Solar-Powered Drone for Extended Flight Time

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Abstract:-Drones can now fly for longer periods and have a smaller carbon footprint. These drones have solar cells that use sunlight's energy to power the drone and other components on board. Agriculture, disaster relief, and environmental protection can all benefit from the development of solar-powered drones. The present research aims to increase battery life so that flights can last longer. It gives a general overview of the drone's parts and solar cells, outlining potential applications. Incorrect weight distribution can cause instability and make it difficult to achieve lift, rendering the drone incapable of flight and confined to ground-based operations The drone being discussed has a well-balanced weight distribution, which restricts its functionality and prevents it from flying correctly. Proper weight distribution has been achieved in the drone under consideration in this study, leading to stable flight and improved endurance.

Keywords: *Solar-powered drones, Solar cells, drone weight distribution, Flight Stability*.

1. Introduction

The vision of achieving solar-powered flight has become a reality through solar cells, small devices capable of generating electricity directly from sunlight. These photovoltaic solar cells can be employed to power generators that propel aircraft, enabling them to harness energy from the sun. To enable nighttime operation, these aircraft store solar energy in batteries.

The drone can collect electricity all day while charging its lithium battery for night flights. The solar drone's entire system must be extremely light, flexible, and aerodynamic to fly day and night for extended periods. Due to their ability to hover and engage in vertical take-off and landing, quadcopters have gained popularity in drone design. The propellers mounted at the end of the frame are driven by brushless DC motors connected to them.

The amount of storage that batteries can hold is one of their drawbacks as an energy source. Conventional drones have a limited range of flight because onboard batteries power them. A larger battery or more can increase energy storage and add weight to the drone, making it harder to fly for longer periods. On the other hand, solar-powered drones use solar energy captured during the day by built-in solar cells to power the aircraft and other equipment or to recharge the batteries on board. Batteries are used when there is no sunlight, such as at night or in cloudy weather.

2. Literature Survey

Most of the research has already been done has focused on using solar energy to improve the performance of winged aircraft [1]. Solar panels are used by solar-powered aircraft to capture sunlight for use right away and storage to enable nighttime flight. The current situation identified limitations and potential uses of solar energy in boosting the aerospace industry are all covered in this thorough survey article.

A flight control system was put in place to facilitate tests and verify the effectiveness of the power plant [2]. The solar panel of the aircraft showed a remarkable 22.5 per cent reduction in battery consumption under controlled weather conditions. Compared to a similar setup without solar panels, the solar drone's design showed a significantly slower loss of battery power during a stable flight.

The various electronic parts relevant to solar-powered aircraft are examined in this article, including photovoltaic cells [3], high-voltage equipment, and rechargeable batteries. Future solar energy applications may benefit from emerging technologies like silicon quantum dot cells, thin-film photovoltaic cells, organic photovoltaic cells, parallel circuits, and photoelectric photovoltaic cells. Significant potential exists for lithium-air (Li-air) batteries to improve the performance of solar-powered aircraft. This article focuses on the optimisation methodology for developing solar-powered unmanned aerial vehicles (UAVs) [4], considering elements like the main mast's high aspect ratio wing and integrating 100 lithium batteries. Batteries are treated as an integral component of the payload model using this optimisation strategy. This leads to redesigned and rigorously tested configurations that outperform the original models, especially regarding mechanical properties.

It is described in detail [5] how to create a simple but effective simulator for predicting the generation and storage of photovoltaic energy in lithium-ion batteries. This simulator aids a parametric analysis of a four-bladed autonomous drone with thin-film photovoltaic solar cells. The article also examines how geographical and security factors affect unmanned aerial vehicles' autonomy (UAVs). The drone can function for up to 12 hours with good weather and sunlight.

