THE ELECTRIC GENERATION CAPACITY OF THE MANCESTEM WIND TURBINE

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ABSTRACT— *This research investigated the electric generation capacity of a MANCESTEM wind turbine, focusing on its design, performance metrics, and comparative analysis of its inner and outer layers. The study employed a Research and Development (R & D) Research Design, aiming to identify its current, voltage, and power generation and emphasizing a strategic balance between maximizing energy capture and ensuring structural stability through detailed engineering considerations. Results indicate the turbine's consistent and stable performance in generating electrical current, voltage, and power, with the inner layer outperforming the outer layer. Statistical analysis confirmed that there is a significant difference on the current, voltage, and power generation capacities between the inner and outer layers of the turbine providing a foundation for targeted optimizations. Recommendations include optimizing the outer layer, conducting detailed performance mapping under diverse environmental conditions, and integrating smart technologies for sustained efficiency. The study contributes valuable insights to wind energy, paving the way for future advancements in turbine technology and sustainable energy solutions.*

Keywords— Current, Electric Generation, MANCESTEM Wind Turbine, Power, Renewable Energy, Voltage

1. INTRODUCTION

In the face of increasing concerns about global warming, environmental pollution, and energy security, the emergence of wind turbines serves as a noteworthy symbol, guiding humanity toward a sustainable future. This shift from fossil fuels to renewable and environmentally friendly energy sources marks a significant step in addressing pressing environmental challenges. Due to the enormous consumption of fossil resources and the increasing perception of environmental protection, wind energy has drawn more attention as one of the most optimistic sustainable renewable energies. Wind turbines play a crucial role in transforming the wind's kinetic energy into electricity [1, 2]. Currently, more than 5% of the world's electricity is generated from wind power, with an installed capacity reaching approximately three-quarters of a terawatt [3]. The rapid advancement of technology and the availability of wind turbines in different sizes for a variety of uses, from local to massive amounts connected to grid utilities have made wind power the dominant source of energy in the world [4]. Wind energy is in many ways already a fully developed technology; it is also a crucial renewable energy resource to increase electrical power capacity, but current understanding will at best reproduce current products on a larger scale and in greater numbers [5][6].

Despite notable advancements in renewable energy, there remains a compelling need to develop a new generation of wind turbines to address the rising global demand for eco-friendly power generation and contribute to a cleaner future [7]. Current wind turbines' inability to capture wind energy at 100% efficiency motivates this pursuit of innovation, aiming to enhance the effectiveness and affordability of wind energy [8]. As international demand for renewable energy escalates, the imperative to improve the efficiency, reliability, and environmental impact of wind turbines becomes increasingly apparent [9]. Innovative turbine design development can achieve a more effective and sustainable adoption in wind energy industry necessities. Despite broad research in this field, there exists a serious research gap regarding the combination of twisted triangular prism with a cove and three vertical blades in wind turbine structure, which holds potential for big improvements in efficiency, performance, and structural integrity [10].

Addressing this knowledge through further research and experimentation is essential to advance the sustainability and effectiveness of wind energy generation, basically contributing to a cleaner and more sustainable energy future. Increasing the devices' total energy efficiency is the goal of developing new wind turbine designs. Increasing energy output and increased wind kinetic energy may be captured by more effective turbines [11]. Enhancing energy capture and efficiency in low wind speed regions is essential to develop double-layered wind turbines. Two rotors' turbines capture energy from a wider wind speed area, making the turbine effective in extracting energy from unsteady winds and making them a sustainable preference for low wind speed environments [12]. In recent times, Malaybalay City in Bukidnon, Philippines has gained fame for frequent power outages, disruptions, and brownouts, causing distress and sadness among its residents, given a big dependence on modern technology for different aspects of daily life. Investigating the development of offshore wind turbine designs specifically developing for locations like Malaybalay holds the substantial potential to ensure the durability of relatedness and support the demands of new living. The technology associated with wind turbines plays a crucial role in advancing the industry, extending electricity access to remote areas, and enabling them to integrate into the modern world. Additionally, it serves as a valuable achievement of knowledge for academics and students, contributing significantly to the academic domain [13]. It serves a dual purpose by intervening in the urgent problems in the energy sector while also fostering the next generation of scientists and engineers. This study supports the promotion of innovation and sustainability in the field of renewable energy by creating capable personnel capable of handling complicated energy-related problems. This is essential for increasing the wind energy industry's economic viability and lowering the levelized cost of electricity. The Axis Wind Turbine (HAWTs) and Vertical Axis Wind Turbine (VAWTs) are two types of wind turbines used for electricity. The choice of materials depends on the specific components and their functions

