Recycle of Waste Plastic into Alternate Fuel

Research Project Report

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In

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Submitted By

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ABSTRACT

This study presents a method to tackle the plastic waste issue by turning plastics into fuel. It explains how certain plastics like LDPE, HDPE, and PP can be transformed into oils. The research differentiates between plastics that can be reshaped with heat and those that cannot. It suggests using plastics that burn well and have less water for making fuel. The study also considers how to do this without harming the environment or health. It looks at how the toughness of plastic affects the way it's prepared, the temperature it's burned at, and its final use. Problems like pollution, leftover ash, and damage to materials are also covered. The report stresses the importance of managing plastic waste sustainably and adapting technology to handle changes. It also highlights the need to evaluate the type of fuel and the quality of stoves to get the most energy and minimize harmful gases and ash.

KEYWORDS: Plastic Waste , Alternate Fuel , Pyrolysis , Liquid Fuel , Compact Fuel , Refuse Derived Fuel , Fuel Production

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ACRONYMS

RDF	Refuse Derived Fuel
SRF	Solid Recovered Fuel
RDP	Refuse Derived Paper
PDF	Plastic Densified Fuel

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CHAPTER 1: INTRODUCTION

This new content aims to provide an overview of the progress already made in converting plastic waste into resources. It shows the way to convert waste plastic into material, liquid and gaseous fuel for immediate use by directly crushing it. They are made from high molecular weight compounds, and other materials can be added to the compounds to improve performance and reduce costs. These compounds can be molded or extruded into the desired shape. It can be made into new plastic products. Examples include polyethylene, polystyrene and polyvinyl chloride, among others. They are not suitable for heat treatment and therefore remain silent. For example, phenol and urea formaldehyde. And its moisture content is less than biomass such as waste. High quality raw materials and flame are used in the process of converting plastic waste into fuel. Each specific non-rubber treatment has its own components. and antimony or resins containing nitrogen, sulfur, or other substances harmful to humans and the environment. Energy, fuel efficiency, emission factors (e.g. removal of pollutants or fumes such as nitrogen dioxide and hydrogen chloride), ash mixture and equipment may contribute to chemical corrosion.

From renewable materials to converters: Before being converted into electronic products, plastic waste is subjected to various pre-treatments for easy conversion and control of the next change, the default property used for each variable. Efficient conversion into fuel products: In the production of fuel products, thermoplastics are separated and combined with other non-chemical liquids such as paper, wood and thermoset plastics and become blankets or briquettes. When wood material is pelletized using a pelletizer, mix the resin with wood or hard paper for the preparation process. Composting is necessary to produce thermoplastic pellets and other combustible waste. The type of plastic used to determine the value of the specification and the value of the product. The presence of unnecessary products and moisture causes energy consumption and helps eliminate side effects of the oil production process. Improved heating recovery function. For example, nitrogen, chlorine and inorganic pollution can affect the composition of the gas and ash produced.

CHAPTER 2: LITERATURE SURVEY

The literature survey encompasses various studies and resources related to the conversion of plastic waste into alternative energy sources. These investigations explore methods such as conventional slow pyrolysis, which involves transforming plastic waste from municipal landfills into fuel oil. The research focuses on different proportions of liquid fuel produced through non-catalyst pyrolysis. Other studies delve into the production, characterization, and fuel properties of alternative diesel fuel derived from pyrolysis of waste plastic grocery bags. Additionally, research investigates the potential of waste plastic, particularly Low-Density Polyethylene (LDPE), as a source of alternative energy. Books and articles cover topics such as suitable plastics for pyrolysis recycling, the mechanism of pyrolytic degradation, and the characterization of pyrolysis products. Furthermore, there are efforts by companies to convert plastic waste into synthetic diesel and kerosene, emphasizing environmental approval and sustainable practices. Overall, these studies contribute to the understanding of plastic waste management and its potential as a valuable energy resource .

CHAPTER 3 : PROBLEM FORMULATION

The research paper addresses the critical issue of plastic waste by exploring a method to convert plastics into alternative energy sources. Specifically, the study focuses on transforming plastics like LDPE, HDPE, and PP into various types of oils. The selection of plastics for conversion is crucial, with preference given to those that are flammable and have low moisture content, as these characteristics are conducive to fuel production. The research emphasizes the importance of choosing high-quality plastics that do not contain harmful substances. Additionally, the study sheds light on challenges related to emissions, residual ash, and equipment corrosion. It underscores the need for sustainable plastic waste management practices and the adaptation of technology to facilitate the conversion process. Ultimately, the research aims to maximize energy recovery while minimizing the environmental impact of emissions and ash[1].