The study also presents a reliable two-stage design approach for sandwich box beams [6]. Traditional methods for estimating buckling eigenvalues rely on low-order stress/deflection measurements and linear buckling analytical techniques; however, this method also incorporates experimental correction features. The three main topics covered in this article are ‘assessing the stiffness and stability of sandwich beam structures’, ‘determining the importance of foam interlayer weight in different box sandwich beam applications’, and ‘enhancing the buckling resistance of these structures. The general ideas and insights support developing small, light, solar-powered UAVs.

A technique for analysing high-altitude, long-endurance unmanned aerial vehicles powered by solar energy is a noteworthy addition [7]. This study focuses on solar-powered HALE drones' aerodynamics, flight capabilities, and power requirements. Analytical techniques assess the power requirements for various flight manoeuvres and the solar radiation that can be captured. The article introduces and assesses the HALE concept, showing that, with current estimates of solar propulsion and energy conversion, such a concept can sustain year-round flight up to a maximum altitude of 108N, offering a helpful starting point for researchers interested in solar HALE concepts.

By thoroughly examining operational aspects, energy dynamics, storage, payment systems, and aircraft design related to solar-powered aviation, this article seeks to advance renewable energy research within the aviation sector [8]. It carefully examines a 2 kg solar-powered plane from various perspectives, paying close attention to the level of construction throughout the entire wing structure to improve overall performance. The article also introduces a technique for overcoming the difficulties in developing such systems [9], particularly for estimating power generation in platforms with contours while considering how contours affect lighting designs. Notably, this technique increases energy production by 8%, improving the effectiveness of the most common energy source algorithm. As a result, this method can be used to determine the power output of a specific LTAP volume.

This article also looks at the development of solar cells and batteries specifically made for small UAVs [10]. This review covers solar cells, batteries, fuel cells, microgenerators, and batteries, particularly emphasising high-performance solar cell technologies. The article emphasises the revolutionary impact of solar and battery technology advances on the creation of solar drones. Electric motors, batteries, and solar cells working together harmoniously provide an effective solution that satisfies the needs of numerous long-term applications.

Drones could be powered by solar energy, a renewable energy source, without adding weight or increasing fuel consumption [11]. The article examines the development of an aircraft with solar cells integrated into its wings considering the basic difficulties solar aircraft encounter, such as operational space, energy generation and storage, payment systems, and design considerations. This study first examines how much solar energy is needed to power the entire aircraft, supporting its conclusions with data from experiments. Additionally, it calculates and analyses energy consumption, acknowledging its crucial role in addressing the negative environmental effects of energy usage.

3. Objective and Proposed Method

Drones and solar power, two of the most cutting-edge technologies, can work better together. The numerous applications of solar-powered drones are currently being investigated by researchers and businesses. Solar power will address one of the main issues with drone durability as both technologies have advanced. Our strategy uses solar energy from the sun to power our aircraft's flight. This entails mounting solar cells directly exposed to solar radiation and varying lighting conditions on the drone's surface. These solar panels convert solar energy into electrical power effectively. The drone's batteries are then charged using the electricity produced, which powers the aircraft.

The objective of the present work involves:

1. Use solar cells to cover the top surface of drones to harvest solar energy.
2. Consider carefully which battery, solar cells, and other parts the drone will need.
3. Design the drone's frame based on the specifications and requirements.
4. Perform tests on the ground to gauge the solar cells' capacity to efficiently recharge the drone's battery and measure the current they produce.
5. Conduct thorough testing to confirm the functionality and performance of the chosen battery, solar cells, and other drone system components to ensure they satisfy power requirements.
6. Conduct a drone test flight to evaluate its functionality and performance when powered by solar energy.

The process and methodology adopted have been illustrated using the flow chart shown in Fig. 1.

