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Review on Development of Mechanical Tracking System for Solar Water Heater

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Abstract: ***The paper reviews the available journalism associated with solar heating and solar tracking. Sun being the never-ending source of energy, has motivated and developed many technologies as solar heating, thermal energy, electricity generation etc. The main aim of each study is to enhance the heating efficiency. Most of the techniques used for solar heating included solar tracking, collectors, phase change materials, active systems, spiral tube for increasing efficiency of solar water heating process. This paper aims to explore similar systems of this type.***
Keywords: Renewable energy, solar heating, solar tracking, PV panels, efficiency, water heating.

I. INTRODUCTION

Solar energy systems have emerged as a viable source of renewable energy over the past two or three decades, and are currently used on large scale in commercial as well as domestic applications. Several literature studies are based on the utilization of solar collectors to implement such applications as light, window covering systems, cookers and heaters. Water heaters have been becoming common now a days in the countries for almost every day use. The conventional heaters such as geysers and boilers are environmentally harmful because the heating process requires fossil fuel burning and greenhouse gas emissions. The higher energy usage for heating purpose is not only creating pressure on national grid for excess supply of electricity but also affecting electricity price badly. One of the alternative technologies is solar water heating, which can be used for heating water without harming the environment by simply using solar power. Also, a modified version of it can be used i.e., solar tracking water heater to increase its efficiency and availability of heated water for more time of the day. In general terms, the power developed in such applications depends primarily upon the quantity of solar energy or solar power captured by the collector, and therefore the matter of developing tracking schemes that are capable of following the trajectory of the sun throughout the day over the years is also important. Current review illustrates various research on the various models and systems related to Solar heating and solar tracking.

II. LITERATURE REVIEW

Mohd Rizwan Sirajuddin Shaikh et al [1] have reviewed on the Electricity Generation from Solar Energy. It described solar energy and its working. The paper emphasized on the modelling of PV panel in cell, module, panel and array assemblies with their use along with the features. Information was given on Solar Concrete Collectors such as Parabolic trough reflectors, Fresnel, Parabolic dish and Central receiver. Merits and demerits of solar energy with applications of the same were discussed.

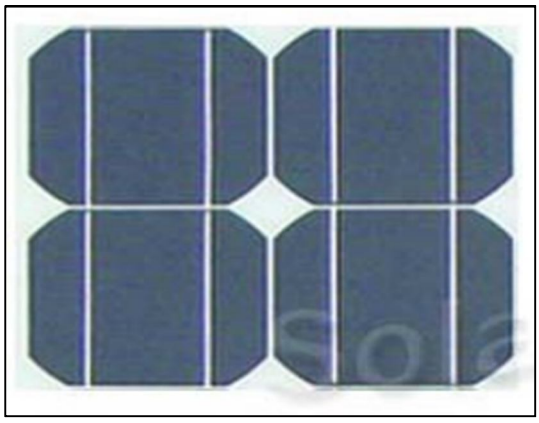

Fig.1.1: Photovoltaic Cell (4 cell) [1]

Fig. 1.2: Parabolic Dish [1]

Sagar Jadhav et al [2] strongly promised solar energy as the most useful resource that is environmentally sound and would save the non-renewable fossil fuels in the paper. It focused onto the study of various kinds of solar water heaters that are recently known. The history of solar water heaters was briefly stated. That included a simple prototype from the year 1767 to the 1900s where many new techniques were invented. The audit of the writing on an altered solar water heater, broadly explored both systematically and exploratory by many researchers. A changed solar water heater framework is an incredible method to reduce energy cost related with heating water. An increment in effectiveness of the flow concentrated in correlation with existing solar water radiator that can be accomplished. Some changed solar water heating plan has been presented on the lookout and is all the more normally used in the tropical districts of agricultural nations. It concluded the study by various illustrations and mentioned number of solar water heaters till date.

