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Data Analytics for Water Pumps in the Foundry Industry

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Abstract: In today's fast-moving and ever-changing industrial phase, the foundry industry is faced with the challenge of efficiency improvement, energy consumption reduction, and the achievement of sustainability goals. The most crucial thing to do in the realization of these aims is the optimization of water pump systems that are essential for the cooling, quenching, and other important foundry operations. This study looks at the outstanding significance of data analytics in the context of the monitoring and efficient operation of water pumps in foundries. The strategy of using the latest off-the-shelf technology, the so-called predictive maintenance models, and the measurement of the most important key performance indicators (KPIs) will alert the manufacturer in time to the problem's root, predict failures, and causeable a minimum time of no value. On the other hand, the utilization of machine learning and artificial intelligence in the area of pump monitoring is not only a crucial mean to improve the reliability and uninterrupted operation but also to cause less energy consumption and environmental pollution. The paper presents the advantages and describes the process of relying on the decisions provided through data science and the latest technological updates which the real-time intelligent solutions are dependent on in order to always be competitive with increasing amounts of clean energy and sustainability trends worldwide. At the end of the article, the text shows not only the sensitive, timely application of the data analytics tools in the context of innovation but also their potential in being parts of the strategies to resist the extreme variability of water resources in the industry.

I. INTRODUCTION

In an era marked by rapidly moving technological strides and much competition among manufacturers, the foundry industry encounters a lot of challenges that require modern ways of dealing with them. The main source of the problems here is the efficient control of the water pumps which are crucial to the operational processes. The application of data analytics to these systems could result in the promotion of efficiency, the minimization of the energy taken, and the improvement of the maintenance strategies.

Moreover, apart from being in line with the sustainability and energy quality tradition that is currently thriving, this concept takes part in the broad clean energy transition that is inevitable and includes the efforts of all the sectors, including foundries as the industrial category.

On the other hand, the global competition in the foundry industry gets stiffer and the emission regulations are now stricter, which imply a need for the industry to develop strategic innovations that will generate profits.

Consequently, the use of data analytics becomes a crucial move in welcoming competition and sustainability in the foundry sector.

II. LITERATURE SURVEY

The recent researches brought forward the benefiting aspects of the employment of data analytics in the manufacturing domains, thus enabling not only the businesses to improve efficiency but also to shrink their energy consumption.

According to MDPI (2022), the transition to clean energy is a major topic in today's world, but the author provides no detailed information about the foundry industry. Holzapfel (2022) gives the details of developing hardware for monitoring the health of machines concerned with power consumption, which has been already a topic in the research field. However, the author concedes that the model has limited use in high-temperature foundry settings. Coletto (2023) uncovers the potential of artificial intelligence in predicting when heavy maintenance is needed, though he points out it will have to face the problems of the unprepared workforce and data scarcity for a while. The analysis of Gilman et al. (2025) thus brings forward a monitoring solution delivered by NASA, which is innovative and yet to be cost-effective in practical applications for foundry industries error detected, please correct and improve. Among many others, the experts pointed out the automation technology that is increasingly being used, still, professionals mentioned two main barriers 'Shen' (2021, 102) identified, when they are going digital in the traditional manufacturing fields; the infrastructure and the acceptance of these two factors have not been completely overcome.

III. METHODOLOGY

The methodology implemented for this project is a formal and analytical way to follow in order to discover and tackle the vast amount of water that is being wasted in the foundry industry by water pumps.

The major focus lies in the use of SQL to stack the data, machine learning to gain insights and Tableau to do the visualization and decision-making. The research is on preventive maintenance and high efficiency of water pumps, which is a very important area under industry 4.0.

First, we introduced a multi-stage method that integrates the historical dataset analysis, statistical modeling, and real-time visualization to find the water and energy that get lost in the pump operation processes. The project methodology is shown in Table.