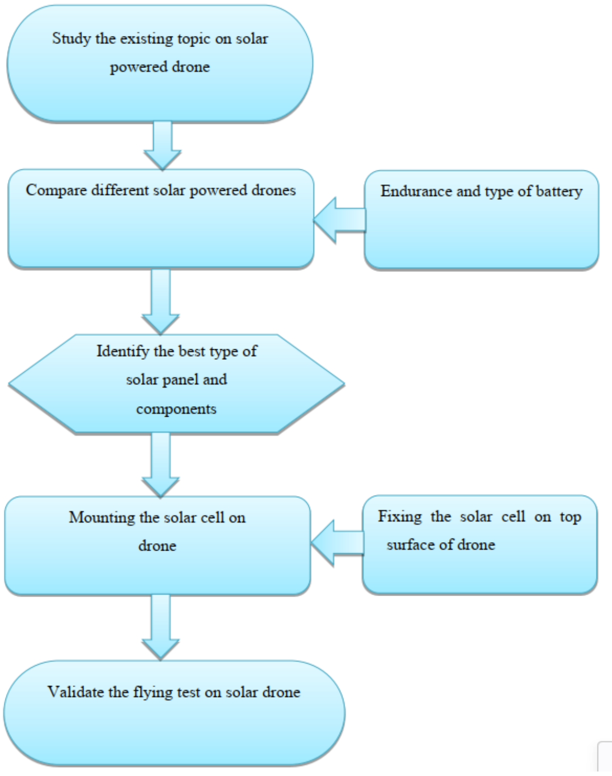

Fig. 1: Flow chart showing the objectives and method adopted

4. Modelling Of Drone

The design of a solar-powered drone must consider a variety of specifications and constraints. This includes calculating the power requirements for the drone's propulsion system, avionics, sensors, communication systems, and payload. The total amount of energy consumed can be used to determine the size and capacity of the solar cells needed to meet these requirements. Additionally, picking solar cells with high conversion efficiencies will maximise power output, allowing the use of a smaller solar array and a lighter weight while still producing adequate energy.

Consider the surface area on the drone that can be integrated with solar cells and optimise their positioning and orientation to maximise exposure to sunlight while in flight. The drone's structure must consider structural integrity, weight distribution, and aerodynamics to support the solar array. The weight of the solar cells and other components must be evenly distributed to maintain the flight's stability and manoeuvrability. The cost of the solar drone design must also be considered. Considering the upfront costs of solar cells, energy storage systems, and other parts and the long-term cost savings from fewer fuel or battery replacement costs is necessary. The proposed model can significantly utilise propellers to enhance the quadcopter's ability to fly.

5. The Requirements

The necessary calculations are shown in the next section. Whether in consumer electronics, electric vehicles, or renewable energy systems, the concept of "Battery Charging Time" is crucial to understanding the efficiency and performance of rechargeable batteries. In this analysis, we focus on a battery with a 2200 mAh capacity, which is the same as 2.2 Ah (Ah). A battery's charge rate, measured in amperes (A), is the rate at which electricity is supplied while charging the battery. Battery Charging Time = Battery Capacity / Charge Rate is the formula used to estimate how long it will take to fully charge this battery. According to the numbers, it takes about 2.2 hours to fully charge the battery in this case. This means that it will take about 2.2 hours to fully charge the battery when connected to a 2.2-amp charger. Learning how long it takes to charge a battery is crucial for improving the efficacy, dependability, and sustainability of a wide range of industries and applications.

In the context of this research article, several key parameters play a pivotal role in selecting the appropriate motor for a drone application. The relationship between current (measured in amperes, Amps) and voltage (Volts) as Watts (power) is fundamental in understanding the power requirements. Additionally, the concept of the All Up Weight (AUW) being approximately half the thrust needed is significant. With a drone weight of 1500 grams, a thrust requirement of 3000 grams translates to 750 grams per motor in a quadcopter configuration. The supplied voltage determines motor speed, which is crucial for efficient drone performance. In this case, a 1V supply results in a motor speed of 1400 RPM, aligning with recommendations for optimal fan performance. Furthermore, choosing a specific 0.254 x 0.114m nylon propeller complements the motor selection process. The A2212 - 1400KV BLDC Brushless Motor is the recommended choice, aligning with the various parameters and requirements outlined in this comprehensive motor selection process for drone applications.