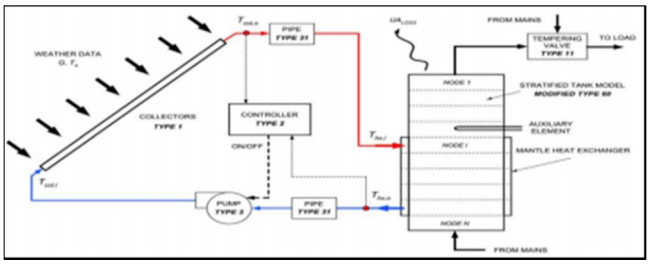

Fig.2: Typical Solar Water Heater [2]

A Carrillo Andre's et al [3] investigated the experiment on new TRNSYS model for solar domestic water heaters with a horizontal storage and a mantle heat exchanger. Some new features were added to the standard cost and a specific heat capacity of the fluid TRNSYS model Types 45 and 38. Heat transfer inside the tank was treated with a fixed node approach or a plug-flow approach, including all possible combinations of both approaches. The mantle heat exchanger was modeled by setting the heat balance between the nodes of a discretized external annulus and the storage tank. The resulting system was solved using the second order implicit method. Inlet mixing is granted by the definition of a mixing zone around the inlet. The storage tank model had its own time step, independent from the TRNSYS simulation time step. Fluids in the primary and secondary loops can be different (i.e., glycol–water and water). When the model-predicted energy delivered by the system was compared with experimental data results, those were quite good (less than 3% of error for daily energy). In terms of draw-off temperature, the model produced the distributed discharges remarkably but shown some discrepancies in large discharges. For the tails of discharges to be matched, one dimensional model must be improved. The study suggested, this model could be used to compute the energy delivered by the fixed system with good precision despite of the drawback. It can be concluded that it was better to select distributed discharge profiles, as in the European standard EN12976-2 because they promised a better representation of the real operation of the system and allow a better extrapolation of the annual system performance. On the contrary, local standards, such as those used in Andalusia, define large discharges. Those are more difficult to match with one dimensional model.

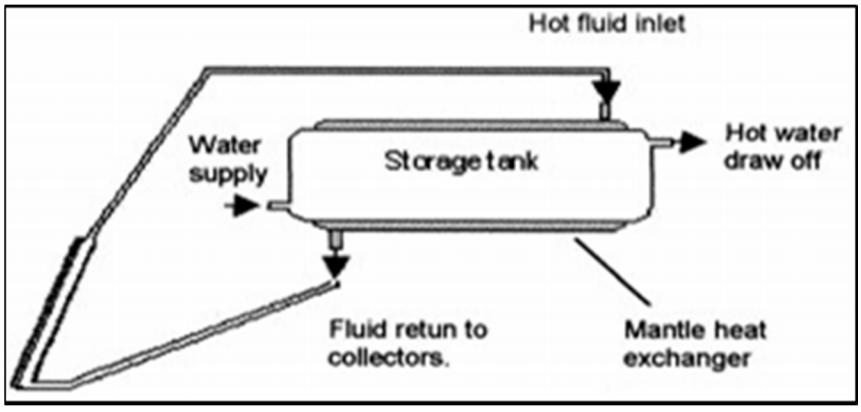

Fig.3: Scheme of a Thermosiphon Solar Water Heater with Horizontal Store and a Mantle Heat Exchanger [3]

Suneetha Racharla et al [4] have presented the Solar Tracking System as the best alternative to increase the efficiency of the photovoltaic panel. They gave the idea of earth's axis of rotation being tilted at an angle of around 23.45° and according to that types of tracking systems were presented that have developed for the past 20 years. Solar systems which track the changes within the sun's trajectory over the course of the day collect a far greater amount of solar power, and thus generate a significantly higher output power. It has been shown that these sun tracking systems are often broadly classified as single axis and dual axis, depending on their mode of rotation. Further, it can be classified as active and passive tracker depending on the actuator. The sub division and their basic principles of every method have been reviewed. The results confirm that the azimuth and altitude dual axis tracing system is more efficient. However, in cost and flexibility point of view, Single axis system is more feasible. In future the details would be useful in selecting an accurate and particular tracker with respect to region, available space and estimated cost. The work may be useful to improve the design characteristics of different types of solar tracking systems to improve performance.

