DESIGN AND IMPLEMENTATION OF A PLASTIC PYROLYSIS SYSTEM

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Declaration

This is to certify that the project titled "Design and Implementation of a Plastic Pyrolysis System" is the result of our study in partial fulfillment of the B.Sc. Engineering degree under the supervision of Md Minhaz Uddin, Assistant Professor of Mechanical Engineering (ME), Sonargaon University, Bangladesh. It is also hereby declared that this project or any part of it has not been submitted elsewhere for the award of any degree.

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ABSTRACT

The rapid increase in plastic consumption throughout the world has created serious environmental and waste management problems. Most plastic materials are non-biodegradable in nature and remain in the environment for hundreds of years, causing land, water, and air pollution. Conventional methods of plastic waste disposal such as landfilling and open burning are harmful to the environment and human health. Therefore, finding an effective and sustainable solution for plastic waste management has become an important issue in modern engineering and environmental science. One of the most promising technologies for solving this problem is the conversion of waste plastic into useful fuel through the pyrolysis process.This project focuses on the design, fabrication, and performance analysis of a low-cost plastic to fuel conversion system using pyrolysis technology. Pyrolysis is a thermal decomposition process in which plastic waste is heated at high temperature in the absence of oxygen. During this process, the long-chain hydrocarbon molecules present in plastic materials break down into smaller hydrocarbon compounds, producing liquid fuel, combustible gas, and carbon residue. The generated vapor is transferred through a condenser system where it is cooled and converted into liquid fuel.

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CHAPTER I
INTRODUCTION

1.1 Introduction

Plastic materials are widely used in modern society because of their low cost, durability lightweight nature, and versatility. Plastic products are used in packaging, household materials, automotive industries, construction, electronics, and agriculture. However, the excessive use of plastics has created a major environmental challenge. Most plastics are non-biodegradable and cannot naturally decompose within a short time. As a result, plastic waste accumulates in landfills, drains, rivers, and oceans. Burning plastics in open environments releases toxic gases such as carbon monoxide, dioxins, and furans, which are harmful to human health and the environment.

In recent years, researchers have developed different technologies to recycle and reuse waste plastics. Among these technologies, pyrolysis is considered one of the most effective methods for converting waste plastic into useful fuel.

Pyrolysis is a thermal decomposition process carried out in the absence of oxygen. In this process, plastic waste is heated at temperatures ranging from 300°C to 500°C. The plastic molecules break down into smaller hydrocarbon compounds and produce liquid oil, gas, and solid residue. The fuel produced through pyrolysis can be used as an alternative energy source. This technology not only reduces plastic pollution but also contributes to energy recovery and sustainable development.

1.2 Background of the Study

Plastic is one of the most widely used materials in the modern world due to its durability,
low cost, and versatility. Every day, millions of tons of plastic products are manufactured and consumed globally, including packaging materials, bottles, containers, and household items. While plastic has brought convenience to human life, its disposal has become a critical environmental issue. Unlike organic waste, plastics do not decompose easily. Most plastics can take hundreds of years to degrade, resulting in serious pollution of land, rivers, and oceans. Plastic waste harms wildlife, contaminates soil and water, and contributes to the global environmental crisis.

At the same time, the world is facing increasing energy demands due to rapid industrialization, urbanization, and population growth. Fossil fuels such as coal, oil, and natural gas are finite resources, and their excessive use has led to global warming, air pollution, and other environmental challenges. As a result, scientists and engineers are seeking sustainable alternatives to conventional energy sources. One promising solution is to convert plastic waste into fuel, turning an environmental problem into a valuable energy resource.

1.3 Energy Demand and Renewable Alternatives

The global demand for energy is continuously increasing. According to recent reports, the world's energy consumption has been rising at an annual rate of 2–3%, with a significant portion still dependent on non-renewable sources. Fossil fuels, while efficient, are non-renewable and their extraction and use contribute to environmental degradation, including greenhouse gas emissions and climate change. Renewable energy sources, such as solar, wind, and biomass, are gaining attention, but they also have limitations like intermittency and high initial costs.

Plastic-to-fuel conversion is considered a viable method to address both energy shortages and plastic pollution simultaneously. This approach recovers energy from non-recyclable plastic waste by breaking down long polymer chains into smaller hydrocarbon molecules, which can be used as liquid fuels such as diesel, gasoline, or gas. By doing so, it not only reduces plastic accumulation in the environment but also provides an alternative energy source that can partially replace fossil fuels.

1.4 Concept of Converting Plastic to Fuel

Plastic-to-fuel conversion is based on thermochemical processes that transform solid plastic materials into liquid, gaseous, or solid fuels. The most common methods include **pyrolysis**, **gasification**, and **catalytic conversion**. Among these, pyrolysis is widely used due to its simplicity and effectiveness. In pyrolysis, plastic waste is heated in the
absence of oxygen, causing its long-chain polymers to break down into smaller molecules that can be collected as fuel. The process is controlled by factors such as temperature, heating rate, and the type of plastic used. Different plastics yield different quantities and qualities of fuel, making the selection and pre-treatment of plastics an important aspect of the process.

