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Experimental Investigation of Stability of Solar Pond using PCM & TES

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Abstract: As technological advancements progress, the energy demands of communities see a corresponding rise. The fulfilment of this energy need is achieved by several energy sources often referred to as conventional energy sources, including coal, fossil fuels, geothermal energy, hydroelectric power, and nuclear energy. These energy sources possess certain drawbacks. The first trio of these energy sources have finite lifespans. The use of hydraulic energy as an energy source is deemed inadequate, whereas nuclear energy presents unresolved concerns pertaining to both environmental impact and safety. Consequently, the scholars have focused their investigations on novel forms of sustainable energy sources often referred to as renewable energy sources. Solar energy is classified as a kind of sustainable energy source. Solar energy refers to the electromagnetic radiation generated by the process of nuclear fusion occurring inside the innermost region of the sun. The sun is responsible for the majority of the heat and light that the Earth gets, hence supporting the existence of all living organisms.

I. INTRODUCTION

Several years ago, a solar pond system was developed and evaluated via an undergraduate project. The construction of the system included the utilization of ferrocement. However, many drawbacks were observed in the system, including insufficient insulation of the side walls, absence of measures to mitigate convection and radiation heat loss to the surrounding air from the top surface, and a limited lifespan of the absorber surface covering. The primary aim of this study is to enhance the performance of the solar pond by addressing the aforementioned constraints and conducting a comparative analysis with its predecessor. In this study, a series of measures were undertaken to account for several aspects that influence the performance of solar ponds, including water turbidity, bottom reflectivity, and heat insulation, among others. To enhance the thermal capacity of the absorber surface, a novel coating with improved durability was used, surpassing the performance of the coating utilised in prior research. There are now two distinct kinds of coatings that are readily accessible on the market: epoxy coating and synthetic enamel paint with a matte finish. The first option has superior qualities, but at a disproportionately high cost. The latter refers to a specific form of cement paint that has exceptional adhesive properties. The product is offered in two distinct finishes, namely glossy and matte, and is capable of adhering to all sorts of primers [4]. In order to mitigate water turbidity, convection, and radiation heat loss to the surrounding air, a transparent cover was used to enhance the effectiveness of the pond

II. LITERATURE REVIEW

Mohammad Reza Assari, Hassan Basirat Tabrizi, Alireza Jafar Gholi Beik carry out an experiment to examine the impact of incorporating phase change material (PCM) into a tiny salinity-gradient solar pond on its performance.[1] In this experiment, the process of extracting heat from the ponds was conducted in the Local Climate Zone (LCZ) on July 24th. The temperature of the incoming water was maintained at a constant value of 350C while it passed through a water storage tank and a pump discharge rate of 68 mL/s (equivalent to 67.7 g/s). The density of the substance, denoted as q, is measured to be 995.7 kg/m3 at a temperature of 30°C, as seen in Figure 2.1. Regarding the pond, In the absence of phase change material (PCM) during the first stages of the extraction process, the liquid chromatography zone (LCZ) and the exit. The water temperatures recorded were 62 °C and 50 °C, respectively. Following a duration of 20 minutes, the temperature of the LCZ experienced a decline to 58°C, while the output water temperature concurrently attained a value of 45°C. Nevertheless, In the case of the pond using phase change material (PCM), the initial temperature of the liquid cooling zone (LCZ) was recorded at 58°C and stayed consistent throughout the duration of the experiment, but the temperature of the water at the exit varied. A. Ramalingam and S. Arumugam conducted both experimental and theoretical studies on the variations in the specific heat capacity of NaCl salt solution at various temperatures and concentrations. It has been seen that sodium chloride (NaCl) solution is often used in the heat storage zone (HSZ) of salt gradient solar ponds (SGSP).

The concentrations of this solution typically range from 20% to 25% (weight percentage). Its primary purpose is to facilitate the capture and storage of solar energy, which may later be retrieved as thermal energy. A range of NaCl solutions, varying in concentration from 25% to 0%, have been used to establish a salinity gradient known as the non-convecting zone (NCZ). These NCZs are layered above the high-salinity zone (HSZ) inside a salinity gradient solar pond (SGSP). The less dense layer is positioned over the heavier layer by maintaining their relative positions. The primary objective of establishing a salinity gradient is to mitigate convective heat loss from the Heat Storage Zone (HSZ) by inhibiting convection resulting from solar heating. They have derived a best-fit relationship for estimating the specific heat capacity that is suitable for SGSP (solar-generated steam production) applications. This relationship is specifically applicable to NaCl brine with concentrations ranging from 20% to 26% and temperatures ranging from 57°C to 75°C. The concentration and temperature ranges mentioned are typically found in the brine environment of the heat storage zone in any SGSP.