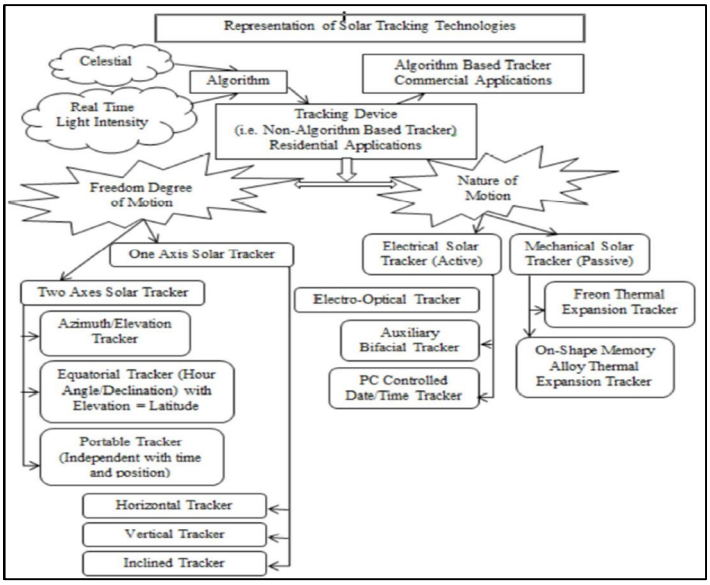

Fig.4: Solar Tracking Technologies [4]

Vishal G. Shelke et al [5] discussed the existing solar water heating systems with their applications. Solar water heating systems were classified as direct and indirect systems on the basis of direct heating of water. A secondary fluid such as a glycol/water mixture that is passed through some form of heat exchanger, such system was named as indirect system. Those were further classified under Active and Passive on the basis of mode of transfer of heat as active solar systems that use forced flow of fluid for convection while passive use natural convection. The active systems were classified as open loop and closed loop systems and thermosiphon type of system was explained under passive type of system. Along with this various shaped solar collector including flat plate collectors, evacuated tube and concentrating collectors were studied. Further the storage tank and heat transfer fluid to maximize the efficiency of the system were explained. The paper concluded that there is a need to work on the generated design procedure to select, install and monitor the solar water heating system as per the availability as in recent times they get installed using different arrangements.

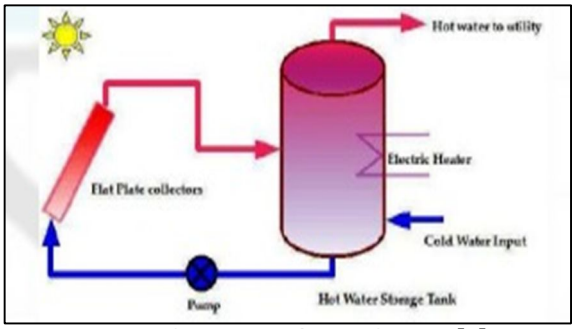

Fig 5.1: Open Loop Active System [5]

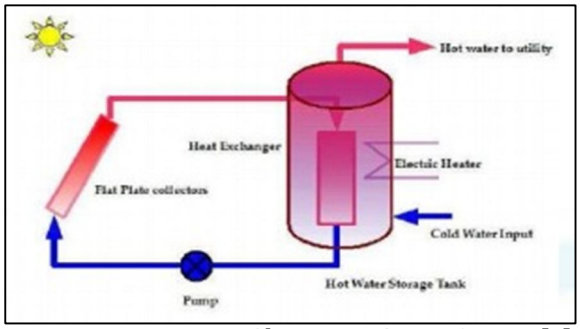

Fig.5.2: Close Loop Active System [5]

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K.K. Chong et al [6] talked about optical analysis, experimental study and cost analysis of the stationary V-trough solar water heater system. In this study, the novel stationary V-trough solar water heater with the maximum solar concentration ratio of 1.8 suns has been proposed to improve the thermal efficiency of the whole system. The advantages of the new proposal said were easy to be fabricated, cost effective and high thermal efficiency. The collected data has shown that the prototype has achieved the optical efficiency of 70.54% or 1.41 suns and the temperature of 85.9 0C. It concluded that the prototype could be easily constructed through DIY using off-the-shelf materials with total cost of RM 1489.40 and total payback period of 12.2 year for discounted form or 8.9 years for undiscounted.

