DESIGN AND FABRICATION OF A CONTINUOUS SCREW AUGER REACTOR FOR WASTE-TO-ENERGY CONVERSION OF PLASTICS

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Introduction:

Plastic waste has become a major environmental challenge due to rapid urbanization and the increasing use of disposable plastic products. In India, the consumption of plastic packaging and single-use plastics has significantly increased plastic waste generation. According to the Central Pollution Control Board, India generates nearly 3.4 million tonnes of plastic waste annually, and a considerable portion remains uncollected or improperly disposed of, causing environmental pollution and landfill accumulation [1]. Since plastics are non-biodegradable and require hundreds of years to degrade, their accumulation poses serious threats to ecosystems and human health [2]. Conventional disposal methods such as landfilling and incineration often lead to soil contamination and harmful emissions [3].

To overcome these challenges, waste-to-energy technologies have been explored as sustainable solutions for plastic waste management. Among these technologies, pyrolysis is considered an effective thermochemical process in which plastic waste is heated in the absence of oxygen to produce liquid oil, combustible gas, and char [4]. Studies indicate that pyrolysis of common plastics can produce high-energy fuel with calorific values comparable to diesel [5]. However, many pyrolysis systems operate using batch reactors, which may result in uneven heating and lower efficiency [6]. Continuous reactor systems improve heat transfer, process stability, and product yield [7]. In particular, the screw auger reactor enables controlled feeding, uniform residence time, and efficient mixing during the pyrolysis process [8]. This design enhances thermal efficiency and supports stable reactor operation [9]. Hence, the development of a continuous screw auger reactor provides an effective approach for converting plastic waste into useful fuel while reducing landfill burden and promoting sustainable waste management [10]. Therefore, this project focuses on the design and fabrication of a continuous screw auger reactor for converting plastic waste into energy. Figure 1 shows the schematic representation of the plastic pyrolysis setup, developed as a compact and low-cost system to convert plastic waste into useful fuel and reduce landfill burden.

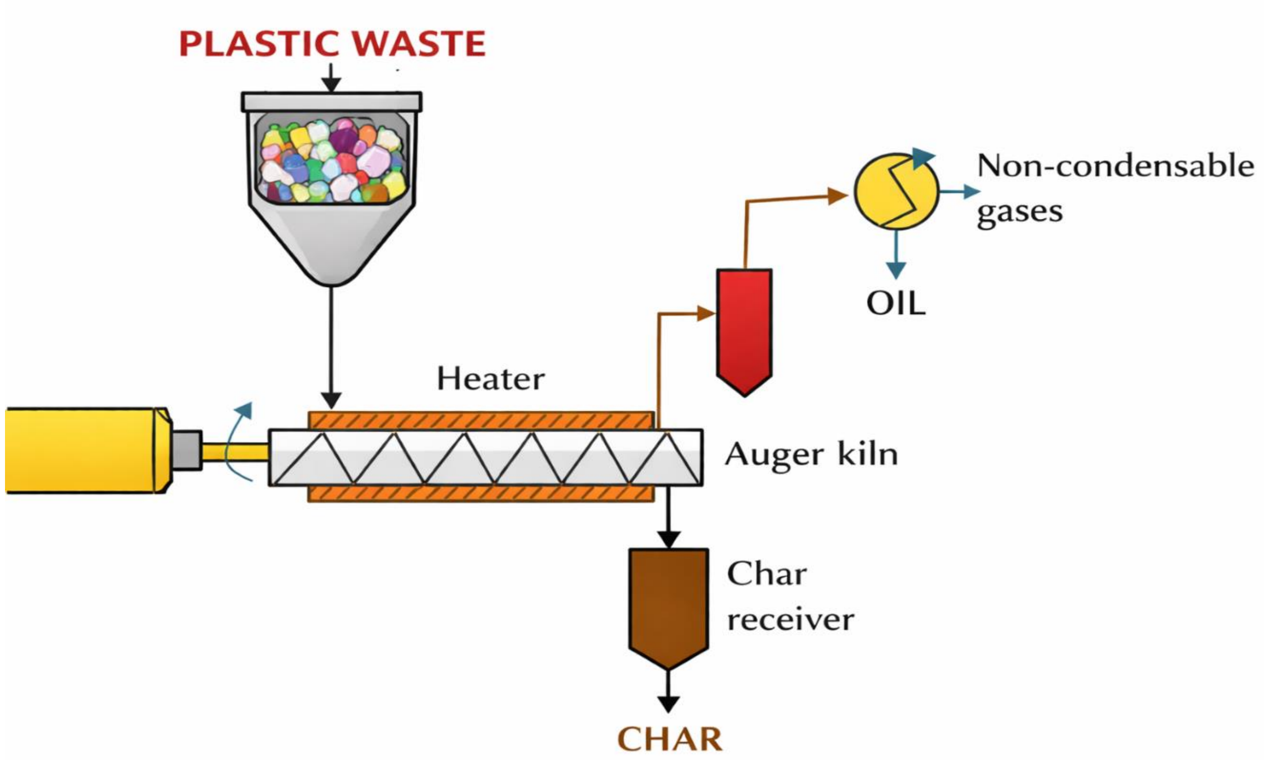

Figure 1: Schematic Representation of Plastic Pyrolysis Setup.

Objectives:

following are the objectives of the project

1. To design a continuous screw auger reactor system for efficient handling and transportation of plastic waste during the thermal conversion process.
2. To fabricate a prototype screw auger reactor using suitable materials capable of withstanding high temperatures involved in plastic pyrolysis
3. To convert plastic waste into useful energy products such as pyrolysis oil, combustible gases, and char through a controlled thermal process.
4. To evaluate the performance and efficiency of the reactor, including parameters such as temperature distribution, feed rate, and energy output.