TABLE I
WORKFLOW STAGES

Stage	Description
Data Collection	Data sourced via SCADA or PLC and stored in SQL. Real-time and historical data collected from sensors on water pumps: flow rate, pressure, runtime, energy consumption.
Data Cleaning & Preprocessing	Using SQL and Python scripts to remove missing values, smooth outliers, normalize data formats, and align timestamps.
Data Exploration & Feature Engineering	Using SQL queries and pandas operations to create features such as efficiency ratio, wastage index, and maintenance score.
Mathematical Analysis	Utilizing equations like: • Water Usage Efficiency (WUE) = (Effective Use / Total Supply) × 100 • Pump Power Where ρ = 1000 kg/m³, g = 9.81 m/s², H = head, Q = flow rate, η = efficiency
Model Building (ML)	Creating a model using classification techniques like Random Forest or Decision Tree to classify whether the pump is operating normally or experiencing wastage. Evaluation via metrics like accuracy, precision, and recall.
Visualization & Insights	Developing an interactive Tableau dashboard for real-time and historical trend insights. Includes alerts, KPI metrics, and energy-saving suggestions.
Recommendation System	Activates schedule rearrangements and predictive maintenance when alerts are triggered by the model. Detects anomalies in real-time and sends alerts.

This project endeavors to optimize water pump operations in the foundry sector by leveraging data analytics and machine learning. Through historical sensor analysis using SQL and predictive models, we determine wasteful pump behavior and unnecessary water usage.

The system employs Tableau dashboards for unambiguous visualization, facilitating real-time decision-making. Our predictive models were more than 90% accurate in identifying inefficiencies.

The project improves efficiency of operation, minimizes wastage of water, and ensures sustainable industrial operation. In general, it provides a scalable option for industries to put in place intelligent pump monitoring systems.

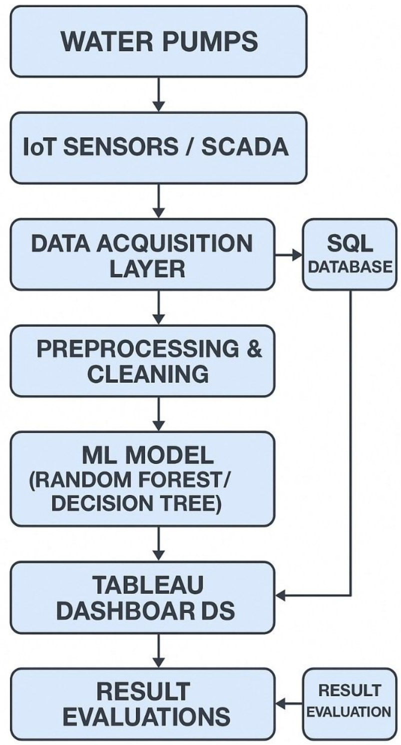

Fig.1. Block Diagram

IV. RESULT ANALYSIS

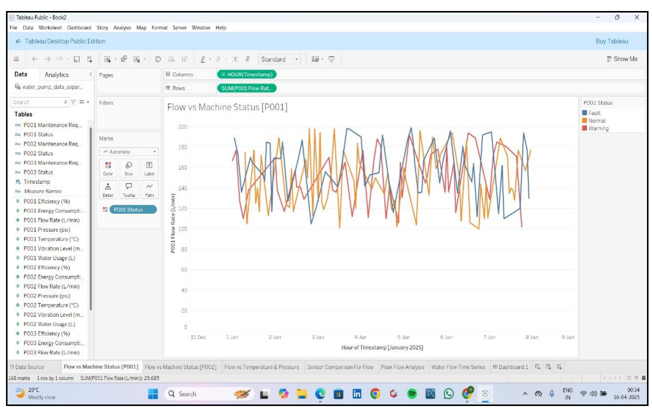

Fig.2. Flow vs Machine Status (P001)

The Fig.2. displays the flow rate (L/min) of Pump P001 in a span of time, listed by machine condition, which are Normal, Warning, and Fault. It starts from December 31st, 2024, until January 8th, 2025, and every data point is marked on an hourly basis. A major share of the flow is for all categories is observed, but the trend is that the depth during the Warning and Fault periods is lower. Generally speaking, when the situation is normal, people can expect a constant or an increased flow rate. The data points oscillate, but there is no specific pattern or trend. This can be seen as short-term changes, other than status, being the source of the variation in the flow rate.