CHAPTER 4 :METHODOLOGY

Conversion of Discarded Plastics into Fuel: A Procedure

4.1 Materials for Processing

1. Discarded tires and rubber.
2. Plastic bags no longer in use.
3. Abandoned buckets.
4. Household plastic waste, including toys and bottles.
5. Hospital waste, such as used injections and plastic bottles.
6. Any other form of plastic waste is also acceptable.

Table 1 : Raw materials and their main products (3)

Main products	Type of plastics	As a feedstock of liquid fuel
Liquid hydrocarbons	Polyethylene (PE) Polypropylene (PP) Polystyrene (PS) Polymethyl methacrylate (PMMA)	Allowed Allowed Allowed Allowed
Liquid hydrocarbons	Acrylonitrile-Butadiene-Styrene copolymer (ABS)	Allowed But not suitable. Nitrogen-containing fuel is obtained, Special attention required to cyanide in oil
No hydrocarbons suitable for fuel	Polyvinyl alcohol (PVA) Polyoxymethylene (POM)	Not suitable, Formation of water and alcohol. Not suitable Formation of formaldehyde
Solid products	Polyethylene	Not suitable Formation of terephthalic acid and benzoic acid.
Carbons products	Polyurethane (PUR) Phenol resin (PF)	Not suitable. Not suitable
Hydrogen chloride and carbons products	Polyvinyl chloride (PVC) Polyvinylidene chloride (PVDC)	Not allowed

4.2 **Essential Machinery**

- Reactor vessel
- Reboiler
- Pressure vessel
- Hydrocarbon-oil

Fig 1 - Plastic purification Machine (5)

4.3 **Machine for Plastic Cleaning (Purification)**

This machine is used to remove water, soil, dust, and other unwanted substances from the plastic. It ensures the plastic is thoroughly dried and cleaned before it is introduced into the reactor vessel.

Fig 2 Model of Convention Waste Plastic into Fuel (3)

4.4 **Utilization:**

The technology for extracting biodiesel from waste tires and plastics is a renewable source. This advanced biodiesel plant design ensures the production of high-quality diesel and gasoline that meet national standards and can be used in motor vehicles. The technology stands out for its low production cost, simplicity, and minimal environmental pollution, addressing the processing issues of waste rubber, tires, and plastics.

4.5. **Overview of the Fuel Production Line from Waste Tire Pyrolysis:**

1. Old tires or rubber items are turned into useful things through a special process. First, they are sorted and brokendown. Next, they are mixed with a special material in a machine that heats them up and breaks them down further. After that, a process is used to take out the black carbon, which can involve cleaning out sulfur or nitrogen. Finally, the material is cut into small pieces and goes through a cleaning process in a tall tower to make oil from tires.

2.The tire oil is heated for degumming and dehydration, and sulfuric acid is added at a Temperature of 30-50 °C for acidification. The process involves separating precipitation and removing acid sludge and gum.

3. To clean something using this method, you need to wash it several times, about three to five times. After that, you .add a chemical called sodium hydroxide to make the solution neutral. Then, the used cleaning liquid is treated, and clay is added to the mix to take away any color, finishing up the process.

4. The crude bio-diesel is filtered by a frame filter, followed by catalytic-distillation. Other oils and catalysts are added to produce high quality bio-diesel.

4.6 **Key Features of the Waste Tire to Pyrolysis Biodiesel Plant:**

1.The acid sludge and gum produced after deacidification and precipitation can be used to make a waterproof membrane.

2.The neutralization of waste acid and alkali after washing can produce sodium sulfate.

3.The waste generated after bleaching and filtration with activated clay can be used as fuel.

4.7 **The Advantage of Plastic20il:**

With its innovative plastic200 (P20) technology, Plastic20il Inc. has developed a process that produces ultra-clean, ultra-low sulfur fuel directly from unwashed, unsorted waste plastics without requiring further refining. Plastic20il Inc. promotes environmental sustainability and stimulates local economies by creating green jobs. We anticipate that our P20 technology will revolutionize management practices, redefine the recycling landscape, and shape the future of recycling. Our P20 technology has successfully overcome significant challenges in the fuel industry. Some of the key differentiators of our process are outlined below.

4.8 **Verification & Liscensing**

The P20 technology has been authenticated by esteemed independent laboratories, including IsleChem (for process engineering) and Conestoga-Rovers & Associates (for emissions stack testing).Plastic2018 has received all the required permits for operation from the New York State Department of Environmental Conservation (NYSDEC).