In this research study, we delve into the critical aspect of evaluating the continuous discharge rate of a battery, a fundamental parameter for various applications ranging from portable electronics to electric vehicles. The calculation begins with the battery's initial capacity, 2200 milliampere-hours (mAh). To facilitate comparisons and analysis, we convert this capacity into ampere-hours (Ah), resulting in a value of 2.2 Ah. The discharge time, a pivotal factor in assessing battery performance, is recorded at 7 minutes, which we convert into hours for precise analysis, equating to 0.1167 hours. Subsequently, the Continuous Discharge Rate, a key metric for understanding how a battery performs under sustained use, is determined by dividing the battery capacity by the discharge time in hours. The calculation yields a Continuous Discharge Rate of 18.8 ampere-hours per hour (Ah/hr), signifying that this battery can consistently deliver this current over an hour of discharge. This comprehensive analysis of the battery's continuous discharge rate provides valuable insights into its suitability for various applications, contributing to the advancement of battery technology and device performance optimisation.

6. Arrangement of Solar Cells

This research examines the solar power generation system integrated into a drone for sustainable energy harvesting. Four solar cells are strategically positioned on the top surface of the drone, each boasting a voltage output of 6V. A configuration optimises power output, with two solar cells connected in series within a row while these rows are connected in parallel. This arrangement effectively doubles the voltage output to 12V, aligning closely with the Li-Po battery's voltage rating of 11.1V. A critical consideration is the current generated by the two cells in series, totalling 0.8A, which then accumulates to a charging-worthy 1.6A. Significantly, this current output surpasses the minimum requirement 1A to charge the battery effectively. Moreover, the system exhibits a peak current production of 1.1A during optimal conditions, showcasing the efficiency and potential of the solar cells in powering the drone and replenishing its energy reserves. This comprehensive analysis highlights the feasibility and effectiveness of the integrated solar power system, furthering the development of sustainable drone technology.

7. Flight Testing and evaluation

Our research involved a comprehensive examination of the integrated solar cell system into the drone, specifically evaluating its current generation capabilities. The drone's top surface incorporates four solar cells, each boasting a voltage rating of 6V. A unique configuration was adopted to maximise power output, connecting two cells in parallel and then linking these pairs in series. This setup effectively doubles the voltage output, reaching 12V, aligning closely with the 11.1V Li-Po battery voltage. Remarkably, the two cells connected in series generated a current of 0.8A, accumulating to a robust 1.6A. This current output comfortably surpasses the battery's minimum charging requirement of 1A, demonstrating the solar cells' capacity to charge the battery effectively. Furthermore, during peak solar conditions, the solar cell system exhibited an impressive maximum current output of 1.1A, emphasising its efficiency and potential for powering the drone and maintaining its energy reserves. These findings validate the viability and effectiveness of the integrated solar cell system, advancing sustainable drone technology development.

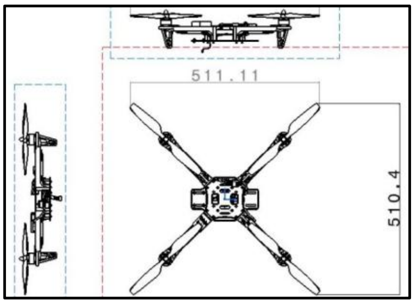

Fig. 2: Structure of the drone

Fig. 3: Drone with solar cells

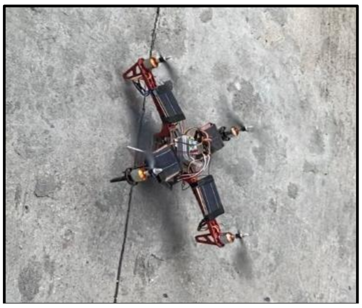

Fig.4: Testing the drone

Fig. 2 provides an informative depiction of the drone's structural intricacies, providing readers with a complete overview of its physical composition and the arrangement of its key components. Fig. 3 is a visual representation of how solar cells are integrated into the drone, providing clarity on how the solar power generation system is implemented. This diagram clarifies the importance of the solar cells and their location within the overall framework of the drone's construction. Fig. 4 depicts a crucial moment during testing, giving readers a visual of the experimental setup and a feel for the research's tangible implications. Together, these visuals make the research article easier to understand, letting readers in on the study's subtleties and its practical applications with greater ease.