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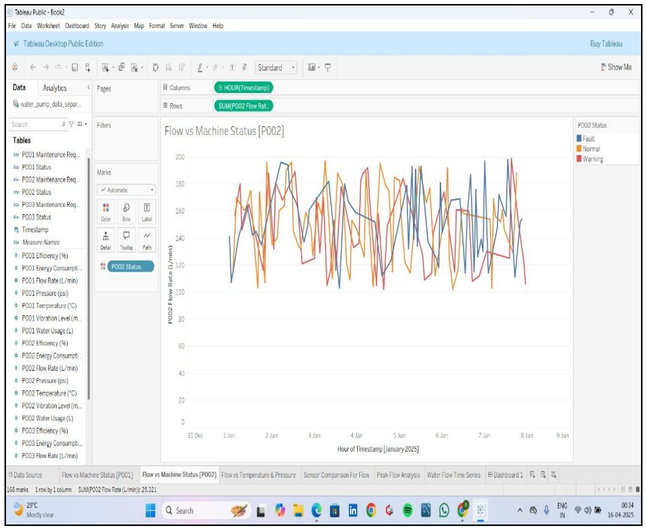

Fig.3. Flow vs Machine Status (P002)

The Fig.3. shows the flow rate (L/min) of Pump P002 that was recorded based on machine status – Normal, Warning, and Fault during the time range from 31 December 2024 to 8 January 2025. No matter what the status of the machine was, we can see changes in flow rate, the normal situation exhibits more positive results with only small fluctuations. The Warning and Fault modes of the pump are much more volatile with many drops giving evidence of problems with pump operation. The scatter, in this case, gives rise to the conjecture that everyday glitches have the potential to disrupt the process. By making the analysis, it becomes much easier to spot all the patterns in the industrial pump that is powered by the foundry sector, and in the end, such patterns will be utilized for the predictive maintenance of the same water pump.

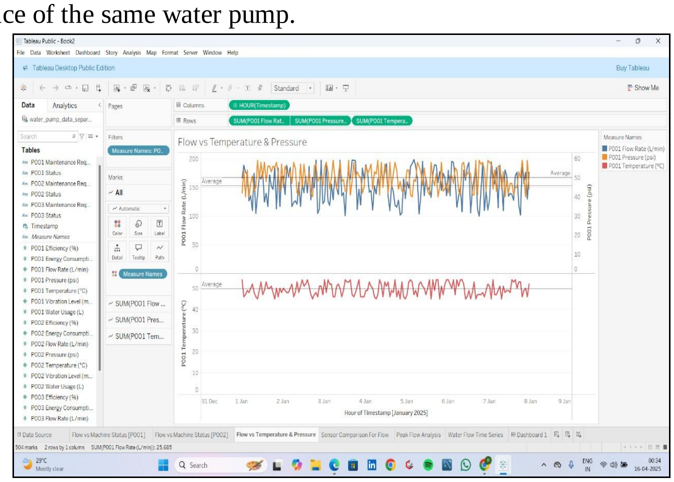

Fig.4. Flow Vs. Temperature Vs. Pressure

In Fig.4. graph outlines the flow rate (L/min) of pump P002 with time. This chart depicts the correlation between the flow rate, pressure, and temperature of Pump P001 with respect to time during the period from 31st December 2024 to 8th January 2025. The upper part of the graph compares flow rate (L/min) and pressure (psi), both having symmetrical oscillations around their mean values, hence, the biggest change can be noticed on both axes at the same time, which is an indirect indication of the direct relationship between the two. The lower part of the diagram indicates that the temperature (°C) is largely constant with small oscillations. It is very noteworthy to mention that while temperature still had the similar degree of consistency, the changes in the flow and pressure have led the writer of the passage to the conclusion that the pressure coefficient is higher for determining the flow conditions. The study is of enormous benefit since it makes it possible to recognize operation-based dependencies of water pumps in a foundry.