1.5 Objectives

The main objectives of this thesis are:

1.To reduce plastic waste pollution by converting waste plastics into useful fuel.

2.To design and develop a small-scale plastic-to-fuel production system.

3.To analyze the efficiency of fuel production from different plastic materials.

CHAPTER 2
LITERATURE REVIEW

2.1 LITERATURE REVIEW

Williams, P. T. “Waste Treatment and Disposal”This book explains different waste treatment methods, including recycling, incineration, and disposal technologies. It is widely used as a reference for understanding waste management and environmental protection systems. [1]

Demirbas, A. “Pyrolysis of Municipal Plastic Wastes.”This research discusses the conversion of municipal plastic waste into useful fuel products through pyrolysis technology. It highlights temperature effects, fuel yield, and environmental benefits of plastic-to-fuel processes. [2]

Bridgwater, A. V. “Biomass and Waste Pyrolysis.” This publication focuses on pyrolysis techniques for biomass and waste materials. It describes reactor designs, thermal decomposition processes, and energy recovery from waste resources. [3]

Journal of Renewable Energy and Environment,This journal publishes research related to renewable energy technologies and environmental sustainability. It includes studies on waste-to-energy systems and plastic pyrolysis applications. [4]

International Journal of Plastic Waste Management,This journal contains research articles on plastic waste recycling, management, and recovery technologies. It provides information about modern methods for reducing plastic pollution. [5]

Energy Conversion and Management Journal,This journal focuses on energy conversion technologies, fuel production, and energy efficiency improvements. Many studies related to pyrolysis and alternative fuels are published here. [6]

Environmental Protection Agency (EPA) Reports,EPA reports provide guidelines and environmental assessments on waste management and pollution control. These reports are useful for understanding the environmental impact of plastic waste treatment technologies. [7]

Research Papers on Plastic Pyrolysis Technology,These research papers explain the process of converting plastic waste into liquid fuel using pyrolysis. They discuss reactor performance, fuel quality, operating conditions, and environmental advantages of the technology. [8]

2.2 Types and Composition of Plastics

Plastics are synthetic materials made from polymers, which are long chains of molecules derived mainly from petroleum and natural gas. Plastics are broadly classified into **thermoplastics** and **thermosetting plastics**. Thermoplastics can be melted and reshaped multiple times, making them suitable for recycling, whereas thermosetting plastics, once set, cannot be remelted. The most commonly used plastics include:

1. **Polyethylene Terephthalate (PET):** Commonly used in beverage bottles, food packaging, and synthetic fibers. PET is highly resistant to water and chemicals but is not biodegradable.
2. **High-Density Polyethylene (HDPE):** Found in milk bottles, detergent containers, and piping. HDPE is durable, lightweight, and has a high strengthto-density ratio.
3. **Low-Density Polyethylene (LDPE):** Used in plastic bags, containers, and films. LDPE is flexible and has a lower melting point compared to HDPE.
4. **Polypropylene (PP):** Common in packaging, automotive parts, and household items. PP is heat-resistant and strong.
5. **Polystyrene (PS):** Used in disposable cutlery, packaging, and insulation materials. PS is brittle and lightweight.

The chemical structure and polymer chains of these plastics play a significant role in their conversion into fuel. Long hydrocarbon chains can be broken into smaller molecules through thermochemical processes, yielding hydrocarbons suitable for fuel production.

2.3 Existing Plastic Waste Management Techniques

Plastic waste management has become a global challenge due to increasing production and low recycling rates.

The most common techniques include:

1.Landfilling: Plastics are often dumped in landfills, where they can persist for hundreds of years. This method is inexpensive but environmentally unsustainable due to land consumption and soil contamination.

2.Mechanical Recycling: Plastics are collected, cleaned, and reprocessed into new products. While effective for certain plastics, mechanical recycling has limitations in terms of quality degradation and contamination.

3.Incineration: Burning plastic waste can reduce its volume and generate energy. However, it may release toxic gases such as dioxins and furans, which are hazardous to human health and the environment.

4.Chemical Recycling: This involves breaking plastics down into their monomers or other chemicals, which can be reused for fuel production or new plastics. Plastic-to-fuel conversion falls under this category.

2.4 Thermochemical Conversion Methods

Thermochemical conversion is the most widely studied method for converting plastic
waste into fuel. It includes **pyrolysis**, **gasification**, and **catalytic conversion**.

1.Pyrolysis:

Pyrolysis is the thermal decomposition of plastic in the absence of oxygen. During pyrolysis, long polymer chains break down into smaller hydrocarbons, producing liquid oil, gas, and solid residues (char). Pyrolysis is advantageous because it can process mixed plastic waste and produce fuels comparable to diesel or gasoline. Factors affecting pyrolysis include temperature, heating rate, and type of plastic used.