III.METHODOLOGY

In this section, we outline the methodology employed in the project, "Enhancing Solar Pond Performance Through Innovative Design and Advanced Thermal Energy Management." The methodology encompasses the steps and procedures undertaken to construct, modify, and evaluate the solar pond system, focusing on improvements in energy efficiency and temperature stability.

1) Review of the literature: ¬ Start by undertaking a thorough literature analysis to comprehend the most recent pond technology, and earlier studies concerning solar pond adjustments. ¬ Identify the main conclusions, problems, and gaps in the literature.
2) Construction and Modification of a Solar Pond: ¬ Create a solar pond in accordance with the project requirements. Install the transparent cover, install cork sheet insulation for the side walls, and apply the specific absorber surface coating. ¬ These are the three adjustments that have been identified. ¬ Ensure accurate measurement and recording of adjustments.
3) Setup for the Experiment: ¬ Install data collection systems, such as temperature sensors, data loggers, and monitoring tools, to gather pertinent information. ¬ Set up a data gathering routine and make sure the solar pond is consistently being watched.
4) Integration of Thermal Energy Storage (TES) ¬ Create and include a TES system specifically for the solar pond configuration. ¬ Implement TES system-wide thermal energy storage and release methods. ¬ Monitoring and data gathering on the TES system's performance in combination with the solar pond.
5) Integration of Phase Change Material (PCM): ¬ Create and incorporate a PCM system into the solar pond configuration. ¬ To improve temperature stability, make sure PCMs are chosen and installed properly. ¬ Gather information on how the solar pond's temperature profiles are affected by PCM integration.
6) Gathering and analysing data ¬ Gather temperature and environmental data over a prolonged period of time, taking into account changes in solar radiation, the surrounding air's temperature, and the wind's speed. ¬ Analyse the data gathered to determine how changes, TES, and PCM will affect the operation of the solar pond, temperature stability, and energy use.
7) Performance Assessment: ¬ Compare the performance of the solar pond system to baseline data and findings from earlier studies. ¬ Improved energy production, efficiency, and temperature stability should all be quantified.
8) Evaluation of Long-Term Performance: ¬ Extend the project's lifespan to evaluate the solar pond system's long-term performance in a variety of seasonal and environmental circumstances. ¬ Observe and note any changes in the system's behaviour over time.
9) Data analysis and reporting: ¬ Analyse the results after interpreting the data that was obtained. ¬ Create thorough reports and graphical summaries of the findings, such as graphs, charts, and tables. ¬ Determine new information, patterns, and opportunities for development.
10) Final results and conclusion: ¬ Summarize the project's results, emphasising how the improvements, TES, and PCM improved the performance of the solar pond. ¬ Offer conclusions for enhancing the architecture of solar ponds and increasing energy efficiency. ¬ Describe how the study's conclusions affect solar energy applications.
11) Presentation and supporting materials: ¬ Keep complete records of the project's design blueprints, equipment specs, and experimental techniques. ¬ Create a thorough project report and presentation for sharing the outcomes.
12) Future Development and Research: ¬ Provide directions for further study, such as investigating new materials for PCM, improving TES integration, and determining the viability of the modified solar pond economically. ¬ Through lectures, conferences, or cooperation with specialists in the subject, seek peer evaluation and validation of the project's methods and conclusions.

13) Project Verdict: ¬ Give a brief summary of the project's general findings, the lessons gained, and how they will advance solar pond technology and sustainable energy systems.

