Plastic to Power - Microwave Energy for Plastic Decomposition

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1 Introduction

Plastic waste has become one of the most pressing environmental issues of the modern era. Billions of tons of plastic waste being found in the natural environment as well as landfills. It is imperative to find an efficient and sustainable way to manage and recycle this waste. Microwave catalytic deconstruction offers a promising solution by converting plastic waste into valuable products like hydrogen and carbon nanotubes using microwave energy and catalysts. This project aims to optimise an existing microwave system to enhance its efficiency, ease of use, and data collection capabilities, thereby contributing to more effective plastic waste management and recycling solutions.

2 Background and Significance

The environmental impact of plastic waste is a significant global concern. With over 4.9 billion tons of plastic waste produced to date and predictions of this number rising to 12 billion tons by 2050, the need for innovative recycling technologies is more urgent than ever. Traditional recycling methods often fall short in efficiency and scalability, leading researchers to explore advanced techniques such as microwave catalytic pyrolysis for up-cycling plastic.

Microwave catalytic pyrolysis utilises microwave energy to break down polyolefins—plastics like polyethylene, polypropylene, and polystyrene—into valuable by-products such as hydrogen gas (used as a green fuel) and carbon nanotubes. This process not only helps in reducing plastic waste but also creates materials that can be reused in various industrial applications.

In 2021, a prototype microwave system designed to facilitate this process was successfully developed and tested at the University of Cape Town (UCT). While the initial results were promising, there is significant room for improvement in terms of electrical efficiency, ease of feeding materials into the system, and the ability to monitor operational data such as temperature and power usage.

This project focuses on enhancing the existing microwave system by incorporating more efficient

electrical components, improving the user interface for easier control and feeding of materials, and integrating advanced data collection capabilities. These improvements aim to make the system more practical for widespread use and to provide detailed operational data that can drive further innovations in microwave catalytic pyrolysis. Instruments used for temperature measurement inside microwave cavities.

3 Objectives

The primary objectives of this project are:

1. **Literature Review:** Conduct comprehensive research on:
    - How microwaves interact and heat metal powders
    - Microwave pyrolysis in decomposition of matter.
    - Techniques and instruments used for temperature measurement inside microwave cavities.
    - Microwave cavities, waveguides, and waveguide modes
    - Differences between transformer and inverter microwaves
2. **System Design and Improvement:** Enhance the existing microwave system to achieve:
    - Increased electrical efficiency
    - Easier feeding of materials
    - Enhanced data collection capabilities, including temperature readings, power usage, and variable power output
3. **Experimental Testing:**
    - Test, characterise, and validate the performance of the upgraded microwave system.
    - Use thermal paper to map heating properties and verify uniform heat distribution.
    - Use various methods to test the ambient temperature inside the cavity as well as the target substance.
    - Provide a mechanism for feedback on factors such as power output, consumption, and temperature readings.
4. **Reporting:** Compile a comprehensive report detailing the improvements made, experimental results, and recommendations for future work.

4 Methodology

1. **Literature Review:** Analyse existing literature on microwave pyrolysis, temperature measurement instruments for microwave cavities, microwave cavities and waveguides, and the differences between transformer and inverter microwaves.
2. **System Design and Improvement:** Focus on upgrading the existing microwave system:
   - Incorporate more efficient electrical components to enhance overall system efficiency.
   - Design and implement an improved user interface for easier use of the system.
   - Integrate sensors and data collection tools to monitor temperature, power usage, and variable power output.
3. **Experimental Setup:**
   - Set up the upgraded microwave system.
   - Use thermal paper to map heating properties and ensure uniform heat distribution.
   - Install sensors and data collection devices for comprehensive monitoring.
4. **Data Collection and Analysis:** Collect data on temperature readings, power usage, and system performance. Analyse the data to evaluate the improvements in efficiency and functionality.
5. **Validation:** Conduct tests to ensure the system meets the desired objectives for efficiency, ease of use, and data collection.

5 Deliverables

1. **Comprehensive Literature Review**
2. **Design Proposal**
3. **Design and Improvement Reports**
4. **Experimental Data and Analysis**
5. **Final Report with Findings and Future Recommendations**

6 Expected Outcomes

By the end of this project, the microwave system used for catalytic deconstruction of plastics is expected to demonstrate significant improvements in efficiency, ease of use, and data collection capabilities. The upgraded system will be more electrically efficient, allowing for more effective

energy use during the deconstruction process. The enhanced design will facilitate easier feeding of materials, making the system more user-friendly. Additionally, the integration of advanced sensors and data collection tools will provide detailed operational data, including temperature readings and power usage, enabling better monitoring and optimisation of the process. These enhancements aim to make the system more practical for widespread adoption and to contribute valuable insights for future innovations in microwave catalytic deconstruction technology.

7 Conclusion

The optimisation of the microwave system for catalytic deconstruction of plastics holds significant promise in addressing the global plastic waste problem. By improving electrical efficiency, enhancing ease of use, and integrating advanced data collection capabilities, this project aims to create a more effective and user-friendly solution for converting plastic waste into valuable products. These advancements will not only contribute to ease of use but also provide the framework for scalability, fostering more sustainable waste management practices. Furthermore, this project aims to lay a foundation for future research and development in large-scale microwave catalytic deconstruction technology.