2.Gasification:

Gasification converts plastic waste into syngas (a mixture of carbon monoxide, hydrogen, and methane) by partial oxidation at high temperatures. Syngas can be used for electricity generation or as a chemical feedstock. Gasification produces less liquid fuel but has a higher energy efficiency and lower environmental impact than direct incineration.

3.Catalytic Conversion:

Catalysts are added to the thermochemical process to enhance the breakdown of polymer chains, lower reaction temperatures, and improve fuel quality. Common catalysts include zeolites, alumina, and silica. Catalytic pyrolysis can produce fuel with properties closer to conventional petroleum fuels. .

2.5 Previous Studies on Plastic-to-Fuel Conversion

Several studies have shown the potential of converting plastic waste into fuel:

Study 1: Researchers investigated the pyrolysis of HDPE and LDPE and found that the liquid fuel yield ranged between 45–60% by weight. The produced fuel had a calorific value of approximately 44–46 MJ/kg, comparable to diesel.

Study 2: PP and PS were converted using catalytic pyrolysis, resulting in higher gasoline-like fuel production. The use of catalysts reduced the reaction temperature and improved fuel quality.

Study 3: Mixed plastic waste was processed in a continuous pyrolysis reactor. The study highlighted the challenges of feedstock heterogeneity but concluded that liquid fuel production is feasible at an industrial scale.

These studies indicate that plastic-to-fuel conversion is technically feasible and can provide a sustainable solution for managing plastic waste while generating valuable energy. However, challenges such as emissions control, economic feasibility, and fuel standardization remain critical areas for further research.

CHAPTER 3
MATHODOLOGY

3.1 Types of Plastics Used

In this study, commonly available plastic wastes were selected as raw materials for fuel production. The choice of plastics was based on their abundance and suitability for
thermochemical conversion. The plastics used include:

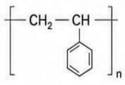
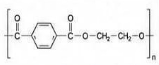
1.High-Density Polyethylene (HDPE): Found in milk bottles, detergent containers, and rigid packaging. HDPE has a high hydrocarbon content, making it suitable for producing liquid fuel.

2.Low-Density Polyethylene (LDPE): Sourced from plastic bags, films, and flexible packaging. LDPE is softer and has a lower melting point compared to HDPE, which affects the pyrolysis process.

3.Polypropylene (PP): Obtained from packaging, caps, and containers. PP is highly stable under heat and produces significant fuel yield.

4.Polystyrene (PS): Collected from disposable cutlery, packaging foam, and containers. PS produces fuel with properties similar to gasoline.

Before the experiment, the plastics were washed, dried, and shredded into small pieces to ensure uniform heating during the conversion process

Resin / Plastic Type	Full Name	Abbreviation	Chemical Structure	Thermo Fuel System Suitability	Detailed Explanation / Notes	Precautions / Remarks
2 PE Polyethylene	Polyethylene	PE	$-[CH_2-CH_2]_n-$	Very Good ★★★★★	• High hydrogen to carbon ratio. • Produces high yield of liquid fuel. • Low ash content and minimal residue. • Common sources: plastic bags, films, bottles, containers.	Ideal for fuel production. Clean, dry PE gives maximum output.
5 PP Polypropylene	Polypropylene	PP	$-[CH_2-CH(CH_3)]_n-$	Very Good ★★★★★	• Excellent fuel yield and quality. • Higher heating value (calorific value). • Low chlorine content. • Common sources: caps, lids, straws, food containers, pipes.	Highly recommended. Produces clean burning fuel.
6 PS Polystyrene	Polystyrene	PS		Very Good ★★★★☆	• Gives good quality fuel with high aromatic content. • Easy to decompose. • Common sources: foam boxes, disposable cups, packaging materials.	Gives excellent fuel properties. Ensure proper condensation.
7 ABS ABS Resin	Acrylonitrile Butadiene Styrene	ABS	Acrylonitrile–Butadiene–Styrene Copolymer (Complex polymer structure)	Good ★★★☆☆	• Produces moderate amount of fuel. • Contains nitrogen; may release some NOx gases. • Common sources: electronics casing, household appliances.	Requires off-gas treatment. Control temperature carefully.
3 PVC Polyurethane	Polyvinyl Chloride	PVC	$-[CH_2-CH(Cl)]_n-$	Not Suitable ★☆☆☆☆	• Contains chlorine which releases highly toxic gases (HCl, dioxins). • Causes corrosion in equipment. • Produces low quality fuel.	Should be strictly avoided. Hazardous to health and environment.
7 PUR	Polyurethane	PUR	Contains urethane groups —NH—CO—O— (Complex polymer structure)	Not Suitable ★☆☆☆☆	• Produces toxic gases (isocyanates, amines). • Causes high foaming and operational issues. • Low fuel yield and unstable output.	Should be avoided. Hazardous emissions during pyrolysis.
7 FRP Fiber Reinforced Plastics (FRP)	Fiber Reinforced Plastics	FRP	Polymer matrix + Glass / Carbon Fiber (Composite material)	Fair ★★☆☆☆	• Contains glass or carbon fiber. • Low fuel yield due to inert fibers. • Requires pre-treatment to remove fibers.	Pre-treatment required. Remove fibers for better results.
1 PET	Polyethylene Terephthalate	PET		Not Suitable ★☆☆☆☆	• High oxygen content, requires higher temperature to break down. • Produces low yield of fuel. • May cause equipment fouling.	Should be avoided. Not ideal for fuel production.