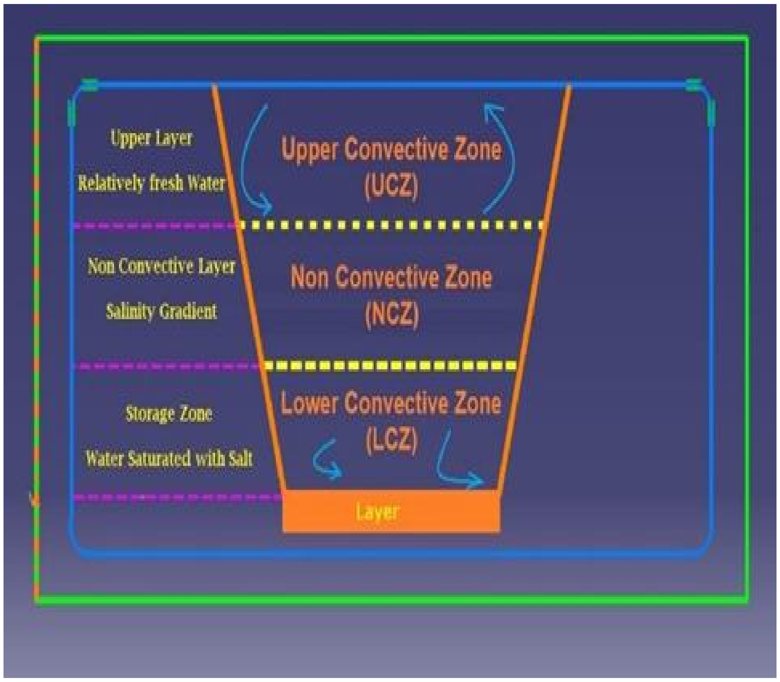

FIG. 1-SOLAR POND

IV. DESIGN AND CALCULATION

Assuming very small-scale pasteurizer which pasteurize 15litre milk on daily basis, temp require for this process in the range of m 4℃ to 62℃.

Hence heat required this process

$q = m * Cp * \Delta T$

$q = 15kg * 3950\ J/kg℃ * 58℃$

$q = 3.4365\ MJ$

$q = 0.9545 kWhperday$

In general effectiveness of heat exchanger is in between 0.3 to 0.9 considering total 40% het loss in heat exchanger

$Q = q + q(0.40)$

$Q = 0.9545 + 0.9545(0.30)$

$Q = 1.2408 kWhperday$

Now the area of pond as follows

$Area\ of\ Pond = Heat\ required/Heat\ available$

Heat available is equal to solar radiation entering pond which is equal to 1020.6005

$Area\ of\ Pond = 1.2408/1.020$

Area of pond =1.2168m2

Hence area of pond required for lower convective zone approximately 1.4 m2

Hence volume of pond is equal to 1.68m

A solar pond was fabricated a few years ago as an undergraduate project in the Mechanical Engineering Department. The earlier research had certain drawbacks. It was not equipped to stop the radiation and convectional heat loss from the upper surface. The performance of the solar pond was improved in the current work by taking a few measures and comparing them to the earlier work. To reduce heat loss from the top surface of the pond, a transparent cover was used.

Better insulation was also used for the side walls, and a specific kind of coating was placed on the absorber surface of the pond system.

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V. RESULT AND DISCUSSION

TABLE I
Without PCM and TES

TABLE 7.1: ENERGY STORE IN SOLAR POND WITHOUT PCM AND TES

Days	Energy store Solar pond $Q=m.C_P.(T_{LCZ}-T_A)$
01-06-2022	105.17
02-06-2022	112.30
03-06-2022	99.49
04-06-2022	121.13
05-06-2022	110.43

With TES
TABLE 7.2: Energy store in Solar pond With TES

Days	Energy store Solar pond $Q=m.C_P.(T_{LCZ}-T_A)$
06-06-2022	174.66
07-06-2022	185.19
08-06-2022	178.95
09-06-2022	178.95
10-06-2022	189.48

With PCM
TABLE 7.3: Energy store in Solar pond With PCM

Days	Energy store Solar pond $Q=m.C_P.(T_{LCZ}-T_A)$
11-06-2022	169.88
12-06-2022	147.43
13-06-2022	146.87
14-06-2022	155.26
15-06-2022	168.63

Overall result of LCZ temperature
TABLE 7.4: Overall result of LCZ temperature

Days	Without TES & PCM	TES	PCM
1	49.18	57.21	53.52
2	49.71	58.23	52.78
3	47.36	58.33	54.2
4	50.92	58.33	54.41
5	50.44	57.36	54.34
AVG.	49.522	57.892	53.85