Methodology:

The methodology for this project involves systematic steps to design, fabricate, and test a continuous screw auger pyrolysis reactor for converting plastic waste into energy:

1. Conduct a comprehensive literature review on existing plastic pyrolysis technologies, reactor types, and screw auger mechanisms.
2. Identify suitable plastic feedstocks for processing, such as polyethylene (PE), polypropylene (PP), and polystyrene (PS).
3. Estimate the expected yield of pyrolysis products, including liquid oil, combustible gas, and residual char.
4. Conceptualize a continuous reactor system, incorporating a feed hopper, heating zone, reactor barrel, screw auger, and condensation units (as shown in Figure 2.).

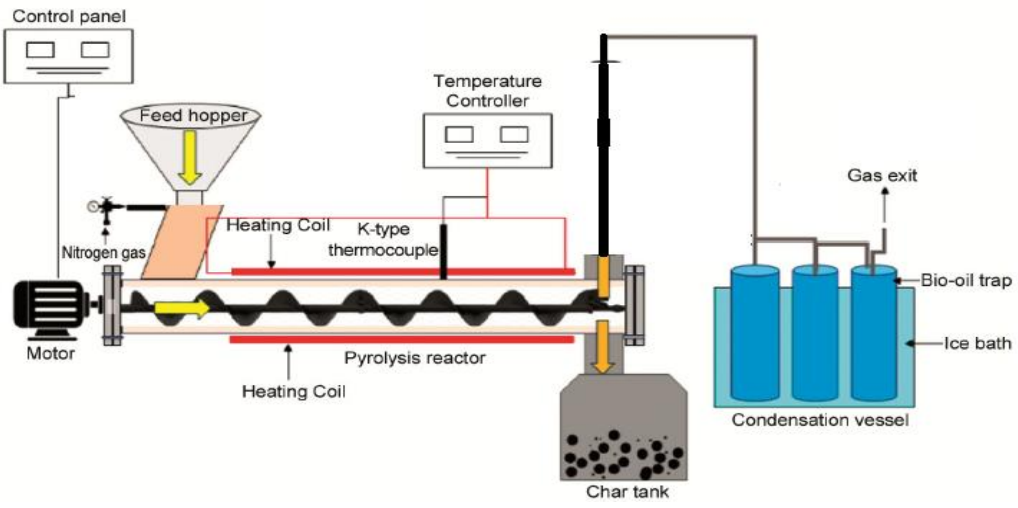

Figure 2: Pictorial Representation of Augur screw Plastic pyrolysis reactor.

5. Determine the design parameters of the screw auger, including diameter, pitch, length, and rotation speed, to ensure adequate residence time of plastics.
6. Develop a 3D CAD model of the reactor using SolidWorks or AutoCAD for visualization and design verification.
7. Perform thermal and mechanical calculations to ensure safe operation at target temperatures ranging from 300°C to 500°C.
8. Select suitable high-temperature and corrosion-resistant materials, such as stainless steel, for the reactor barrel and screw.
9. Choose insulation materials to minimize heat loss during pyrolysis.
10. Procure necessary metals, mechanical components, and electrical systems for fabrication.
11. Fabricate the screw auger, reactor barrel, heating system, feed inlet, and condensation units according to design specifications.
12. Assemble the reactor, ensuring proper alignment of the screw and airtight sealing to prevent leakage of pyrolysis vapors.
13. Integrate a control system to maintain optimal reactor temperature and screw rotation speed.
14. Conduct initial setup, and testing of the reactor system.
15. Optimize operational parameters, including screw speed, feed rate, and heating profile, to maximize energy recovery.
16. Perform pyrolysis experiments with selected plastic feedstocks.
17. Collect and separate the pyrolysis products: liquid oil, combustible gas, and residual char.
18. Analyze product yields, composition, and quality to evaluate efficiency.

Result and Conclusion:

Here’s a concise Result and Conclusion section tailored for the project titled “Design and Fabrication of a Continuous Screw Auger Reactor for Waste-to-Energy Conversion of Plastics”:

Results

1. The continuous screw auger reactor was successfully designed, fabricated, and assembled as per the specified parameters.

Figure 3: Pictorial Representation of Augur screw as per the design

2. Plastic feedstocks such as polyethylene (PE), and polypropylene (PP), need to be processed efficiently.
3. The pyrolysis experiments yielded three primary products:
    - Liquid oil – collected in condensation units.
    - Combustible gas – channeled through the gas outlet.
    - Residual char – accumulated in the char collection tank.
4. Optimal operational parameters (screw speed, feed rate, and heating profile) were established for maximum energy recovery.
5. The reactor operated safely at the target temperature range (300–500°C) without leakage or mechanical failure.
6. Thermal and mechanical stability of the reactor materials was maintained throughout the process.
7. The system may be proved capable of continuous operation with consistent product yield.

In conclusion, the continuous screw auger reactor successfully demonstrates the conversion of plastic waste into valuable energy products such as oil, gas, and char. PE and PP plastics, being abundantly available in Kalaburagi, showed high conversion efficiency. This project provides a sustainable approach for plastic waste management and energy recovery.

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Future Scope:

1. The reactor can be scaled up for industrial applications to handle larger volumes of plastic waste and enhance energy recovery.
2. Integration of advanced catalysts, automation, and sensor-based control can improve pyrolysis efficiency, product yield, and operational safety.
3. The system can be adapted for mixed plastic or organic waste, and the pyrolysis products can be upgraded to higher-quality fuels for sustainable energy production.