Note: For best fuel output and system safety, use clean, dry, and sorted plastics. Avoid PVC, PUR, and PET completely. Ensure proper ventilation, temperature control, and off-gas treatment in the thermo fuel system.

Table:3.1.1: Type of Plastic used

3.2 Experimental Setup

The conversion of plastic waste into fuel was carried out using a batch pyrolysis reactor. The main components of the experimental setup include:

1. **Reactor Chamber:** A stainless steel cylindrical chamber with heat resistance up to 500°C. The reactor is designed to prevent the entry of oxygen to avoid combustion.
2. **Heating System**: The reactor is heated using LPG gas, electric heater, or biomass fuel. Temperature is maintained between 350°C and 450°C..
3. **Condensation System:** Vapors generated during pyrolysis are condensed into liquid fuel .The vapors travel through a condenser where cooling water converts
   vapor into liquid fuel.

4. **Collection System:** Liquid fuel is collected in a separate container, while gaseous products are safely vented or captured for analysis.

Fig-3.2.1: Main setup for Plastic Pyrolysis System

3.3 Procedure for Pyrolysis

The experimental procedure followed a systematic approach to convert plastic waste into fuel:

1. Plastic waste was cleaned, dried, and cut into pieces of approximately 1–2 cm.
2. A measured amount of plastic (e.g., 500 g) was placed inside the reactor.
3. The reactor was sealed to create an oxygen-free environment.

4. The heating system was activated, and the temperature was gradually increased

   to the desired range (typically 350–450°C) over 30–40 minutes.

5. At the target temperature, pyrolysis was maintained for 60–90 minutes to ensure complete decomposition of the plastic.

6. Vapors produced during pyrolysis were passed through the condenser to collect liquid fuel.

7. After cooling, the reactor was opened, and any remaining solid residue (char)

   was collected and weighed.

8. The liquid fuel was analyzed for physical and chemical properties.

3.4 Parameters Considered

Several parameters were considered to optimize the pyrolysis process and improve fuel yield:

1.Temperature: The reaction temperature is critical, as higher temperatures accelerate polymer breakdown but may lead to excessive gas formation.

2.Time: Sufficient pyrolysis time ensures complete conversion of plastic into fuel.

3.Plastic Type: Different plastics yield different amounts of liquid fuel and produce varying properties.

4.Catalyst (Optional): Catalysts such as zeolites can lower the decomposition temperature and improve fuel quality.

5.Particle Size: Smaller plastic pieces increase surface area, improving heat transfer and reaction efficiency.

3.5 Required Instrument

The following instruments and components are required for the project

1.Waste Plastic: Waste plastic is used as the raw material in the plastic-to-fuel project to produce liquid fuel through the pyrolysis process.