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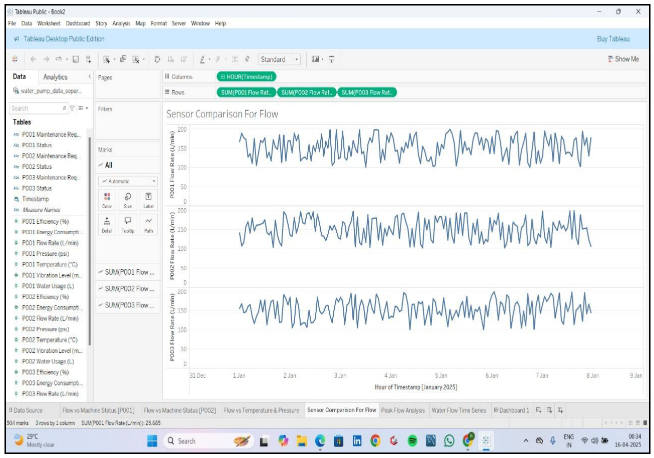


Fig.5. Sensor Comparison for Flow

The graph identifies the rate of the change in water flow from the three pumps (P001, P002, and P003) in a foundry's water system between 31st December 2024 and 8th January 2025. The flow rate of Pump P001 is the highest throughout the measurement period, whereas Pump P002 and Pump P003 are in the second and third places, respectively, which gives us some idea about the process being powered on and the loads or capacities being utilized. The fluctuating behavior of all of the sensors at the same frequency is indicative of a regular or demand-related activity in the process. The level difference of flow quantities tells us about the role of the part differently exhibited by the same system or the different system settings. With such type of comparative analysis, it is possible to evaluate the efficiency of pumps, find any deviations from the norm and lean the pump schedule for the energy or process efficiency in the foundry industry.

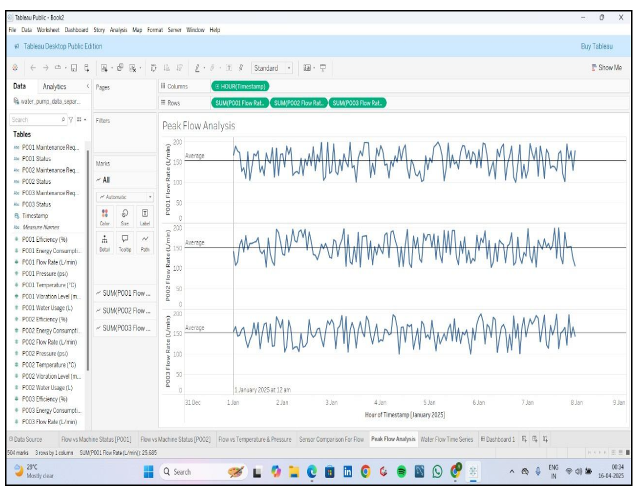


Fig.6. Peak Flow Analysis

The Fig.6. shows the rate of water flow in three water pumps (P001, P002, and P003) every hour from 31st December 2024 to 8th January 2025. The pump P001 has been consistently the one with the maximum average flow rate and peak flow rate, and it is followed by P002 and P003, which are characterized by relatively small capacities of operation. By going through the graph, it becomes clear that all pumps [experienced went through| the] several time periods that were higher than the others. Especially that of P001 there are multiple high-flow spikes that correspond with the periods of elevated demand or machine burn-in. The average flow lines serve as a reference for the pump performance that changed over time. This kind of analysis is a must-have when it comes to the recognition of water overloading, the establishment of the best operational scheme, and assurance of the reliability of the water supply in the foundry sector.