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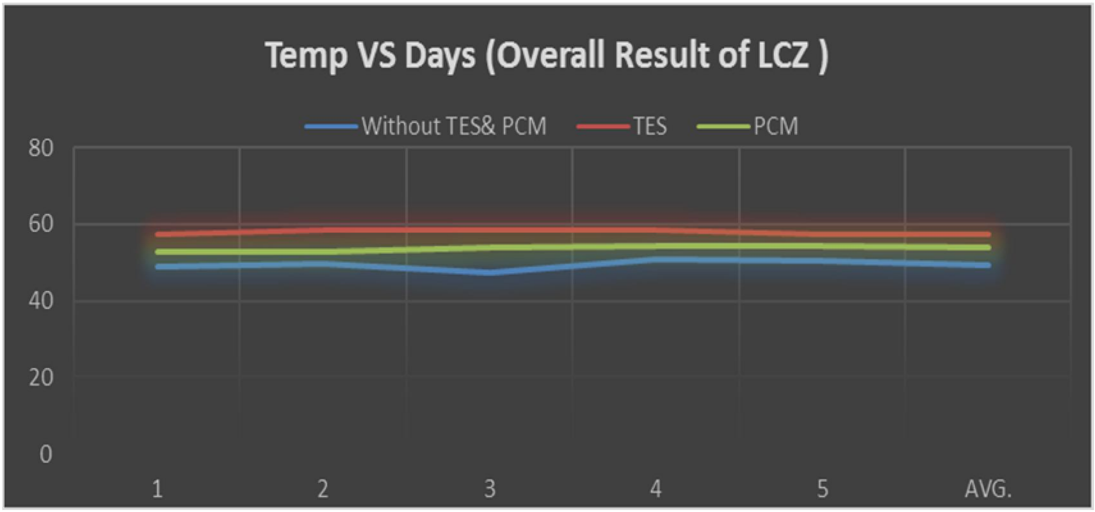

Comparison of LCZ temperature of solar pond at different conditions

Following tables illustrate the temperature changes for three separate zones for made-up solar pond models. While alterations in solar radiation were seen between 830 and 970 W/m2 , variations in ambient temperature were seen between 30 to 40°C. The readings were taken from 9:00 a.m. to 6:00 p.m. at regular intervals of one hour and shown on the average basis values of ambient conditions for the specific day as part of all the experiments for performance evaluation of the solar pond model in the climatic conditions of Jalgaon (425001). A solar pond model's thermal performance has been studied. The performance testing is carried out in the month of June 2022. According to, dated March 6, 2022, the temperatures exhibit a marginal increase in comparison to the first day. Temperature rises are seen in all zones. The LCZ experiences its peak temperature around 2:00 PM, reaching a maximum of 57.4°C. The mean temperatures recorded in the UCZ, NCZ, and LCZ are 33.28°C, 36.3°C, and 47.36°C, respectively. According to, dated April 6, 2022, the temperatures recorded at 9:00 AM exhibit a resemblance to those seen on preceding days. The temperatures in urban and rural areas see a notable increase during the course of the day. The LCZ has the maximum recorded temperature of 60°C at 2:00 PM. The mean temperatures recorded are as follows: UCZ (Urban Core Zone) with an average temperature of 33.23°C, NCZ (Neighbouring Core Zone) with an average temperature of 35.76°C, and LCZ (Peripheral Core Zone) with an average temperature of 50.92°C. May 6, 2022, the temperatures observed at 9:00 a.m. exhibit variation across different zones. The temperatures in UCZ and NCZ see a dramatic increase during the course of the day. The LCZ has the maximum recorded temperature of 60.4°C at 2:00 PM. The mean temperatures for UCZ, NCZ, and LCZ are 34.23°C, 35.67°C, and 50.44°C, respectively. Across general, temperatures tend to rise during the day across all geographical regions. The LCZ has a propensity for experiencing elevated temperatures, which may be attributed to its relatively lower elevation, facilitating the accumulation of heat. The temperatures in UCZ and NCZ see an increase, but to a lesser extent compared to the more pronounced rise observed in LCZ. There is observable variability in average temperatures throughout different days and geographical zones. In results, the data presented in this study illustrates the fluctuations in temperature seen throughout several zones inside a solar pond over a span of numerous days. The temperature patterns seen in the pond are controlled by several variables, including sun radiation, heat buildup, and heat transport processes. It is essential to acknowledge that the present research only covers a limited duration, hence necessitating a more extensive investigation to ascertain long-term patterns and identify particular components that contribute to temperature changes. Furthermore, the lack of thermal energy storage (TES) and phase change materials (PCM) might potentially result in decreased effectiveness in the storage and transport of heat inside the solar pond.