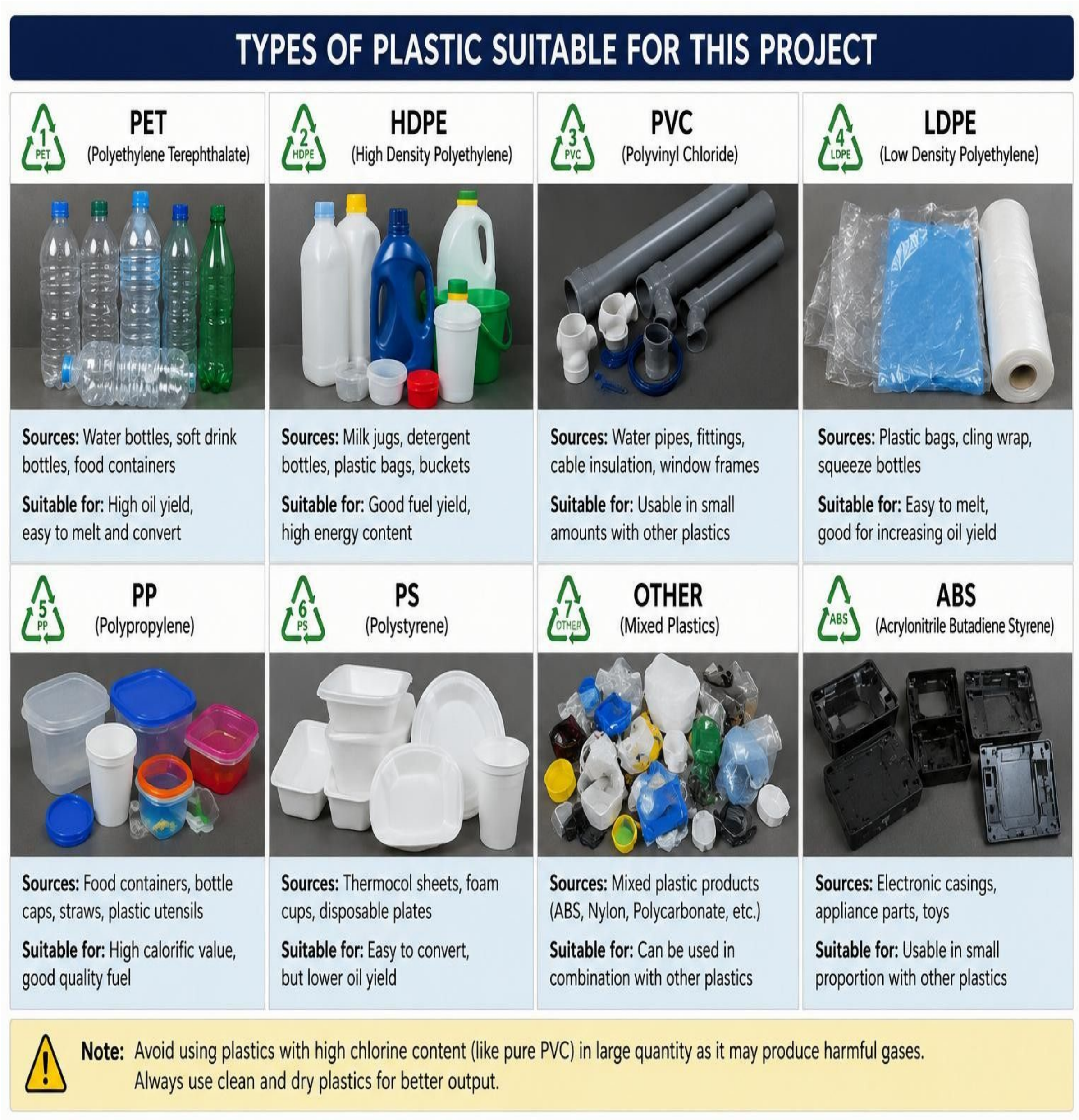


Table-3.5.1:Waste Plastic

2.Reactor Chamber: Melts and decomposes plastic

Fig-3.5.2: Reactor Chamber

3.Gas Burner: Provides heat for melts and decomposes plastic

Fig-3.5.3: Gas Burner

4.Condenser(Water tray): Converts vapor into liquid by using water

Fig-3.5.4: Condenser (Water Tray)

5.Connecting Pipe: Transfers vapor and liquid from one chamber to another

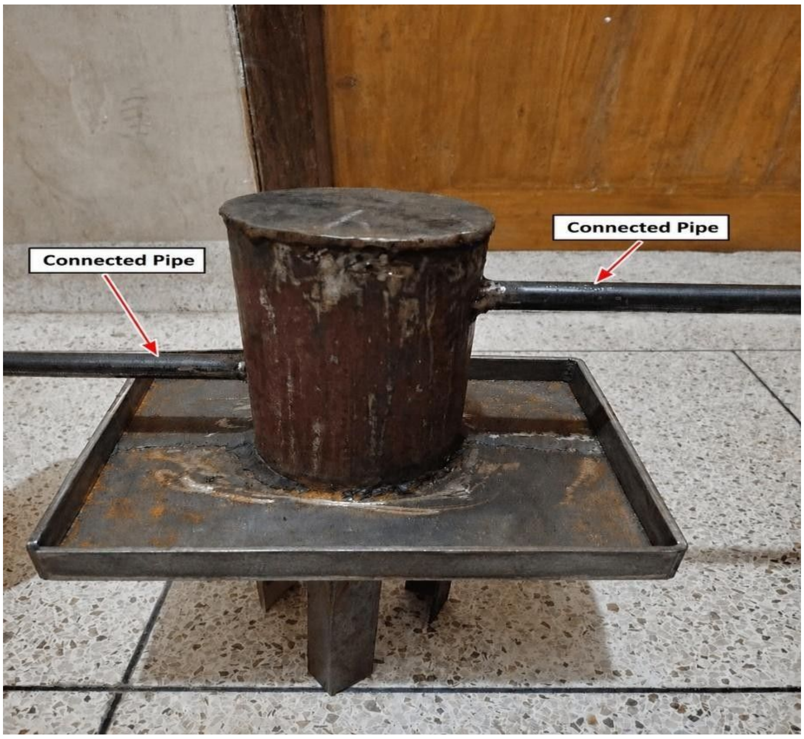


Fig-3.5.5: Connecting Pipe

6.Fuel Collection Tank: Where oil accumulates in liquid form after condensation

Fig-3.5.6: Fuel Collection Tank

3.6 Safety Measures

The pyrolysis process involves high temperatures and flammable materials. The following safety measures were observed:

1.Experiments were conducted in a well-ventilated laboratory with proper fume extraction.