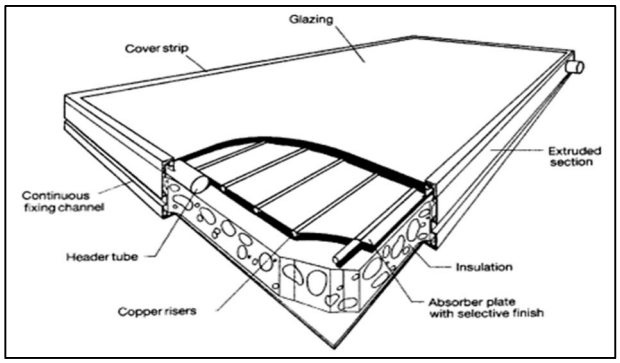

Fig. 6.1: Pictorial View of Flat Plate Collector [6]

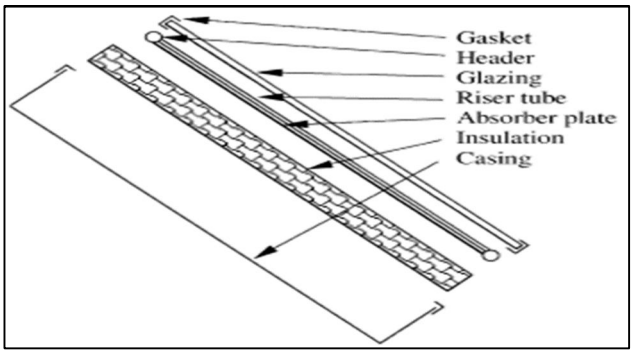

Fig. 6.2: Exploded View of Flat Plate Collector [6]

M. S. Mohanraj et al [7] reviewed on the test study that was conducted to examine the performance of the solar heating coil with tracking and without tracking. The aftereffects of trial demonstrated that on account of uncovering the solar heating coil to the sun for 20 minutes, the heating coil with two axes tracking increase the water temperature. Concepts of active or passive and single or dual axis solar trackers were briefly explained. In the same way two types of dual axis solar trackers were mentioned and demonstrated too. The reviewers enormously explained the construction of single axis tracker and dual axis tracker along with the components that will be used in the same. Further active, passive and chronological tracker systems and its working were also explained in short for better understanding. The comparison between circuit diagram and its modifications were found out by the working and components used.

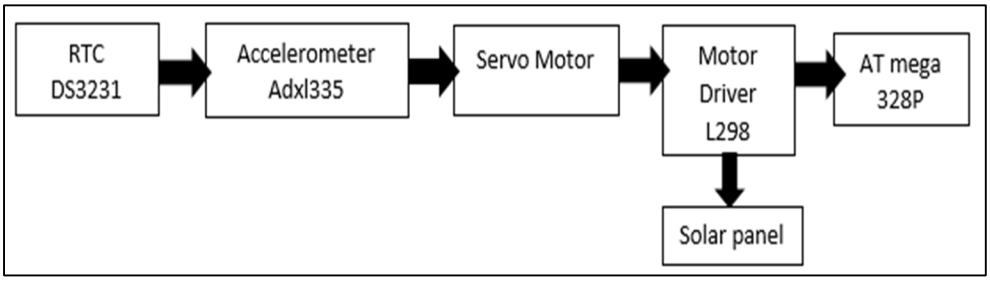

Fig.7: Proposed Assembly for Solar Tracking System [7]

P. Surendhar Selvam et al [8] presented the work of Efficient Solar tracking System using GPS. A brief idea about the conversion of solar energy using photovoltaic cells was given. The paper delivers a detailed description of the components being used such as Arduino UNO (ATmega328P AVR microcontroller having 20 digital input or output pin), Solar Panel (for converting the solar energy from the sun directly to electric energy by the use of the photovoltaic cells), Accelerometer (Adxl335), Real Time Clock (DS3231), Servo Motor (driven by Arduino) and Motor Driver (L298). The block diagram can be seen from the Fig 8. The software used was Arduino IDE (version 1.0.3) with the program written in C language. The system put forward had the solar panels mounted top of one another, being connected with servo motors which were controlled by the Arduino. The microcontroller records the time and date details from the Real Time Clock RTC as the tracking gets started. With the sunrise and sunset timings fed into the microcontroller, signals are forwarded to the motor for rotating the solar panels. It also has an actuator which when activated after the sun passing an angle, provides full exposure of the upper as well as lower panels at maximum position.

