – Length - 110 mm, Width - 100mm Thickness - 1mm	Perforations positioned at the middle of the fin regardless of the dia. gives maximum improvement in the thermal performance.	 al Abstract (Osamah Raadet all, 2020)

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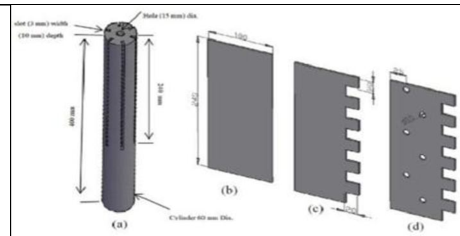
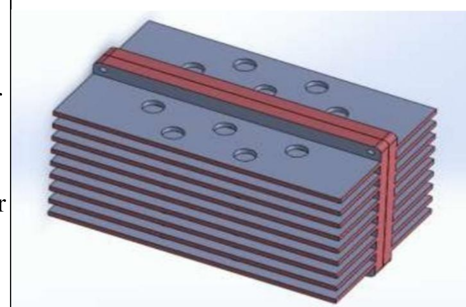
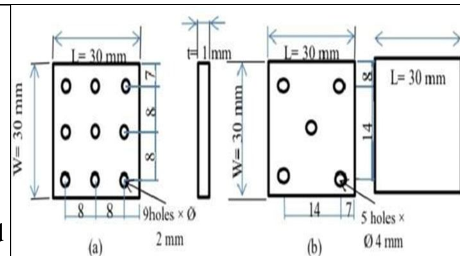
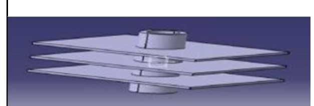
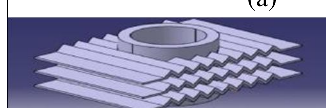
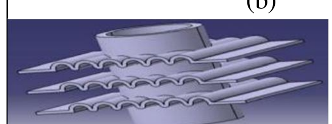
Maha A. Hussein [4]	Fins with rectangular edge,and fins with circular perforations witha rectangular edge	Material –Aluminium Fin dimensions - Length - 24 cm Width - 10 cm Thickness - 3mm	Heat sink with circular perforationswith a rectangular fin edge gives maximum performance, heat dissipation, and minimum fins weight and cost.	 – The schematic experimental rig(Maha A. Hussein et all, 2021)
AkhileshKumar Singh [5]	Hole pattern - Zigzag Hole size	Fin dimensions – Length - 75 mm Width - 27 mm Thickness - 2mm Effect of perforations diameter & fin inclination	Increase in heat transfer coefficient with the increase indiameter of holes. Also heat transfer rate increases whenthe fin inclination isvaried from 0° to 90°.	 Array Block (Akhiles KumarSing et all, 2017)
Basima S.Khalaf [6]	Square fins with circular perforations	Fin dimensions - Length - 30 mm Width - 30 mm Thickness - 1mm 9 holes *dia.2mm 5 holes *dia.4mm	The temperature difference betweenbase and tip of perforated fins is greater than for those of non- perforated fins.	 ted Fins (Basima S. Khalafet all, 2020)
shin NathKK [7]	Fins with different geometries (rectangular,zigzag, wavy)	Heat transfer & heat transfer coefficient of conventional, zigzag & wavy finmodels.	Heat transfer rate of conventional fins are greater for low velocity w.r.t. that ofzigzag & wavy. Zigzag & wavy fins can be preferred over conventional fins for higher speedvehicles as it induces greater turbulence and thus greater heat transfer rate.	 (a)  (b)  (c) Fig 7 – (a) Wavy Fin, (b) Zig Zag Fin, (c) Conventional Fin (Rashin Nath KK et all, 2017)

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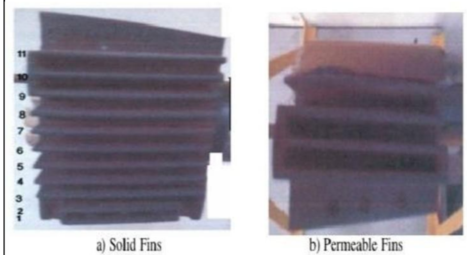
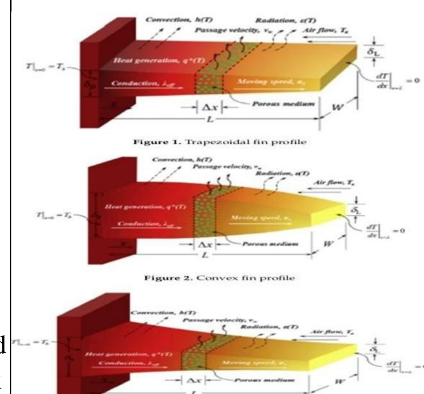
Ashok Tukaram Pise [8]	Rectangular fins with circular perforations in application for 2-wheeler cylinder block.	Fin dimensions - Length - 110 mm Width - 66 mm Thickness - 5mm Perforations (hole) diameter - 5mm	For the same heat transfer, the material removedby mass in permeable fins is about 10-30%. Therefore, reductionin material cost is 30%.	 ges of Fins (Ashok TukaramPise et all,2010)
Mahathir Mohammad[9]	Circular, rectangular & triangular perforated fins	Fin dimensions - Length - 120 mm Width - 85 mm ness - 4mm	Heat transfer coefficient increasesmost for triangular perforations followed by circular, rectangular and no perforations. Perforation shapesof fins shows a significant effect inconvention heat transfer.	 - Heat Sink Design (MahthirMohammad et all, 2019)