VI. CONCLUSIONS

Solar pond was constructed in which three modifications were made. Transparent cover was placed over the system, cork sheet was used as insulator for the side walls and special type of absorber surface coating was used. The present work shows better output than the previous work. In the previous work, minimum temperature obtained at the LCZ was 30oC whereas the maximum temperature obtained in the present work is 70.2oC. Temperature difference between UCZ and LCZ was 6oC in the previous work where 27oC temperature difference between UCZ and LCZ was obtained in the present work. Increased lifetime of the solar pond is expected because of insulation provided at the bottom and absorber coating used are of better quality.

The "Design, Fabrication, and Experimental Investigation for Stability of Solar Ponds Using TES and PCM" project provides important insights into the dynamic interaction between thermal energy storage (TES) and phase change materials (PCM) inside a solar pond system. The five-day temperature data collection indicates unique trends: the integration of TES leads to higher average temperatures, highlighting its effectiveness in successfully storing and releasing thermal energy. In contrast, the presence of PCM causes temperatures to drop because the substance absorbs heat while going through a phase transition. These results show that TES and PCM have the potential to have a major impact on temperature stability and energy management in solar pond systems. The results of the experiment highlight the significance of thoughtful design decisions when attempting to improve temperature management and energy use in solar thermal applications. Further investigation into the solar pond's deeper levels and an examination of the system's long-term performance under various environmental factors may lead to more effective design methods and increased energy efficiency.

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REFERENCES

[1] Mohammad Reza Assari, Hassan Basirat Tabrizi, Alireza Jafar Gholi Beik.: “Experimental studies on the effect of using phase change material in salinity-gradient solar pond”, Solar Energy 122, 204–214, (2015).

[2] A. Ramalingam, S. Arumugam.: “Experimental Study on Specific Heat of Hot Brine for Salt Gradient Solar Pond Application”, International Journal of ChemTech Research, Volume 4, Issue 3, 956-961, JulySept 2012.

[3] Karakavalasa Goutham, Chukka Siva Krishna.: “Solar Pond Technology”, International Journal of Engineering Research and General Science, Volume 1, Issue 2, December 2013.

[4] Abhishek Saxena, Varun Goel.: “A Technical Note on Fabrication and Thermal Performance Studies of a Solar Pond Model”, Journal of Renewable Energy, (2013).

[5] Huanmin Lu, John C. Walton, Andrew H.P. Swift.: “Desalination coupled with salinity-gradient solar ponds”, Elsevier (Desalination) 136, 13-23, (2001).

[6] J. Wang, J. Seyed-Yagoobi.: “Effect of Water Turbidity on Thermal Performance of a Salt-Gradient Solar Pond”, Solar Energy, Volume 54, Issue No. 5, 301-308, (1995).

[7] Nuri Ozek, Mehmet Karakilcik, Nalan Cicek Bezir.: “A Solar Pond Model with Insulated and Glass Covered Surface (IGCSP)”, Bulgarian Journal of Physics 27, Issue No. 4, 67-70, (2000).