Plastic20il has been granted an exemption from Air Permitting in the state where the first site will be established under the agreement with Rock-Tenn Company ("Rock-Tenn"). An engineering report conducted by SAIC confirms and validates the technology and its economic feasibility.

4.9. **Processing Unit**

1. The processing unit necessitates 4,600 sq. ft. of operational area.

2. The height requirement is approximately 18 to 22 ft.

3. The unit is highly automated, resulting in a very low operator-to-processor ratio.

4. The system is made with parts that fit together easily, so it can be set up quickly and work well without any hassle.

4.10 **Input Materials**

The P20 processor is capable of managing unwashed and unsorted waste plastics, with a focus on polyethylene and polypropylene as the preferred feedstock. The New York State Department of Environmental Conservation (NYSDEC) has granted approval for the P20 process to handle up to 4,000 pounds of plastic feedstock per machine per hour at the company's facility in Niagara Falls, NY.

4.11. **Processing Method**

1.Fuel Conversion Rate: On average, 86% of waste plastic can be converted into fuel. Specifically, approximately 1 gallon of fuel can be produced from every 8.3 pounds of plastic.

2. Energy Efficiency: The processor efficiently utilizes its own off-gases as fuel, accounting for approximately 10-12% of the process output. This design minimizes the external energy required to operate the machine. Additionally, around 2-4% of the end product is Petcock (Carbon Black), a high BTU fuel.

3. Emissions: The emissions from this process are lower than those from a natural gas furnace of a similar size. Furthermore, the quality of emissions improves as the feed rates increase.

4.12 **Resource Consumption**

The P20 processor is intentionally designed for energy efficiency, which greatly impacts its commercial viability. It utilizes water solely for cooling, recycling it in a closed loop to maintain cleanliness and prevent contamination. The entire process requires only 53 kilowatt-hours (kWh) of electricity, with no energy consumption during the plastic-to-fuel conversion.

4.13 **Fuel Production**

The fuel produced by the P20 processor has undergone rigorous validation by independent petrochemical labs, including Intertek, Petro Labs, Alberta Resource Council, and Southwest Research Institute. All shipments leaving the P20 plant in Niagara Falls are meticulously tested in the company's fully equipped internal fuel testing lab. Notably, the fuel is ready for sale immediately after processing, eliminating the need for additional refinement step.

4.12.**Extent of Liquid Fuel in this Compendium**

The process involves decomposing plastics in a reactor at temperatures between 450°C and 550°C. Depending on the pyrolysis conditions and plastic type, carbonaceous matter gradually forms. Liquid fuel, derived from specific thermoplastics like PE, PP, and PS, can be produced without further refinement. However, contaminants such as amines, alcohols, and inorganic substances may be present, affecting fuel quality. Users should consider additives for optimal burner or engine performance. A JIS technical specification exists for pyrolytic oil used in boilers and diesel generators, but safety precautions are crucial due to the formation of highly flammable substances.

4.13 **Method of Production**

The process of converting plastic waste into liquid fuel involves several key steps. First, the plastics undergo **pyrolysis**, a thermal decomposition process in which they are heated in an inert gas (such as nitrogen). During pyrolysis, the plastics break down into smaller hydrocarbons.Next, the plastics are fed into a reactor, where they decompose further. Any residue or deposit on the reactor's inner surface is removed to maintain efficient heat conduction. The resulting mixture of liquid hydrocarbons, known as **oil**, is continuously distilled. As the waste plastics decompose, the evaporated oil rises to the reaction temperature.

To optimize the process, the evaporated oil is **cracked** using a catalyst. The boiling point of the produced oil is carefully controlled by adjusting the operating conditions of the reactor, cracker, and condenser. In some cases, **fractional distillation** equipment is used to meet specific user requirements.

High-boiling-point hydrocarbons like diesel, kerosene, and gasoline are condensed in a water-cooled condenser. These liquid hydrocarbons are then collected in a storage tank. However, gaseous hydrocarbons such as methane, ethane, propylene, and butanes cannot be condensed

4.14 **Feeding Methods and Reactor Types**

Feeding Methods: Depending on the type of waste plastic, different feeding methods are employed. The simplest approach is to directly introduce the waste plastics into the reactor without any pre-treatment. However, for soft plastics like films and bags, a shredder and a melter (hot melt extruder) are often used to facilitate their entry into the reactor, as they would otherwise occupy a significant volume.

Reactor Types: Various reactor designs exist, including kiln-type and screw-type reactors. Additionally, induction heating using electric power has emerged as an alternative to traditional burners.