G. M. Sobamowo [10]	Fins with trapezoidal, concave & convexprofiles of copper, aluminium, and stainless steel	Effect of different materials with different profiles on heattransfer rate	Copper obtains the highest temperature while the stainless steel gets the lowest. Fins with concave geometry gives the highest volume adjusted efficiency while convex profilehas the least.	 Fig 10 – (a) Trapezoidal Fin Profile, (b) Convex Fin Profile, (c) Concave Fin Profile (G. M. Sobamowo et all, 2019)

III. CONCLUSION

From the above, we can obtain a basic understanding of various parameters such as fin shape and orientation when structuring a heat sink. The heat transfer coefficient increases with the number of perforations and the size of the perforations. It has also been observed that a hole in the center of the fin gives the optimum heat transfer coefficient.

Moreover, it is well justified that triangular perforated fins give higher heat transfer coefficients, followed by circular rectangles than regular (non-perforated) fins. The perforation geometry of the fins has a great influence on the convective heat transfer. The performance of perforated fin arrays is very good compared to regular fin arrays.

A literature review therefore provides preliminary evidence that perforated fin heat sinks are most commonly used for practical heat transfer applications compared to plate fin heat sinks. This extensive study will help future heatsink design studies.

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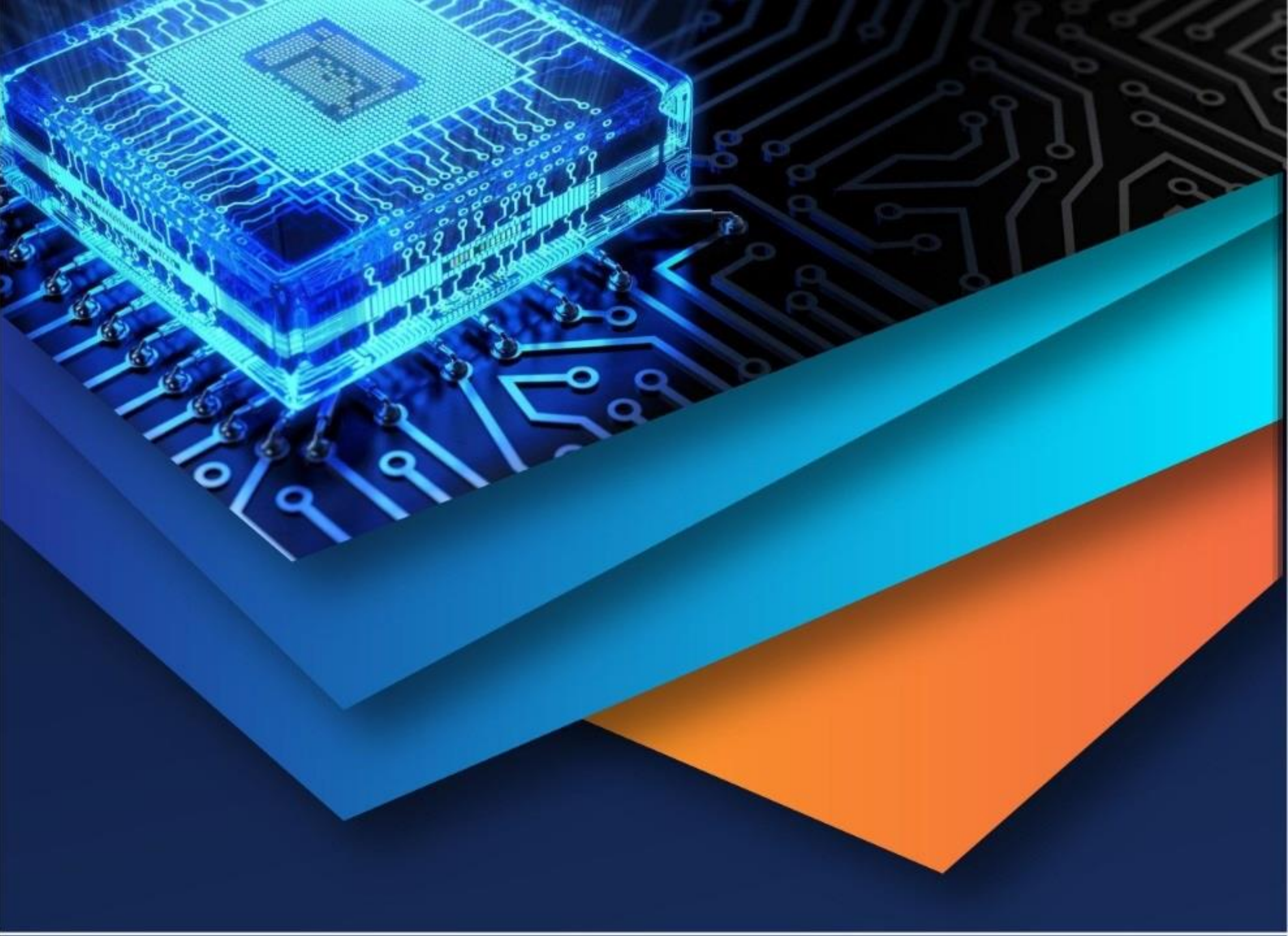

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