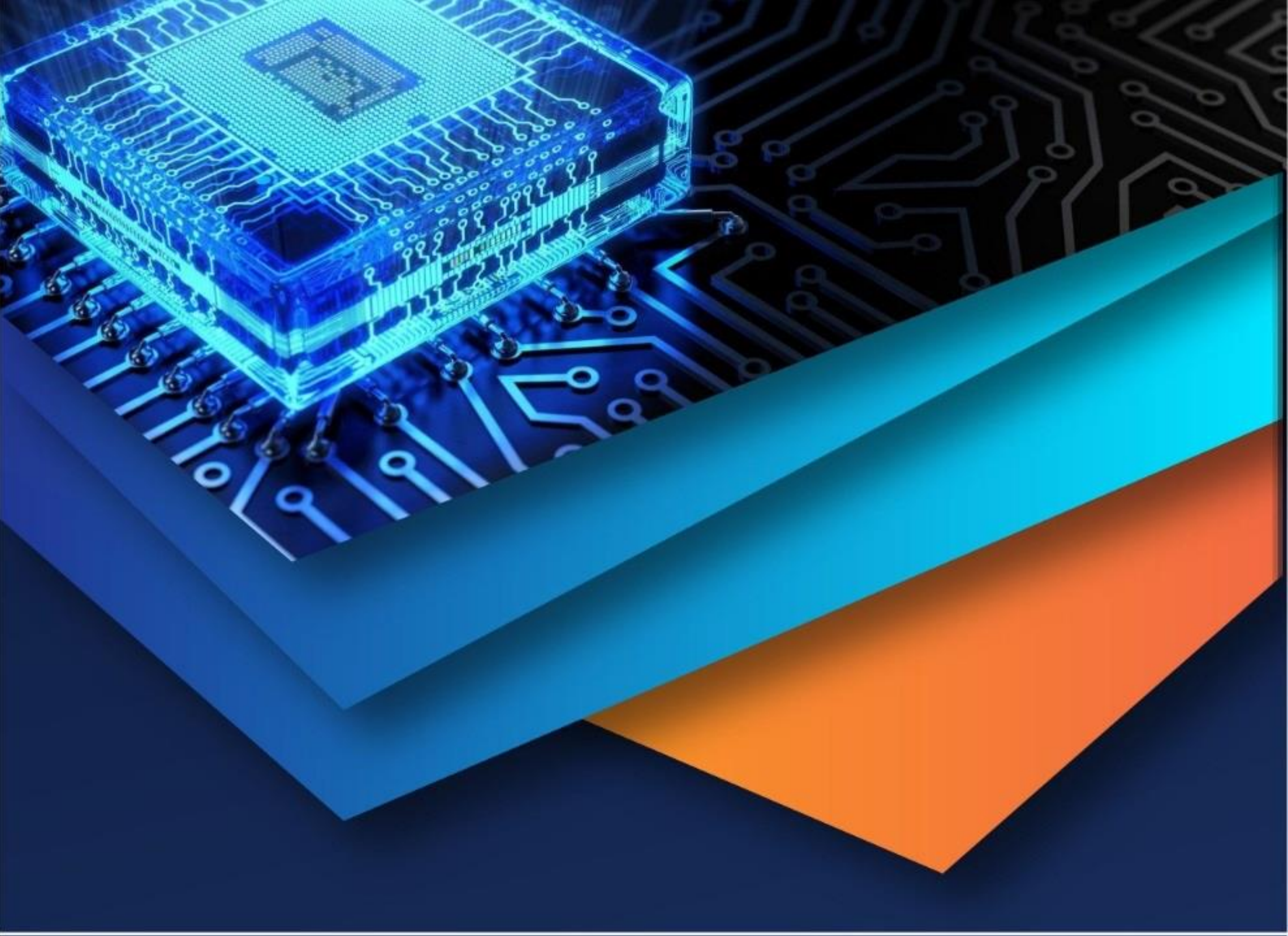
[8] Muhammad Tawalbeh, Rana Muhammad Nauman Javed, Amani Al-Othman.: “Fares Almomani Salinity gradient solar ponds hybrid systems for power generation and water desalination”, Energy Conversion and Management, Volume 289, 1 August 2023.

[9] Rudhrala Sivaprasad, B. Srinivasarao.: “Experimental Investigation of Solar Pond Integrated with PCM Storage”, International Journal of Innovative Research in Technology, Volume 5, Issue 1, 208-212, June 2018.

[10] G.R. Ramakrishna Murthy, K.P. Pandey.: “Solar Ponds- A Perspective from Indian Agriculture”, Department of Agricultural and Food Engineering, Indian Institute of Technology, Kharagpur-721302, India.

[11] Velmurugan V, Srithar K.; “Prospects and scopes of solar pond: A detailed review”, Renew Sustain Energy Rev (2007). [

[12] Er. R. K. Rajput, Heat and Mass Transfer, Sixth Edition 2015, S. Chand Publication, New Delhi



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