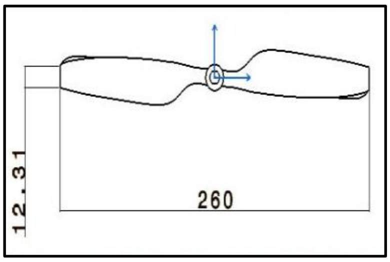

Fig. 5: Propeller used

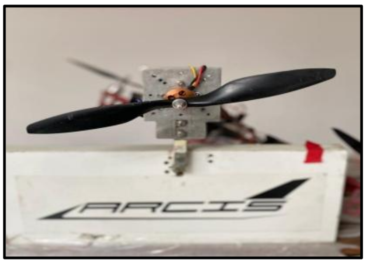

Fig.6: Thrust Measurement

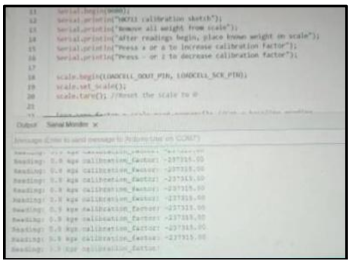

Fig.7: Arduino code for Thrust measurement

Fig. 5 depicts the propeller used in the study, enabling readers to comprehend better its design and dimensions, which are crucial for comprehending aerodynamic performance. Fig. 6 is a graphical representation of the thrust measurement procedure, highlighting the experimental setup and instruments for accurate thrust measurement. In addition, Fig. 7 provides insight into programming by displaying portions of Arduino code.

The successful accomplishment of the flight test indicates the significance of weight distribution in drone design. In the early stages of the drone's development, improper weight distribution prevented it from taking flight. This resulted in an unfavourable centre of gravity, which caused instability and launch issues. In addition, the unbalanced weight distribution had the potential to strain-specific components, such as motors and propellers, which could have reduced thrust and propulsion efficiency. However, with the corrected weight distribution, the drone's flight controller easily managed the balance, resulting in stable flight dynamics, improved performance, and a reliable flight system. This successful test proves the significance of weight distribution for optimal drone flight. With the successful completion of the flight test, it has become evident that optimal weight distribution is necessary for maximising the drone's aerodynamic performance. Initial concerns regarding the effect of improper weight distribution on the drone's aerodynamic profile have been effectively addressed. This change has significantly decreased drag, allowing the drone to continue flying effectively. As a result, the drone now requires less energy to overcome drag, resulting in extended flight times and improved battery efficiency. The flight controller's responsibility to ensure level flight has been greatly simplified due to the aircraft's balanced weight distribution. In addition, the payload capacity has been increased, allowing for more efficient delivery and transportation of equipment or cargo. By maintaining a well-distributed centre of gravity and well-balanced components, the drone has achieved dependable and performance-optimized operation in every respect.

8. Conclusion

In conclusion, solar-powered drones provide numerous benefits and opportunities for more effective and environmentally friendly aerial operations. By incorporating solar panels, these drone designs can achieve longer flight times, reduced environmental impact, and increased energy independence. Multiple industries, including aerial surveying, monitoring, surveillance, and remote sensing, could benefit from using solar-powered drones.

Nonetheless, there are numerous obstacles and limitations to consider. When designing solar-powered drones, it is crucial to consider power requirements, solar panel efficiency, weight constraints, sunlight availability, and design factors. The deficiencies of solar panel technology, including inconsistent power output and high initial costs, must be addressed.

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