[14, 15]. Wind turbine aerodynamic performance is influenced by wind velocity, air density, and blade geometry. Structural construction must overcome wind loads, and electricity availability depends on wind conditions like speed and direction [16]. Wind turbine power is influenced by various factors such as wind speed, direction, terrain, humidity, date, and time. Balancing power supply and demand is crucial for distribution networks, as wind energy is directly proportional to the cube of wind speed. However, wind speed fluctuates with air temperature and seasons, making it difficult to accurately estimate wind energy needs. In engineering, wind turbines are clustered over a wide geographic region with rich wind resources, and the wind speed time series among different turbines within a certain area shows significant spatiotemporal correlations [17].

Furthermore, this project aimed to develop a new type of wind turbine that utilizes a dual-layered design to boost efficiency and wind energy collection. The major objectives were to build a structure with two spinning vertical layers to introduce new ideas to wind turbine technology and to assess the design's performance by tracking elements including energy output, volatility, and current. The investigation involved locating and resolving problems with current designs of conventional wind turbines in addition to the more general goal of developing wind energy technology to enable higher efficiency and the long-term viability of wind energy collection.

2. MATERIALS AND METHOD

Research Design

This study employs a quantitative approach, specifically Research and Development Design, to fabricate a wind turbine and explore its performance. This method involves systematic activities like experimental design, data collection, rigorous analysis, and structured conclusions. Researchers adhere to established protocols to ensure the validity and reliability of findings. The study aimed to boost energy conversion efficiency, increase electricity generation from wind, and maximize power output. It involves collecting numerical data on various methods to enhance electric generation capacity, including power generation efficiency, wind speed, and other critical factors. This data is vital for the study's success.

The MANCESTEM Wind Turbine shows meticulous attention to its dimensions and design. The turbine's dimensions are carefully determined through extensive engineering analysis and optimization processes. Factors such as wind speed, turbine height, and desired power output play a crucial role in shaping its dimensions. The outer layer of the MANCESTEM Wind Turbine consists of three vertically stacked blades. These blades are designed with specific dimensions, including length, width, and curvature, to efficiently capture the kinetic energy of the wind. The dimensions of the outer layer blades are optimized to ensure maximum wind capture and power generation. In contrast, the inner layer of the turbine features a twisted triangular prism with a cove. The dimensions of this inner layer are also meticulously calculated to guide the airflow toward the blades, further enhancing the turbine's efficiency. The specific length, width, and shape of the inner layer are designed to create optimal conditions for wind energy conversion. The overall design of the MANCESTEM Wind Turbine aims to maximize energy capture while ensuring structural integrity and stability. The dimensions of both the outer and inner layers are carefully engineered to strike a balance between capturing as much wind energy as possible and maintaining the turbine's durability.

Locale of the Study

This research took place in Barangay Imbayao, Malaybalay City, Bukidnon, Philippines. Imbayao is in the northern part of Malaybalay City, the capital of the province of Bukidnon, which was located on the island of Mindanao in the southern Philippines. The barangay is known for its strong winds which served as the best place during the conduction of the study.

Research Instrument

The researchers used the following during the investigation: A multimeter is a versatile tool used to measure electrical parameters such as current and voltage. To measure current, it is connected in series with the circuit, providing an immediate reading of the flow of electric charge. For voltage measurement, the multimeter is connected in parallel to the circuit, displaying the potential difference. Visual documentation captures turbine responses, aiding immediate observations and forming valuable archives for in-depth analysis. This multifaceted approach exemplifies the marriage of innovation and scientific rigor, propelling the wind energy sector toward a future of clean, renewable power.

Within the domain of mechanical engineering, two distinguished professionals have provided their transparent endorsement of the MANCESTEM design, signifying its considerable merit. Concurrently, they have expressed their desire to solicit constructive input and innovative insights to improve the standard and effectiveness of this study, emphasizing a collaborative approach toward the enhancement of the MANCESTEM project.

