SUSTAINABLE CAPSTONE PROJECTS (SCAP)
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CYPRUS INTERNATIONAL UNIVERSITY

WIND TURBINE DESIGN AND CONSTRUCTION

GROUP MEMBERS

- **Ali Bin Eshaq 21811522 (Mechanical Engineering)**
- **Micheal Oso 21906284 (Mechanical Engineering Department)**
- **Maher Alrawashdeh 21911318 (Energy systems Engineering)**
- **Yasmine Iyazghi 22014855 (Energy Systems Engineering)**
- **Boima Fahnbulleh 22013081 (Mechanical Engineering)**
- **Abdulrahman Omer 21910556 (Electrical and Electronics Engineering)**
- **Ibrahim Modibbo Ahmed 22218574 (Energy Systems Engineering)**
- **Mohamed 22117436 (Mechatronics Engineer)**

INTRODUCTION

Wind turbines offer a sustainable solution for generating electricity, but their environmental impact can be reduced by using recycled materials. This project explores the design and construction of wind turbines with recycled materials, aiming to enhance sustainability and resource conservation.

The primary objectives of this project are to:

- Gain a comprehensive understanding of wind turbine design principles, focusing on the integration of recycled materials
- Identify and evaluate potential recycled materials for various wind turbine components
- Design a scalable wind turbine concept that incorporates recycled materials
- Analyze the financial and environmental implications of using recycled materials in wind turbine construction
- Construct a simplified scale model wind turbine utilizing recycled materials

MATERIALS USED IN CONSTRUCTION

Materials Used in the Construction

Re-Used/Recycled Materials:

- Blades: Cut-up sections of recycled plastic pipe
- Hub: Recycled triangular wooden board
- Belt: Recycled rubber

Other Materials:

- Screws: Standard metal screws
- Yaw System: Bearings, metal rods, and metal plates
- Wind Vane: Small metal sheet
- Generator: (Optional) Recycled or non-recycled materials

Materials Selection Rationale:

The selection of recycled materials was guided by the following principles:

- Resource Conservation: Minimizing the use of virgin materials to conserve natural resources and reduce environmental impact.
- Sustainability: Choosing materials that are inherently sustainable or can be easily recycled, contributing to a circular economy.
- Cost-Effectiveness: Considering the economic viability of using recycled materials, ensuring the project's affordability and accessibility.
- Structural Integrity: Ensuring that the recycled materials selected can meet the structural requirements of the turbine, including strength, durability, and weight distribution.
- Functional Efficiency: Selecting recycled materials that do not compromise the functionality and performance of the turbine, such as blades that effectively capture wind energy and a hub that securely attaches the blades.

FINAL PRODUCT

The final product of this project is a functioning vertical axis wind turbine (VAWT) that incorporates recycled materials throughout its design and construction. The turbine is composed of a hub, blades, shaft, belt drive, generator, wind vane, and yaw system, all of which were carefully selected to minimize environmental impact and maximize resource conservation.

Hub and Blades

The hub serves as the central axis of the turbine and connects the blades. It is constructed from a recycled triangular wooden board, which provides a sturdy and lightweight foundation for the blades. The blades, fashioned from cut-up sections of recycled plastic pipe, are attached to the hub using durable screws. This blade design enables the turbine to capture wind energy effectively, converting it into rotational motion.

Belt Drive and Generator

A belt drive system connects the turbine shaft to the generator, transferring rotational energy from the blades to the electricity-generating component. The belt, made from recycled rubber, ensures smooth and efficient power transmission. The generator, also utilizing recycled materials, converts the mechanical energy into electrical energy, which can be used to power various devices.

Wind Vane and Yaw System

The wind vane, a small metal sheet attached to the tower, acts as a directional sensor. As the wind direction changes, the wind vane rotates the tower, aligning the turbine with the prevailing wind. This continuous orientation ensures maximum wind energy capture and optimal turbine efficiency. The yaw system, mounted on a bearing within the tower, is driven by the wind vane to smoothly adjust the turbine's orientation.

Operation and Performance

When wind strikes the turbine's blades, their aerodynamic shape causes them to rotate, generating rotational energy. This energy is transferred through the belt drive to the generator, which converts it into electricity. The yaw system ensures that the turbine remains aligned with the wind, maximizing energy capture and efficiency.

Figure 1. The wind turbine in operation

Figure 2. Welding the wind vane

Figure 3. Drilling screw holes into the wind blade

Figure 4. Final cut-out of the wind blade

Figure 5. The wind blades assembled onto the hub

Table 6. SCAP 1st Wind Turbine

RESULTS AND DISCUSSION

Performance Evaluation

The vertical axis wind turbine (VAWT) was tested in various wind conditions to assess its performance and efficiency. The turbine was able to generate electricity from wind speeds as low as 3m/s, indicating its suitability for operation in locations with moderate wind resources.

The maximum power output of the turbine was achieved at a wind speed of around 7m/s. However, further optimization of the blade design and yaw system could potentially increase the turbine's power output and efficiency at higher wind speeds.

Material Selection and Resource Conservation

The integration of recycled materials throughout the turbine's design and construction significantly reduced the environmental impact of the project. By utilizing recycled plastic for the blades, wooden scraps for the hub, and repurposed rubber for the belt drive, we minimized the reliance on virgin materials and contributed to resource conservation.

The project's emphasis on recycled materials aligns with the principles of sustainable engineering and circular economy, where materials are continuously reused and recycled to minimize waste generation and environmental degradation.

Challenges and Future Directions

One of the primary challenges encountered during the project was the limited availability of specific recycled materials. This required careful consideration of alternative materials and a willingness to adapt the design to ensure the project's success.

To further enhance the sustainability of the VAWT, future iterations could explore the use of bio-based or biodegradable materials for the blades and other components. Additionally, incorporating advanced aerodynamic designs and optimizing the yaw system could lead to improved efficiency and power output.

In addition to these technical improvements, expanding the project scale to construct larger VAWTs could potentially generate more electricity and contribute to broader energy needs. Furthermore, exploring the potential of VAWTs for integration into microgrids or off-grid applications could address the growing demand for renewable energy in decentralized settings.

CONCLUSIONS

The project successfully designed and constructed a vertical axis wind turbine (VAWT) utilizing recycled materials, demonstrating the feasibility and environmental benefits of this approach. The integration of recycled plastic for the blades, wooden scraps for the hub, and repurposed rubber for the belt drive reduced the reliance on virgin materials, minimized resource depletion, and contributed to a circular economy approach. The project also highlighted the potential of VAWTs as a sustainable and scalable renewable energy solution.

The project provided valuable hands-on experience in engineering design, construction, and material selection, fostering a deeper understanding of sustainable engineering principles. The limited availability of specific recycled materials presented a challenge, requiring careful consideration of alternative materials and design adaptations. The project reinforced the importance of considering the environmental impact of our designs from the outset, emphasizing the potential of innovation in sustainable energy solutions. The SCAP program provided a supportive and collaborative environment for learning and experimentation, aligned with the project's goals and furthering our understanding of sustainable engineering. Ultimately, the project was a valuable learning experience that deepened our understanding of sustainable engineering principles and demonstrated the feasibility of incorporating recycled materials into real-world applications.

REFERENCES

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- "Vertical Axis Wind Turbines: A Sustainable Approach to Wind Energy Generation" by Dr. Saeed Abbasi and Dr. Saeed Rahimi