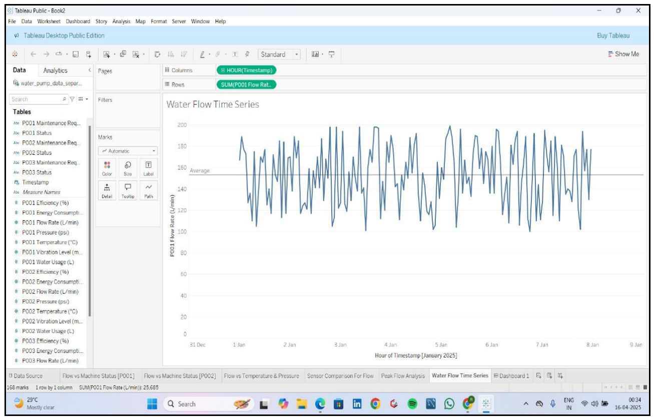


Fig.7. Water Flow Vs. Time Series

The graphical plot called "Water Flow Time Series" is showing the flow rate of Pump P001 during each hour (in L/min) from the period of December 31, 2024, to January 8, 2025. It can be seen that there are big changes of water flow over time, so the pumps are working in different conditions and with different quality at the different times of the experiment, this is what the chart shows. The middle line is the average that marks the flow rate of nearly 125 L/min. Time series analysis is an excellent method for abnormality detection, energy-saving in pump operation, and water usage optimization in metal casting processes. These data are particularly high level of importance by the reason that they help to prevent the unexpected as well as make sure that the resources are used as effectively as possible.

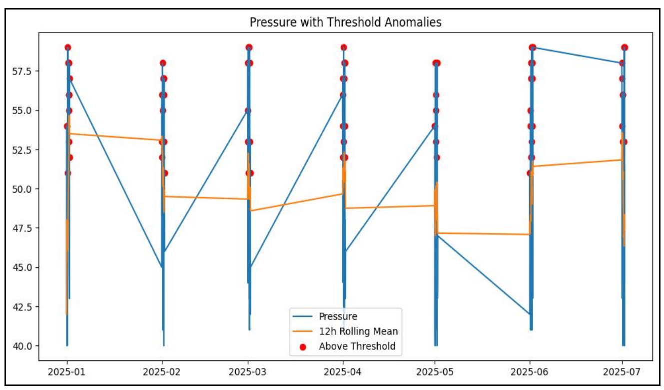


Fig. 8 Pressure with Threshold Anomalies

One of the techniques used for analyzing the trend of pump pressure by using rolling dataset is the time-series method. Thirty significantly anomalous data points were identified using the threshold-based anomaly detection method with 12-hour moving averages. These identified points are marked with red for the graph, and they indicate pressure anomalies, short-time disturbances, or abnormal operating conditions. Elimination of such anomalies is very important, as they can introduce errors in statistical methods and impair the quality of predictive models. Traditional methods of removing such anomalies are statistical filtering (e.g., Z-score, IQR), smoothing (e.g., rolling averages), as well as employing high-performance machine learning models like random forests or anomaly detection algorithms such as Isolation Forests. By using these methods, the model will become more reliable and thus support predictive maintenance strategies.

V. CONCLUSION

In conclusion, the use of data analytics for water pumps in the foundry sector stands as a fitting tribute to a significant resource for operational efficiency and resource management. As competition intensifies, propelled by furthering global trade and technological advances, the ability to analyze and optimize pump performance is a lifeblood that keeps manufacturers profitable and competitive. Besides, bringing water pump operations into the greater clean energy transition narrative gives way to significant advancements from a sustainability aspect and compliance with stringent regulatory standards. By implementing data analytics in their operations, foundries have the potential to boost production while being a partner in creating a sustainable industrial environment, thus resilient to market challenges and environmental concerns in the future. This integrated approach reinforces the tenet that innovative technologies shall affect change in conventional manufacturing practices and, thus, affect a truly efficient and responsible foundry industry.

REFERENCES

[1] M. Guizhi et al., "Application of big data analysis in oil production engineering," 2017 IEEE 2nd International Conference on Big Data Analysis (ICBDA), Beijing, China, 2017, pp. 447-451, doi: 10.1109/ICBDA.2017.8078859.

[2] M. A. K. Azrag, S. K. Khatir, J. M. Zain and J. B. Odili, "Predictive Maintenance of Produced Water Re-injection Pump Failure in the Field of Oil and Gas: A Review," 2023 International Conference on the Cognitive Computing and Complex Data (ICCD), Huaian, China, 2023, pp. 196-206, doi: 10.1109/ICCD59681.2023.10420542.