Data Collection

In the quantitative assessment of a modified wind turbine's electrical generation capacity, specific tools played a crucial role in gathering essential data. Multimeters or data loggers, versatile electronic measurement devices, are employed to gauge voltage and current at pertinent points within the wind turbine's electrical framework. This data was fundamental in comprehending the operational points of the wind turbine and evaluating its overall performance.

The acquired wind data, facilitated by a multimeter, and complemented by electrical measurements, served as the foundation for informed decision-making in wind energy management. Wind farm managers rely on this information to optimize turbine placement, fine-tune blade pitch angles, and enhance overall energy capture, thereby boosting the efficiency and productivity of wind energy facilities. Furthermore, this data aided in the comprehensive assessment of wind resources, a crucial aspect when contemplating the potential development of new wind farms. In summary, the coordination between specialized measurement instruments empowers the quantitative study of modified wind turbines, enabling more efficient and sustainable harnessing of renewable energy sources for a greener future.

Statistical Treatment of Data

Inferential Statistics was used to summarize the main features of the data. This includes the One-Way Analysis of Variance (ANOVA) to determine the significant difference in the data to provide a clear overview of the

electric generation capacity data of voltage and current of the Modified MANCESTEM Wind Turbine.
The test-generated data underwent thorough recording via tables, followed by meticulous analysis and interpretation that aligned with the results of the statistical examination.

3. RESULTS AND DISCUSSION

Design of MANCESTEM Wind Turbine

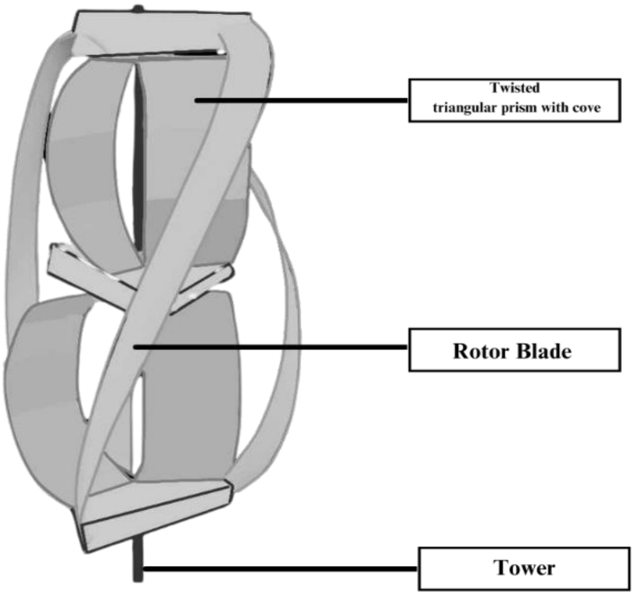

Figure. 3 Digital Sketch of MANCESTEM Wind Turbine Design

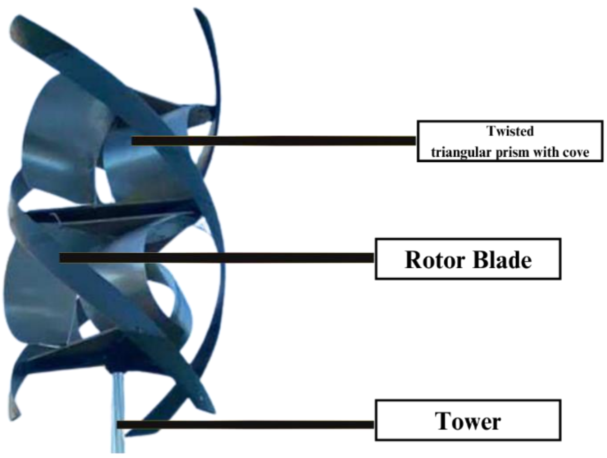

Figure. 4 Actual Picture of MANCESTEM Wind Turbine Design

Table 1. The dimensions of the outer and inner layers of the MANCESTEM wind turbine