Carbonaceous Matter: During the pyrolysis process, carbonaceous matter forms in the reactor. This acts as a heat insulator, affecting efficiency. In some tank reactors, a stirrer is used specifically to remove this carbonaceous residue. Alternatively, reactors may be equipped with a screw conveyor at the bottom to eliminate the carbonaceous matter.

Distillation and Composition: Once the liquid product of pyrolysis is obtained, it undergoes distillation. High-boiling-point hydrocarbons like diesel, kerosene, and gasoline are condensed, while gaseous hydrocarbons (such as methane and ethane) are incinerated. Operators must understand the relationship between waste plastic quantity, composition, and operating conditions. Energy consumption and plant costs relative to plastic treatment capacity are essential performance criteria.

4.15**. Products and By-products**

Liquid fuel serves as a substitute for liquid petroleum in burners or engines. A table presents the properties of fuel derived from waste plastic and petroleum fuels. Considering the stability of the burner or engine operation, it is feasible to mix plastic-derived fuel with petroleum fuel. Samples A and B represent the whole distillate and middle distillate of waste plastic pyrolytic oil, respectively.

Table 2 : Properties of waste plastic derived fuel & diesel fuel (19)

Category	Sample A (Whole distillate)	Sample B (Whole distillate)	Diesel Fuel	Heavy Oil
Specific gravity (15°C), g/cm^3	0.8306	0.8430	0.8284	0.8511
Flashing Point (°C)	-18(PM)	68.0 (Tag)	69.0 (Tag)	64 (PM)
Kinetic viscosity (30°C/50 °C), mm^2/s	1.041/-	-/1.73	3.822/-	-/2.29
Carbon residue on 10% bottoms; wt%	-	0.85	0.01	0.46
Ash weight (%)	0.00	<0.001	-	0.006
Gross heating value (cal/g)	11294	10746	-	10708
Total chlorine (wt ppm)	47	10	<	11.6
Nitrogen (wt%)	0.14	0.033	-	0.015
Sulfur (wt ppm)	100	910	310	0.41%

4.16. **Liquid Fuel Production Example**

Fig. 3 Toshiba plant for manufacturing liquid fuel (14)

Table 3 : Main features of Toshiba plant (14)

Main features	
Feed	Thermoplastics waste and/or biomass
Processes	(excluding chlorine-containing plastics)
Main equipment	Pyrolysis
Special features	Rotary kiln with external heating
Main product	Continuous feeding

As shown in Figure | our system of thermal treatment for organic waste consists of a hopper, feeder, rotary kiln, condenser, gas refiner, oil (gas) storage tank and dual fuel engine generator.