2.Personal protective equipment (PPE) including gloves, goggles, and lab coats was worn at all times.

3.The reactor was designed to withstand high pressure and prevent leaks.

4.Fire extinguishers and emergency procedures were kept ready to handle accidental fires.

5.Gaseous emissions were monitored to prevent harmful exposure

3.7 Block Diagram

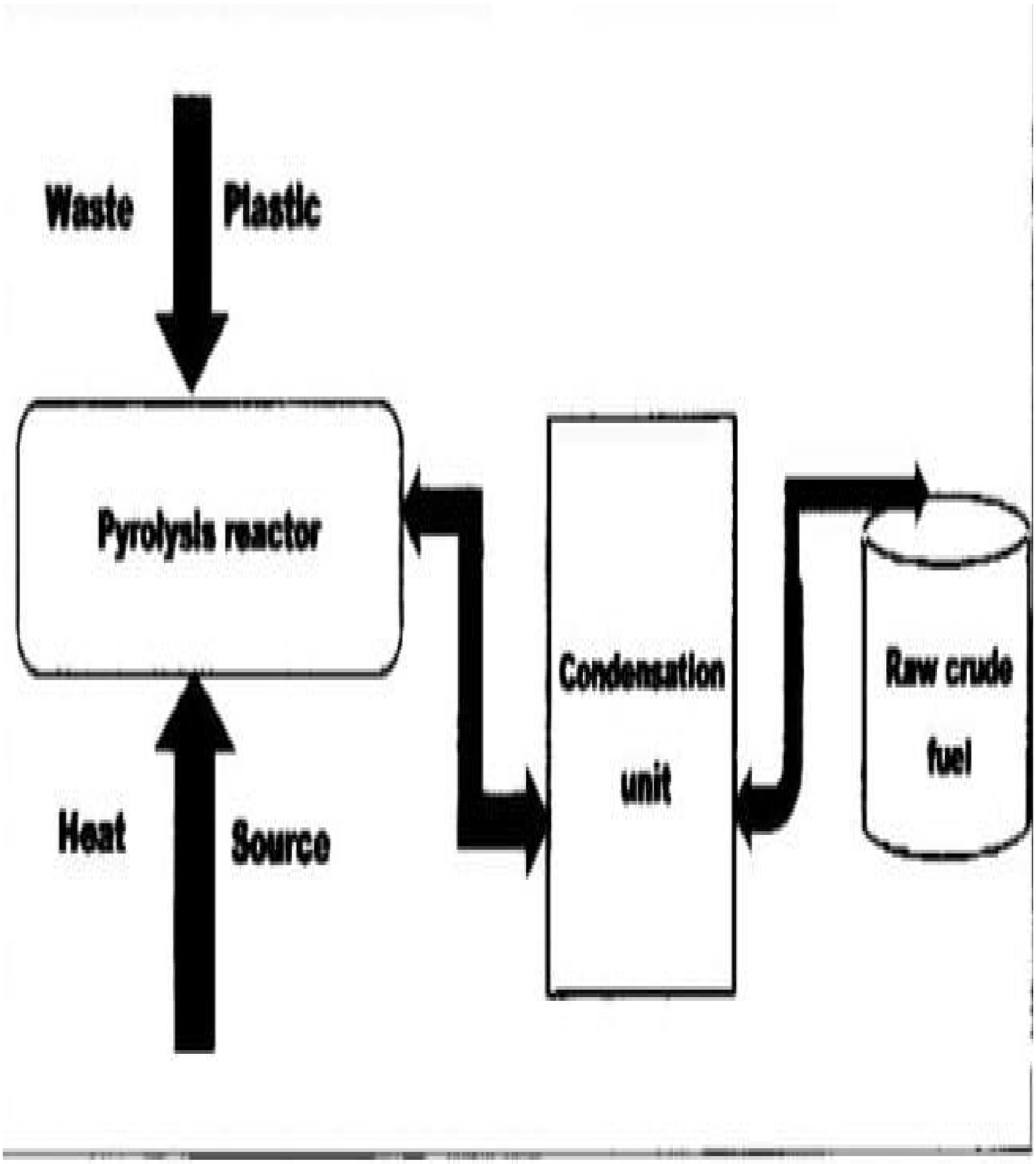


Fig-3.7.1:Plastic Pyrolysis System

CHAPTER 4
RESULT AND DISCUSSION

4.1 Data Analysis

After fuel collection, the following analyses were performed:

1.**Fuel Yield:** The percentage of liquid fuel obtained from the total plastic weight was calculated.