Layers	Design's Sizes (in)	
	Length	Width
Inner	14.5	6
Outer	40.9	2

Table 1 details the dimensions of the MANCESTEM Wind Turbine, shedding light on crucial aspects like blade length and width for both the outer and inner layers. This data is not only valuable for understanding the physical characteristics of the turbine but also provides insights into the engineering considerations for optimal performance. Moreover, the outer layer of the turbine boasts substantially longer blades (72 inches) compared to the inner layer (12 inches). This design choice aligns with the study's emphasis on capturing wind energy efficiently. Longer blades provide a larger surface area for wind capture, potentially maximizing energy generation.
In the same manner, the blade width exhibits an interesting pattern. The outer layer has a narrower blade width (2.6 inches) compared to the wider blades of the inner layer (6.3 inches). This design strategy appears to balance between capturing wind energy effectively (outer layer) and maintaining structural stability (inner layer), in line with the study's goal of optimizing energy capture while ensuring turbine durability. In addition, the specific dimensions chosen for the turbine blades seem calculated to strike a balance between maximizing wind energy capture and maintaining structural integrity. This aligns with the study's focus on designing a turbine that efficiently converts wind energy while ensuring the turbine's durability and stability. The demand for electrical energy in remote areas has necessitated the exploration of alternative sources such as wind energy. To cater to the energy needs of remote residential areas, a low-speed hybrid VAWT design has been proposed [18]. This aligns with the observed dimensions of the MANCESTEM Wind Turbine, emphasizing the importance of tailoring wind turbine designs to meet specific energy requirements.
In summary, the dimensions of the MANCESTEM Wind Turbine, as outlined in Table 1, reflect a design strategy supported by Chandrashekhar's study. The emphasis on tailoring wind turbine designs for remote energy needs and the specific choices in blade length and width underscore a meticulous approach to optimize energy capture and ensure the turbine's overall efficiency and sustainability.

Electric Capacity of MANCESTEM Wind Turbine in Terms of Current and Voltage

Table 2. Electric Generation Capacity of MANCESTEM wind turbine in terms of current.

Test	Current	Sum	Average Current
Test 1	0.044A	0.155A	0.052A
Test 2	0.049A		
Test 3	0.062A		

The electric generation capacity of the MANCESTEM Wind Turbine is scrutinized through a comprehensive analysis of values derived from three distinct tests, as presented in Table 2. The recorded data from Test 1 (0.044A), Test 2 (0.049A), and Test 3 (0.062A) is pivotal in evaluating the turbine's performance under diverse conditions. The summation of these values (0.155A) and the subsequent calculation of the average current (0.052A) serve as crucial metrics in understanding the turbine's overall efficiency. The remarkably close values across the tests imply a consistent performance, suggesting that the turbine reliably generates current under varying conditions. The calculated average current of 0.052A provides a central tendency measure, establishing a baseline for the expected electrical generation capacity of the MANCESTEM Wind Turbine. In addition, an observation emerges in the form of an increasing trend in current from Test 1 to Test 3, indicating a potential enhancement in performance or exposure to more favorable conditions in the latter test. This trend merits further investigation to unveil the factors contributing to the observed improvement.

Notably, the small difference between the minimum and maximum current values (0.018A) signifies low variability in the turbine's performance, pointing to a high degree of precision. This precision is pivotal for the consistent generation of electrical current, reinforcing the reliability of the MANCESTEM Wind Turbine.

To contextualize these findings, Chandrashekhar's study [18] emphasizes the need for precision and consistency in wind turbine performance, especially in remote areas with a demand for alternative energy sources. The observed low variability aligns with this emphasis on precision, reinforcing the significance of the turbine's stable performance. In conclusion, the meticulous analysis of the electric generation capacity, considering both the close values and trends in the current, positions the MANCESTEM Wind Turbine as a reliable and precise energy generation solution.

Table 3. Electric generation capacity of MANCESTEM wind turbine in terms of voltage.

Test	Voltage	Sum	Average Voltage
Test 1	12V	36.3V	12.1V
Test 2	11.3V		
Test 3	12.9V		

Table 3 outlines the voltage readings from three distinct tests measuring the electric generation capacity of the MANCESTEM Wind Turbine. The recorded results are as follows: Test 1 (12.1 V), Test 2 (11.3 V), and Test 3 (12.9 V). The sum of these values (36.3 V) and the subsequent calculation of the average voltage (12.1 V) provide crucial insights into the turbine's performance. Despite some variability in the voltage readings, the average voltage of 12.1 V indicates a consistent performance across the three tests. Notably, Test 3 registers the highest voltage (12.9 V), suggesting potential performance improvements or more favorable wind conditions during that specific test. It's intriguing to draw a comparison with the previous analysis of the average current, which stood at 0.052 A. Such a comparison could yield valuable insights into the turbine's power output and efficiency. The observed small difference between the minimum and maximum voltage values (1.6 V) is indicative of relatively low variability, underscoring stability in the turbine's voltage generation. This stability aligns with the importance of consistent and reliable energy generation, crucial especially in the context of remote areas where alternative energy sources, as emphasized by Chandrashekhar's study (2019) [18], need to exhibit stability and precision.