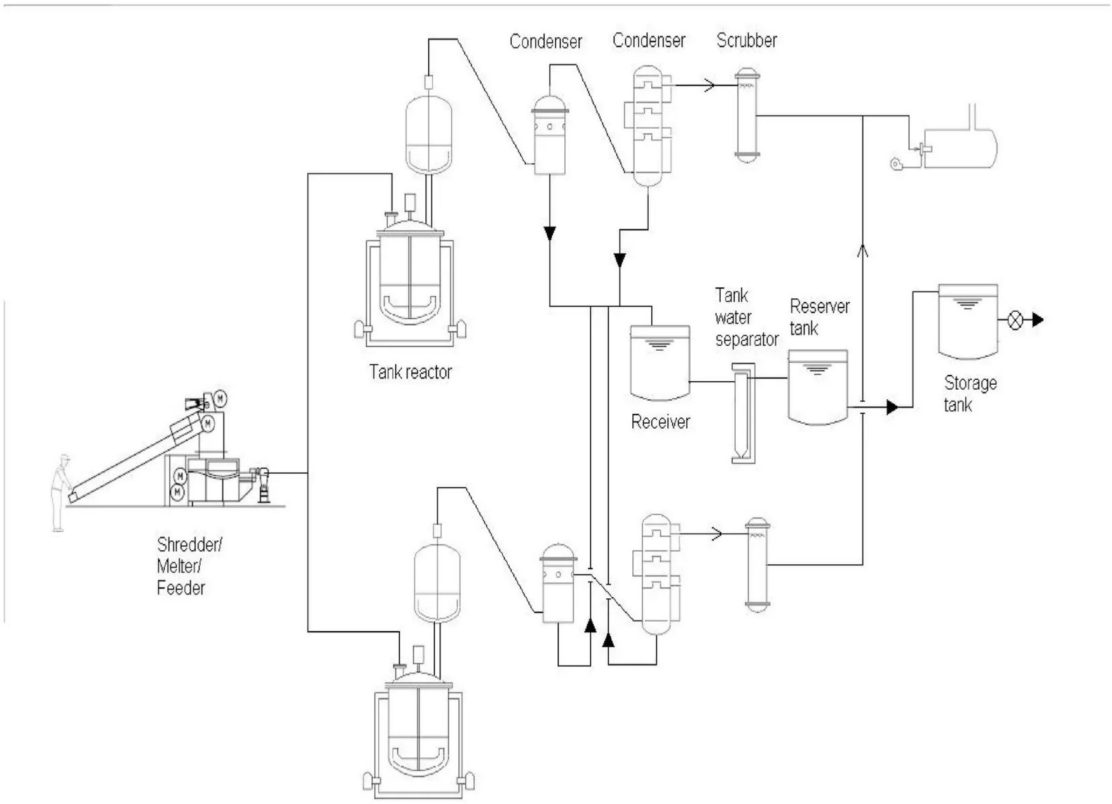

Fig. 4 Schematic diagram of typical plant (14)

4.17 **Scope of solid fuel in this compendium**

Compact fuel, derived from a combination of urban and industrial non-hazardous waste, represents an innovative solution for sustainable energy production. Unlike traditional coal-based fuels, compact fuel rejects their harmful environmental impact. Moreover, it extends beyond coal to encompass other solid fuels like firewood and dry manure. Notably, compact fuel may also contain biofuels as a valuable component. Within this context, two distinct types of compact fuel emerge: Refuse Derived Fuel (RDF), also known as Solid Recovered Fuel (SRF), and Refuse Derived Paper and Plastic Densified Fuel. These advancements contribute to both waste management and cleaner energy alternatives, fostering a more environmentally conscious future.

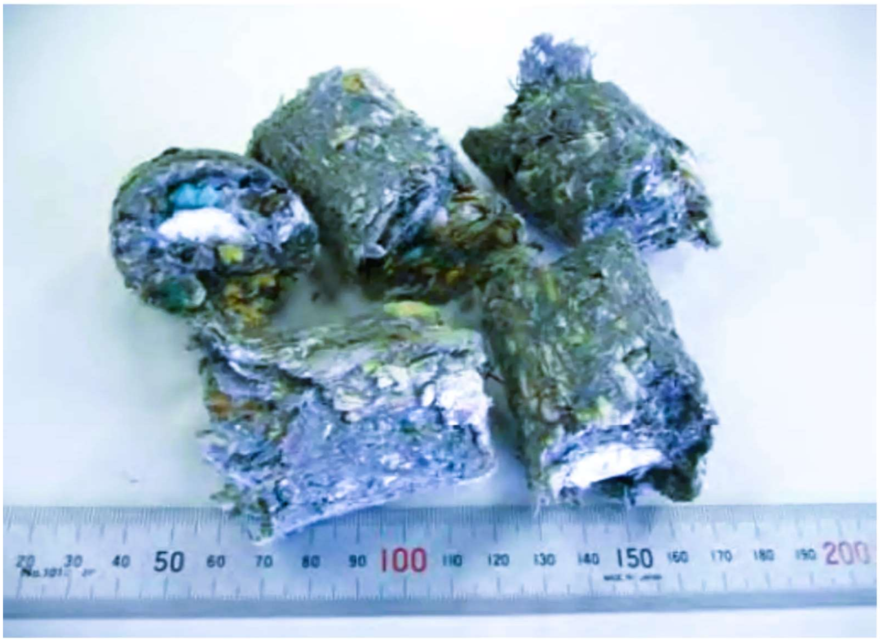

Fig.5 Raw RDF Fuel (17)

RDF is primarily produced from municipal kitchen waste, shredded paper, wood waste, and plastic waste. Due to the presence of kitchen scraps, a drying process is implemented before converting them into fuel to remove moisture, allowing the scrap to solidify into its proper shape and density. This process is considered a drawback due to the significant amount of energy required for the cycle.

On the other hand, RPF (Figure 3.1) is derived from scrap paper, plastic waste, and other dry raw materials. In plastics, thermoplastics serve a crucial role as a binder for various components, such as thermoset plastics and other combustible wastes, which cannot be formed into pellets or briquettes without them. Approximately 15% by weight of thermoplastic is the minimum that must be used as an adhesive to bond various components together; however, an excessive amount, more than 50% by weight, will cause difficulties during pellet preparation. A portion of the RPF is primarily discarded from industrial waste and is sometimes also recovered from segregated municipal waste.