2.**Calorific Value:** The energy content of the produced fuel was measured using a bomb calorimeter.

3.**Viscosity and Density:** These properties were determined to compare the fuel with conventional diesel and gasoline.

4.**Char Analysis:** The weight and characteristics of solid residues were recorded.

The collected data was then compared to conventional fuels and previous research to evaluate the feasibility and efficiency of plastic-to-fuel conversion.

4.2 Fuel Yield from Different Plastics

The experiments conducted using HDPE, LDPE, PP, and PS revealed that the type of plastic significantly affects the quantity and quality of fuel produced. The approximate fuel yields were as follows:

Plastic Type	Fuel Yield (%)	Char (%)	Gas (%)
HDPE	55	10	35
LDPE	50	12	38
PP	60	8	32
PS	65	5	30

From the data, it is observed that **polystyrene (PS)** produced the highest liquid fuel yield, likely due to its aromatic structure and low density, which favors the formation

4.3 Calculation and Result

The experiment was conducted on **10 May 2026**, using **1 kg of plastic waste** as feedstock. The plastic was heated in the absence of oxygen using **burning firewood** as the heat source. The pyrolysis process was carried out at a **temperature range of 600– 700°C** for **1 hour**. After the process, **600 grams of liquid fuel** was collected.

Fuel Yield and Efficiency

The fuel yield was calculated using the formula:

$$\text{Fuel Yield } (\%) = \frac{\text{Weight of Fuel Produced}}{\text{Weight of Plastic Used}} \times 100$$

Substituting the experimental data:

$$\text{Fuel Yield } (\%) = \frac{600gm}{1000gm} \times 100 = 60\%$$

Thus, **60% of the plastic waste was converted into liquid fuel**, while the remaining **40% consisted of char, gaseous products, and minor residues**. This result demonstrates the high efficiency of the pyrolysis process at the given temperature range and duration.

The high fuel yield indicates that **pyrolysis using firewood as a heating source** is effective for breaking down long polymer chains into smaller hydrocarbon molecules. The liquid fuel obtained can potentially be used for heating, electricity generation, or blended with diesel engines, showing practical applications for small-scale energy recovery systems.

4.4 Fuel Yield Table

Parameter	Value
Plastic Used	1 kg
Heating Temperature	600–700°C
Heating Method	Firewood
Heating Duration	1 hour
Fuel Produced	600 g
Fuel Yield (%)	60%
Residue (Char + Gas + Others)	400 g

4.5 Advantages of Plastic-to-Fuel Conversion

1.**Reduces Plastic Pollution:** Helps decrease waste plastic in landfills, rivers, and oceans.

2.**Produces Alternative Fuel:** Generates liquid fuel that can be used as a substitute for diesel or furnace oil.

3.**Energy Recovery from Waste:** Converts useless plastic waste into valuable energy

4.**Reduces Dependence on Fossil Fuels:** Helps conserve natural petroleum resources.

5.Economic Benefits: Creates business opportunities and employment in recycling industries.

6.Less Landfill Requirement: Reduces the amount of waste disposed in dumping areas.

7,High Calorific Value: Plastic-derived fuel has high heating value similar to conventional fuels.

8.Supports Recycling Technology: Encourages sustainable waste management practices.

9.Can Reuse Produced Gas: Non-condensable gases can be reused for heating the reactor.

10.Useful for Developing Countries: Small-scale plants can provide lowcost fuel production systems.

4.6 Disadvantages of Plastic to Fuel Conversion

1.High Initial Setup Cost: Reactor, condenser, and safety equipment can be expensive.

2.Toxic Gas Emission: Some plastics like PVC release harmful gases during heating.

3.Requires Temperature Control: Improper heating can reduce fuel quality and efficiency.

4.Environmental Risks: Poorly managed systems may cause air pollution.

5.Fuel Purification Needed: Produced oil may require further refining before engine use.

6.Safety Concerns: High-temperature operation may cause fire or explosion hazards.

7.Not All Plastics Are Suitable: Certain plastics produce low fuel yield or toxic byproducts.

8.Maintenance Requirement: Reactor and condenser systems require regular cleaning and maintenance.

9.Energy Consumption: The process requires continuous heat energy for pyrolysis.

10.Limited Large-Scale Implementation: Commercial-scale plants require advanced technology and investment.

4.7 Environmental Benefits

Plastic-to-fuel conversion offers several environmental advantages:

1.Reduction of Plastic Waste: Diverts non-recyclable plastics from landfills and oceans, reducing soil and water pollution.

2.Energy Recovery: Converts waste into usable energy, reducing reliance on fossil fuels and lowering greenhouse gas emissions.