The whole setup resets to its original position when the sun gets set by the actuator. The outputs regarding direction of panel, Time allocation along with the tilt of panels and the result of the Global Positioning System co-ordinates shows the achievement of the tracking. It was concluded that efficiency is not much affected keeping the circuit quite simple.

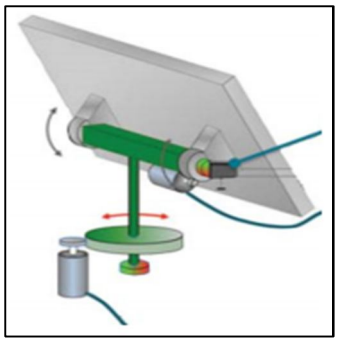

Fig 8. Block Diagram of Solar Tracking [8]

Divya Gnanarathinam et al [9] worked on the Design and Implementation of a Dual Axis Solar Tracking System. The paper called for the enhancement of the power gained by tracking the sun accurately. The system consists of Arduino with Atmega328P microcontroller (for controlling the Servo motor), LDR sensors (for detecting high intensity sunlight), Servo motor (for rotating solar panels) and Solar panels (for converting light energy to electric energy). As shown in Fig 9, two pairs of LDR (Light dependent resistors) track the sun's position. One of the pair tracks the sun in east-west direction whereas the other pair senses the sun in north-south direction. Arduino microcontroller being the main control unit directs the movement of motors in both vertical as well as horizontal axes. This model is set in such a manner, that if the sunlight does not fall perpendicular to the PV panel; the shadow covers one or two LDRs causing dissimilar intensity of lights received by the sensors. Thus, opted dual axis solar tracking for more efficiency as the time availability can be extended by monitoring the sun. They concluded their design being simple, cost effective and precise in tracking.

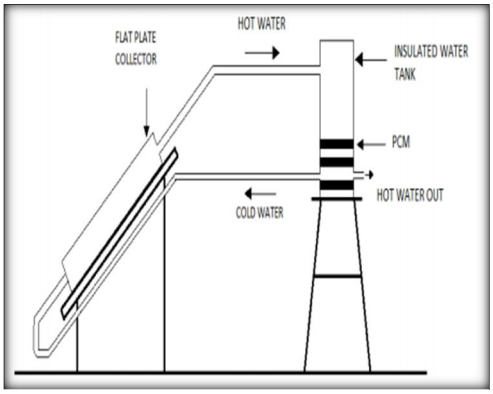

Fig. 9. Pair of LDR Sensors [9]

Manikandan. M et al [10] performed on the Design and Fabrication of Solar Water Heater with Phase Change Material and Concentrating Lens. The work focuses on the ability to store solar energy with the help of phase change material (PCM) and use that to heat water after a decrease in the temperature. The working principle of thermosiphon effect has been used in the project. Project setup was done as shown in Fig 10. The test was performed with a water tank capacity of 50 litres. The water passed through copper tubes and pipe get heated due to solar energy from the sun by convection heat transfer. The copper tubes were attached via the PVC pipe or the rubber hose pipes to the insulated plastic tank. The solar radiations were focused using concentrating lenses onto the copper sheet coated with black colour to absorb more energy. The PCM (sodium thiosulfate) placed inside of the water tank absorbed the excessive heat energy at the peak time which then melts and provides that at night. That aslo helps in maintaining constant temperature of the water. They carried out the experiment twice, one with PCM and one without PCM. The results proved that with the use of PCM in solar water heaters helped in reduction of water cooling rate, thus improving the efficiency of the system.

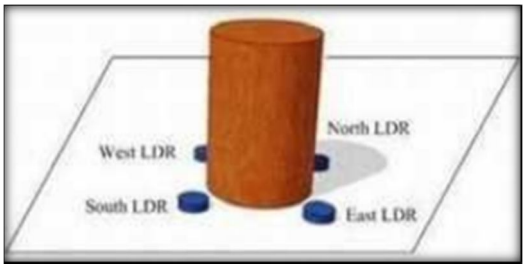

Fig 10: Outline of SWH with PCM [10]

III. CONCLUSION

The research papers above provide succinct information on solar energy and different possible alternatives of solar water heating. A brief idea about PV panels for solar tracking was given. The role of PCM material in heating and maintaining the water temperature was stated understanding the role of Thermosiphon effect, The TRNSYS model with heat exchanger, classifications and merits of collectors, advantages of spiral tube for water heating were studied. Detailed comparison of single and dual axis solar tracking and efficiency of flat tube collector were described. Where possible, explanations are done with the help of images, graphs and diagrams. Thus, it can be concluded from the above study that by experimenting numerous techniques, increased efficiency of the system can be achieved by arranging proper setup and ensuring no or less errors.