Therefore, the MANCESTEM Wind Turbine, as evidenced by these voltage results, appears to maintain a stable performance with promising implications for its efficiency.

Difference of Inner, Outer, and MANCESTEM Wind Turbine

Table 4. Means and analysis of variance of MANCESTEM wind turbine and its layers in terms of current

Test	N	Mean	Source	DF	AdjSS	P-Value
Inner	3	0.052	Test	2	0.0002	0.425
Outer	3	0.041	Error	6	0.0065	
MANCESTEM	3	0.052	Total	8	0.0009	

Table 4 presents the most recent data obtained from three distinct layers, each subjected to three testing instances. A noteworthy observation in this dataset reveals that both the MANCESTEM Turbine and its inner layer consistently yield identical current outputs, recording a value of 0.05167. These consistent findings suggested a shared characteristic in the inner layer and the MANCESTEM Turbine's ability to generate current. Conversely, the outer layer exhibited a distinctive current output of 0.04133, marking a significant deviation from the identical current outputs of the inner layer and the MANCESTEM Turbine. This disparity implied a noticeable reduction in current production within the outer layer, placing it at a disadvantage compared to its counterparts. The delineation of these current outputs in Table 8 not only highlights the distinct performance of each layer but also points towards potential areas for optimization and refinement in the MANCESTEM Turbine's design and functionality.

Table 4 provides a detailed analysis of the MANCESTEM Turbine's inner and outer layer, as well as the overall turbine, in terms of current variance, utilizing the one-way analysis of variance (ANOVA). The degrees of freedom (DF) for tests is 2, with an adjusted sum of squares (Adj SS) of 0.000214. and a p-value of 0.425. The relatively high p-value (0.425) suggests that the observed differences in current among the inner layer, outer layer, and the overall turbine were not statistically significant at conventional significance levels. This indicates that any variance in current production is likely due to random fluctuations rather than meaningful differences between the layers. The degrees of freedom for error is 6, with an adjusted sum of squares of 0.000648 and an adjusted mean square of 0.000108. The total degrees of freedom is 8, with a total adjusted sum of squares of 0.000862. This comprehensive analysis implies that, based on the current data, there is no conclusive evidence to suggest significant differences in current production among the inner layer, outer layer, and the overall MANCESTEM Turbine.

Table 5. Means and analysis of variance of a MANCESTEM wind turbine and its layers in terms of voltage

Layer	Current	Voltage	Power
Inner	0.05167A	19.400V	1.002398 Watts
Outer	0.04133A	5.200	214.916 Milliwatts
MANCESTEM	0.05167A	12.100	625.207 Milliwatts

The table presents the data collected from three sets of tests on three different layers. The inner layer exhibits a distinct advantage in voltage production, recording the highest value at 19.400. Following closely is the MANCESTEM Turbine, which was the second-highest producer with a voltage of 12.100. Conversely, the outer layer lags, producing the least voltage at 5.200. These results highlighted a significant disparity in voltage generation among the layers, indicating that yielded different outcomes. Notably, the inner layer excelled in voltage production, showcasing its superior performance in this regard.

Table 5 presents a detailed analysis of the MANCESTEM Turbine's inner and outer layers, as well as the overall turbine, in terms of voltage variance using the one-way analysis of variance (ANOVA). The degrees of freedom (DF) for tests is 2, with an adjusted sum of squares (Adj SS) of 302.540. The highly significant p-value of 0.000. The very low p-value (0.000) indicates that the observed differences in voltage among the inner layer, outer layer, and the overall turbine were highly statistically significant. This implied that the variance in voltage production was unlikely due to random fluctuations but rather meaningful differences between the layers. The degrees of freedom for error are 6, with an adjusted sum of squares of 3.960 The total degrees of freedom are 8, with a total adjusted sum of squares of 306.500. This comprehensive analysis strongly suggests that, based on the current data, there are significant differences in voltage production among the inner layer, outer layer, and the overall MANCESTEM Turbine. Further exploration and interpretation of these differences provided valuable insights into the factors influencing voltage generation in the MANCESTEM Turbine.