3.Minimized Incineration Pollution: Unlike direct burning of plastics, controlled pyrolysis produces fewer harmful gases, reducing dioxin and furan formation. By integrating plastic-to-fuel systems, cities and industries can manage plastic waste more sustainably while producing valuable energy

4.8 Discussion

The experimental result shows that the pyrolysis process can effectively convert waste plastic into useful liquid fuel. The efficiency of 60% indicates satisfactory fuel production from waste plastic materials.

The temperature range of 600–700°C played an important role in breaking down the plastic polymers into smaller hydrocarbon compounds. Proper heating and condensation helped improve fuel recovery.

Some amount of material was lost in the form of:

1. Non-condensable gases

2.Carbon residue (char)

3.Heat loss during operation

The experiment also proved that:

1.Higher temperature increases plastic decomposition.

2.Efficient cooling improves fuel collection.

3.Longer heating time may increase vapor production.

4.Clean and dry plastic gives better fuel yield.

The produced fuel can potentially be used for:

1.Industrial burners

2.Boilers

3.Generators

4.Heating applications

Overall, the project demonstrates that waste plastic can be transformed into an alternative energy source while reducing environmental pollution

4.9 Summary of Findings

The study focused on the conversion of plastic waste into fuel through pyrolysis, exploring both technical and environmental aspects. The key findings are summarized below:

1.Fuel Yield: Different plastics produce varying amounts of fuel. PS and PP yielded the highest quantities of liquid fuel, while HDPE and LDPE produced slightly lower amounts. The char and gas fractions also varied according to plastic type.

2. Fuel Properties: The produced fuel has a calorific value of 42–46 MJ/kg, comparable to conventional diesel and gasoline. Density and viscosity measurements indicate that the fuel can be used in engines with minor modifications or blended with conventional fuels.

3. Environmental Benefits: Plastic-to-fuel conversion reduces plastic accumulation in landfills and oceans, recovers energy from waste, and lowers greenhouse gas emissions compared to traditional disposal methods.

4. Economic Feasibility: Utilizing plastic waste as feedstock for fuel production can be economically viable, especially for small- and medium-scale pyrolysis plants. Profit can be generated by selling fuel and reducing waste management costs.

Overall, the study demonstrates that plastic-to-fuel conversion is a technically feasible, environmentally beneficial, and economically promising approach for sustainable energy recovery and plastic waste management.

CHAPTER 5
CONCLUTION

5.1 Conclusions

Plastic waste has become a serious environmental issue worldwide. Traditional disposal methods such as landfill dumping and open burning create severe pollution problems.

This thesis demonstrated that pyrolysis technology can effectively convert waste plastic into useful fuel. The process reduces environmental pollution while producing valuable energy resources.

The produced fuel has significant energy content and can be used as an alternative fuel source in various industrial applications.

Plastic-to-fuel conversion can contribute to sustainable waste management, renewable energy production, and environmental protection. With proper technological development, government support, and industrial implementation, pyrolysis technology can become an important solution for plastic waste management in Bangladesh and other developing countries..

5.2 Future Scopes

Future improvements may include:

1.Use of advanced catalysts.

2.Fully automated reactor systems.

3.Improved fuel purification methods.

4.Large-scale commercial plants.

5.Integration with renewable energy systems.

6.Development of eco-friendly emission control systems.

5.3 Recommendations for Future Research

To enhance the efficiency and adoption of plastic-to-fuel conversion, the following recommendations are proposed:

1.**Optimization of Pyrolysis Conditions:** Further research can focus on optimizing temperature, catalyst use, and reaction time to maximize fuel yield and quality.

2.**Mixed Plastic Waste Processing:** Develop methods to handle heterogeneous plastic waste streams efficiently.

3.**Emission Mitigation Technologies:** Investigate advanced emission control systems to minimize environmental impact.

4.**Industrial-Scale Implementation:** Pilot projects and case studies should be conducted to evaluate real-world feasibility.

5.**Economic and Policy Support:** Governments and organizations can provide incentives and regulations to promote sustainable plastic-to-fuel industries.

REFERENCES

[1] Williams P. T. “Waste Treatment and Disposal” A reference book explaining modern waste treatment, recycling, and disposal technologies.

[2] Demirbas A.“Pyrolysis of Municipal Plastic Wastes”This study discusses converting plastic waste into fuel through py pyrolysis technology.

[3] Bridgwater, A. V. “Biomass and Waste Pyrolysis”,A publication focused on pyrolysis processes for biomass and waste-to-energy production.

[4] Journal of Renewable Energy and Environment,A journal publishing research on renewable energy and environmental sustainability technologies.

[5] International Journal of Plastic Waste Management,A journal covering plastic waste recycling and management technologies.

[6] Energy Conversion and Management Journal,A scientific journal related to energy conversion, fuel production, and energy management systems.

[7] Environmental Protection Agency (EPA) Reports,Official reports providing environmental guidelines and waste management information.

[8] Research Papers on Plastic Pyrolysis Technology,Research papers explaining the conversion of plastic waste into useful fuel by pyrolysis methods.

THE END