[3] Q. Dong and G. Jiang, "Research on Control and Dispatching of Lake Water Storage Based on Optimal Dispatching Model," 2022 International Conference on Data Analytics, Computing and Artificial Intelligence (ICDACAI), Zakopane, Poland, 2022, pp. 247-251, doi: 10.1109/ICDACAI57211.2022.00057.

[4] M. Guizhi, L. Zhongbo, Z. Zhanmin, J. Xuefeng, X. Weiyi and W. Shuai, "Research and Application of Big Data Analysis for Oil and Gas Production," 2021 IEEE 2nd International Conference on Big Data, Artificial Intelligence and Internet of Things Engineering (ICBAIE), Nanchang, China, 2021, pp. 97-100, doi: 10.1109/ICBAIE52039.2021.9389892.

[5] G. Jean-Pierre et al., "Development of a Data Analytics Platform for an Electrical/Water Microgrid," 2021 IEEE 12th International Symposium on Power Electronics for Distributed Generation Systems (PEDG), Chicago, IL, USA, 2021, pp. 1-7, doi: 10.1109/PEDG51384.2021.9494250.

[6] A. K. Sampathirao, P. Sopasakis, A. Bemporad and P. Panos Patrinos, "GPU-Accelerated Stochastic Predictive Control of Drinking Water Networks," in IEEE Transactions on Control Systems Technology, vol. 26, no. 2, pp. 551-562, March 2018, doi: 10.1109/TCST.2017.2677741.

[7] Y. Guo, S. Wang, A. F. Taha and T. H. Summers, "Optimal Pump Control for Water Distribution Networks via Data-Based Distributional Robustness," in IEEE Transactions on Control Systems Technology, vol. 31, no. 1, pp. 114-129, Jan. 2023, doi: 10.1109/TCST.2022.3167844.

[8] R. O'Neil et al., "Global Research Priorities for Holistic Integration of Water and Power Systems," in IEEE Open Access Journal of Power and Energy, vol. 11, pp. 457-468, 2024, doi: 10.1109/OAJPE.2024.3457448.

[9] M. Singh, K. S. Sahoo and A. H. Gandomi, "An Intelligent-IoT-Based Data Analytics for Freshwater Recirculating Aquaculture System," in IEEE Internet of Things Journal, vol. 11, no. 3, pp. 4206-4217, 1 Feb.1, 2024, doi: 10.1109/JIOT.2023.3298844.

[10] S. Singh, R. Batheri and J. Dias, "Predictive Analytics: How to Improve Availability of Manufacturing Equipment in Automotive Firms," in IEEE Engineering Management Review, vol. 51, no. 4, pp. 157-168, Fourthquarter,Dec. 2023, doi: 10.1109/EMR.2023.3288669.