Table 6. The power capacity of MANCESTEM turbine and its layers

Test	N	Mean	Source	DF	AdjSS	P-Value
Inner	3	19.400	Test	2	302.540	0.000
Outer	3	5.200	Error	6	3.960	
MANCESTEM	3	12.100	Total	8	306.500	

The table presents the power data collected from three different layers of the MANCESTEM Wind Turbine. The inner layer exhibited a distinct advantage in power production, recording the highest value of 1.002398. Following closely is the MANCESTEM Wind Turbine with 625.207 milliwatts. Moreover, the outer layer produced the lowest value, 214.916 milliwatts. In summary, the inner layer excelled in power production.

4. CONCLUSION

In conclusion, this study provided a comprehensive exploration of the Electric Generation Capacity of a MANCESTEM Wind Turbine, addressing critical questions related to its design and performance. The study not only highlighted the turbine's current capabilities but also indicated the potential for enhanced performance through targeted refinements.

The MANCESTEM design not only successfully addressed the predefined objectives of the study but also demonstrated its adaptability to remote locations, such as Malaybalay City. The vertical orientation of the design aligns coherently with the findings from Chandrashekhar's study, providing a strong foundation for its applicability in diverse geographical settings. The innovative features of the MANCESTEM design, characterized by its verticality, ensure a sustainable and efficient solution for areas with limited space and challenging regions. The incorporation of Chandrashekhar's insights enhanced the credibility and reliability of the design, emphasizing its potential to be an applicable and practical solution for remote environments.

The analysis of the turbine's dimensions emphasized a strategic balance between maximizing energy capture and ensuring structural stability.

The MANCESTEM Wind Turbine's current and voltage results are optimistic, highlighting the importance of consistent performance in wind energy. This was especially crucial in remote areas needing alternative energy sources. The stable output makes it a reliable choice for offshore locations. These findings showed that the turbine works well, making it a dependable and sustainable energy option for places without regular power access. This study was a game-changer for clean energy in challenging environments. The turbine's consistent and stable performance in generating electrical current and voltage, as evidenced by the test results, positions it as a reliable and precise energy generation solution.

The MANCESTEM and its layer have the same amount of current which means that the outer layer is at the bottom in producing current. While in the voltage the inner layer is more generated by voltage than the other two. A pivotal aspect of the research was the comparison between the inner and outer layers of the turbine. The discernible differences in current and voltage outputs underscore the need for layer-specific optimizations. Statistical analyses affirmed the significance of these distinctions, providing a solid foundation for future design modifications.

RECOMMENDATIONS

Based on the result of the study, the following were the recommendations:

1. Prioritize research and development efforts on optimizing the outer layer of the MANCESTEM Wind Turbine. Addressing the observed performance gap between the inner and outer layers is crucial for achieving uniform efficiency throughout the turbine.
2. Conduct an extensive environmental performance mapping of the turbine under diverse conditions. This includes variations in wind speed, temperature, and other relevant factors. Understanding how the turbine responds to different environmental variables will guide further enhancements.
3. Explore the integration of smart technologies, such as sensors and data analytics, to enhance the turbine's performance monitoring capabilities. Real-time data collection and analysis can provide valuable insights for proactive maintenance and continuous optimization.
4. Establish a robust monitoring and maintenance protocol to ensure the long-term reliability of the MANCESTEM Wind Turbine. Regular inspections, preventive maintenance measures, and prompt response to any anomalies detected during monitoring will contribute to sustained efficiency.
5. Foster collaboration with research institutions, industry partners, and governmental bodies to leverage collective expertise and resources. Additionally, initiate public awareness campaigns to promote the benefits of wind energy and the advancements made with the MANCESTEM Wind Turbine. Building a supportive community and garnering public interest can contribute to the broader adoption of sustainable energy solutions.
6. It is recommended to write a data logbook about the

observation on the testing.

7. It is recommended to use an Anemometer to measure the wind speed.
8. It is recommended to check the Intellectual Property Office of the Philippines (IPOPHL) for the originality of the design.

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