In both cases, the plastic components can be adjusted (for a period of time) to address the customer's fuel needs. The form of the fuel will vary depending on the type of alternator equipment used (for instance, screw extruders are often used to produce cylindrical and hollow fuels of various diameters and lengths). The enclosure in Figure 3.1 contains RPF samples in lengths of 40 mm and 50 mm. During the development of compact fuels, plastic pollution indicated by various plastics containing nitrogen, halogen lamps (CI, Br. F) sulfur, and other harmful substances can lead to air pollution by seasonal flu fluxes and ash-emitting incineration (e.g., inorganic and ground fractions, e.g., aluminum foil food packages produce fly ash). Various foreign substances, such as hydrogen chloride, can potentially damage the boiler through corrosion.

4.18 **Manufacturing Method**

The manufacturing method for compact fuel generally consists of two stages: processing and small rigid structure production:Processing involves shredding and removing non-flammable materials from the plastic. Small rigid production includes minor crushing and small size compact structure (<200°C). However, no pre-treatment is necessary if the compact fuel manufacturer can manage the waste with proper separation.Two types of marketable manufacturing systems are outlined below. One is a full-scale model with processing to separate unwanted contaminants such as chlorinated alloys and plastics. The other is a small-scale model with no preprocessing equipment.

4.19 **Large-scale model (36 ton/day)**

To process plastic waste, we use a reactor. You can just throw the waste in, but for things like plastic bags, it's better to chop and melt them first so they don't take up too much space. There are different kinds of reactors that heat up in various ways. Some even use electricity instead of fire. Sometimes, the reactor gets coated with a layer of carbon, which keeps the heat in. To get rid of this layer, some reactors have special mixers. After we heat the plastic and turn it into a liquid, we clean out any leftover carbon. This can be done with a vacuum or a moving screw at the bottom of the reactor. it's crucial for the people running the reactor to know how the type and amount of plastic they use can change the process. They also look at how much energy the reactor uses and how much it costs to run compared to how much plastic it can handle.

Fig.6 Compact Fuel Production Facility (15)

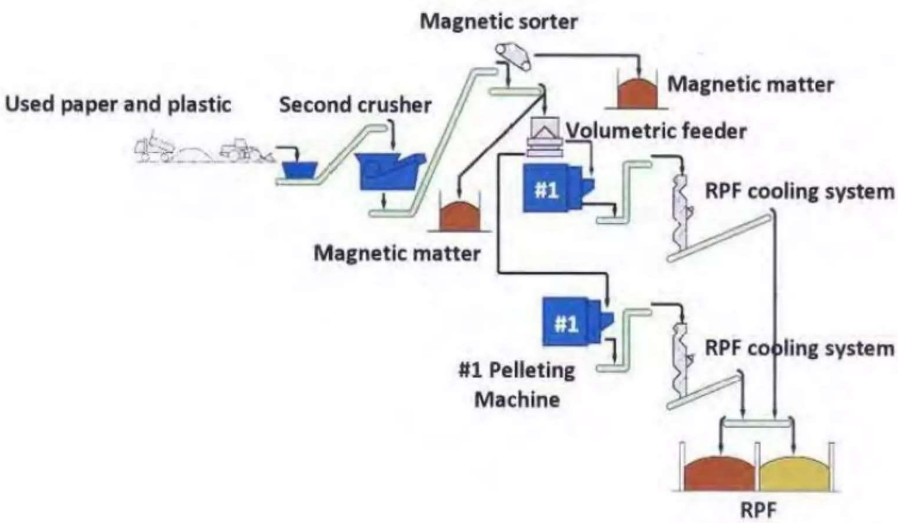

Fig. 7 RPF Production Process (15)

Table 4 : Heating values of different fuels (11)

Fuel or waste	Typical heating value (kcal/kg)
RDF	4000 5000 *1
RPF	6000-8000*2
Coal	6000 8000 *3
Heavy oil	9500
Wood paper	4300
Plastics (polyethylene)	11000
Typical municipal waste	1000-1500 *1

CHAPTER 5: RESULT AND DISCUSSION

Figure 8 below illustrates the pyrolysis temperatures for converting various municipal waste plastics into fluid(liquid) fuel oils. The types of plastics, including PP, LDPE, HDPE, and a mixed category, demonstrate distinct thermal behaviours, transitioning from solid to liquid and gaseous states below 300°C. Specifically, PP undergoes pyrolysis at an average temperature of 225°C, LDPE at 210°C, HDPE at 213°C, and mixed plastics at 197°C. The duration of pyrolysis also varies, with PP and L.D.P.E requiring 214 and 235 minutes respectively, H.D.P.E 220 minutes, and mixed plastics 260 minutes. These variations in temperature and time influence the length of the hydrocarbon chains produced during decomposition. For instance, pyrolyzing waste plastic bags at 420-440°C yields a 74% conversion rate to a liquid product, often termed plastic crude oil. The study indicates that higher temperatures favour the production of liquid products with lower boiling points and gaseous outputs. This is attributed to the oxidative degradation process, where atmospheric oxygen reacts with organic materials, initially forming peroxides and ultimately resulting in a substantial fluid(liquid) yield.