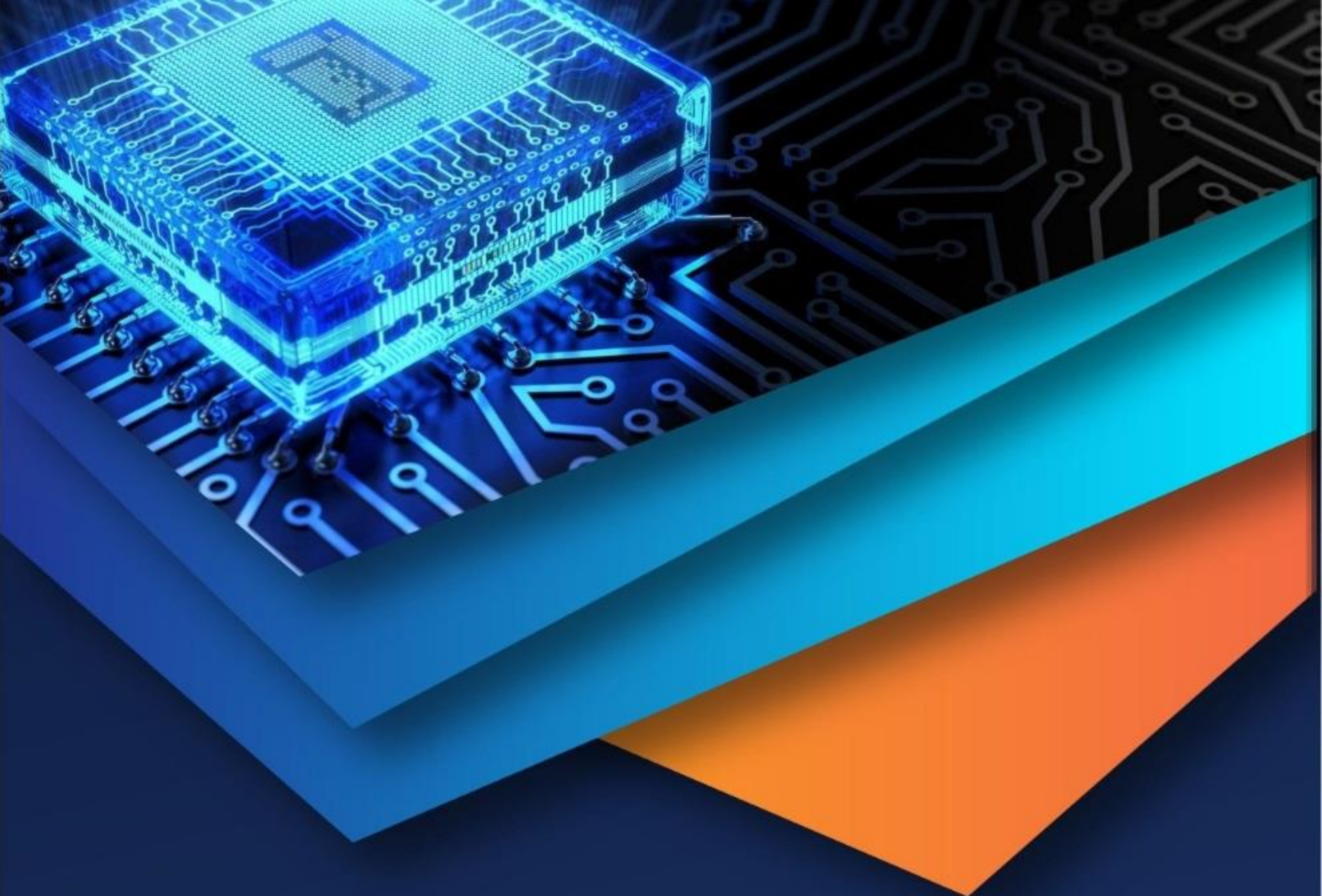
[11] A. G. Apdohan, "Water Resource Potential Assessment for Pump Irrigation Systems for Open Source in Caraga Region, Philippines," 2021 IEEE 13th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM), Manila, Philippines, 2021, pp. 1-5, doi: 10.1109/HNICEM54116.2021.9732006.

[12] L. Y. Kiaw Wang, J. Wei Bong, Y. X. Eng and W. Sheng Wong, "IoT Based Wastewater Dissolved Oxygen and Total Dissolved Solids Monitoring with Data Analytics," 2024 11th International Conference on Future Internet of Things and Cloud (FiCloud), Vienna, Austria, 2024, pp. 98-103, doi: 10.1109/FiCloud62933.2024.00023.

[13] B. Xu, W. Wang, Y. Wu, Y. Shi and C. Lu, "Internet of things and big data analytics for smart oil field malfunction diagnosis," 2017 IEEE 2nd International Conference on Big Data Analysis (ICBDA), Beijing, China, 2017, pp. 178-181, doi: 10.1109/ICBDA.2017.8078802.

[14] K. K. Rout, S. Mallick and S. Mishra, "Solar Powered Smart Irrigation System Using Internet of Things," 2018 2nd International Conference on Data Science and Business Analytics (ICDSBA), Changsha, China, 2018, pp. 144-149, doi: 10.1109/ICDSBA.2018.00033.

[15] Y. Wang et al., "Research on Control Optimization of integrated intelligent energy system based on big data analysis," EMIE 2022; The 2nd International Conference on Electronic Materials and Information Engineering, Hangzhou, China, 2022, pp. 1-6.



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