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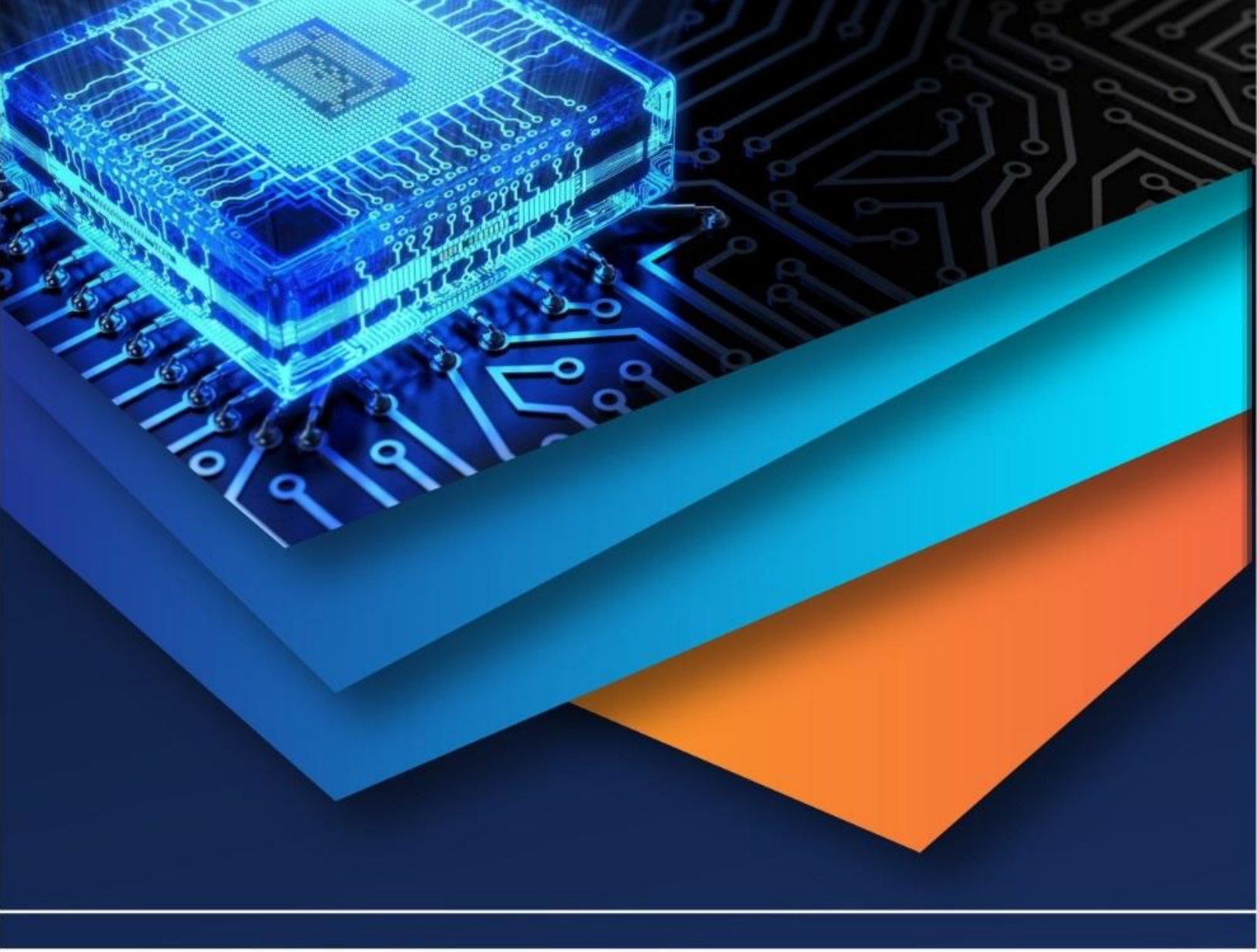

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