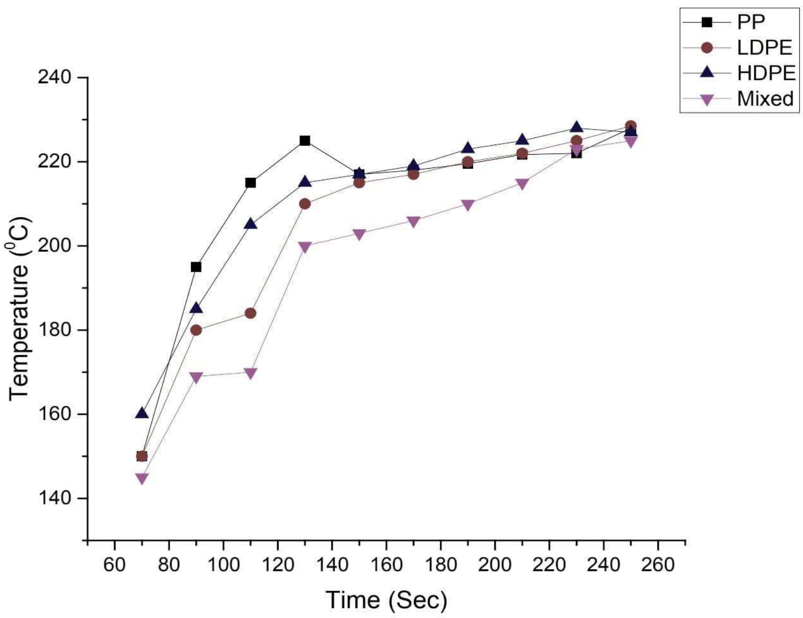

Figure.8 :- The impact of varying reaction temperatures on the production of liquid fuel.

Figure 9 analysis reveals that the yield of liquid fuels derived through pyrolysis of plastics sourced from municipal landfills exhibits variability. Specifically, polypropylene (PP) generates a liquid fuel yield of 4,820 ml, equating to 80% of its weight. Low-density polyethylene (LDPE) produces a yield of 4,400 ml, approximately 73% by weight. High-density polyethylene (HDPE) results in a yield of 4,150 ml, or 70% by weight. Conversely, a mixture of plastics yields 2,700 ml, representing 46% by weight. Notably, the yield correlates with the pyrolysis process's temperature and duration. It is hypothesized that elevating both parameters could enhance the thermal cracking process, potentially increasing the output of the sought-after crude oil fraction from plastics. The effect of varying conditions on the fluid (liquid) yield was systematically evaluated, acknowledging that the thermal decomposition of plastics proceeds via a radical mechanism initiated by heat-induced radicals.

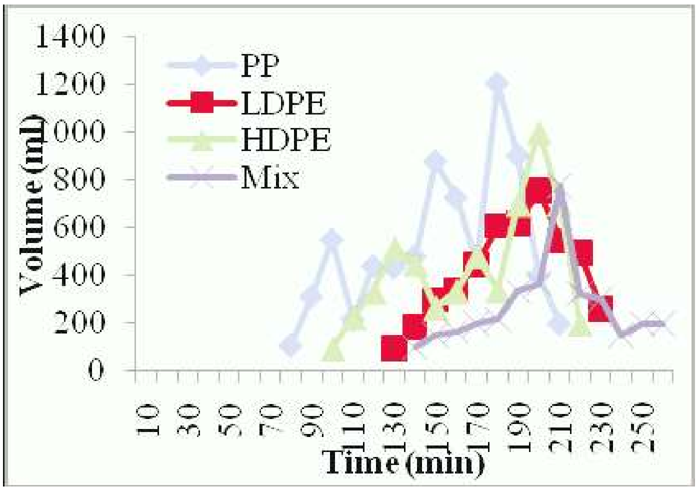

Figure 9:- The Distillation temperature for the pyrolytic oils derived from various municipal wasteplastics such as polypropylene(P.P), low density polyethylene(L.D.P.E), high density polyethylene(H.D.P.E),and mixed plastic materials

From Figure 10, the process of pyrolysis necessitates careful consideration of both temperature and duration to initiate the necessary chemical reactions. There is a critical interdependence between these two factors. Pyrolysis can occur at varying rates, categorized into rapid and gradual phases. The latter can be further divided into traditional pyrolysis and the carbonization process. The conversion ratios of different plastics sourced from municipal waste (such as PP, LDPE, HDPE, and assorted plastics) into pyrolytic liquid fuel are depicted in the accompanying figure. For instance, PP converts into pyrolytic liquid fuel (PLF) at a rate of 80% by weight, leaving behind 13% as non-condensable gases and 7% as other residues. In the case of LDPE, it transforms into PLF at a rate of 73% by weight, with 15% becoming non-condensable gases and the remaining 12% as other forms of waste. HDPE's conversion into PLF occurs at a rate of 70% by weight, with equal proportions (15%) of non-condensable gases and other residues. The conversion rate for mixed plastics into PLF is 46% by weight, with 40% turning into non-condensable gases and 14% remaining as residue. The study utilized a conventional slow pyrolysis method, operating at temperatures ranging from 250-350°C to facilitate the reaction. The findings indicate that higher temperatures lead to an increased production of liquid products with lower boiling points and gaseous outputs. This is attributed to the oxidative degradation process where atmospheric oxygen binds to organic molecules, leading to the initial formation of peroxides. As the reaction progresses, the oxygen integrated into the organic compounds results in a higher yield of liquid products.

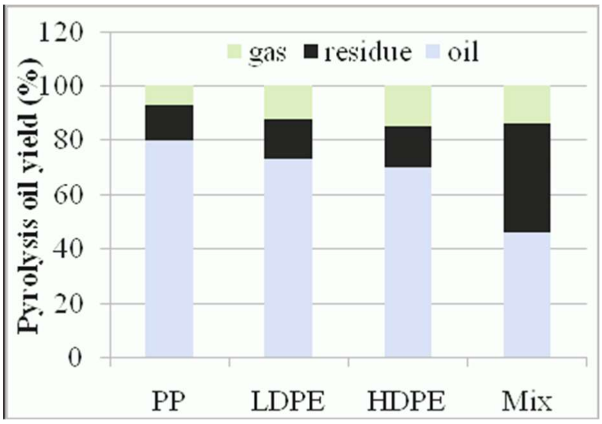

Figure 10:- The proportion of liquid fuel derived through pyrolysis from mixed plastics in municipal landfills, including PP, LDPE, and HDPE.

From Table 5, Research indicates that the energy content of fuel derived from plastic waste is on par with that of conventional petroleum-based diesel when refined through distillation. This process effectively segregates the various oil densities light, medium, and heavy mirroring the separation found in standard diesel. The calorific values, as outlined in Tables I and II, demonstrate this similarity. For instance, the calorific value of standard diesel, as per ASTM D240, is 45.50 MJ/kg, while the values for fuels from different plastics range from 40 to 42.50 MJ/kg, with variations based on the distillation temperature . Specifically, fuels distilled below

170°C have a calorific value of 37 MJ/kg. Those distilled between 170°C and 250°C have a value of 40 MJ/kg, and those above 250°C reach 46 MJ/kg. The empirical formula of CH2 for waste plastic bags, akin to polyethylene, along with a higher ratio of carbon and hydrogen, contributes to the elevated energy content of these fuels. The kinematic viscosity and specific gravity of these fuels also show comparable figures to diesel when measured at 40°C and 15.6°C respectively, according to ASTM standards D445 and D1298. The cetane index, flash point, and distillation temperatures further align with diesel specifications, albeit with some variations across different plastic-derived fuels. In summary, the pyrolysis of mixed plastic waste not only offers an alternative route for feedstock recycling but also produces liquid hydrocarbons that can potentially blend with or replace conventional diesel. The high calorific values surpass those of biomass and low-grade coal, suggesting a viable use as a standalone fuel or in combination with other materials. Moreover, engines running on 100% waste plastic oil have demonstrated increased thermal efficiency, highlighting the potential of converting plastic waste into a valuable energy resource.

Table 5 :- Characteristics of the liquid fuel derived from plastic waste in relation to conventional diesel fuel from petroleum sources.

Fuel Type	PP	LDPE	Mixed	HDPE	Diesel
Gross calorific value	41	41.6	42	42.5	45.5
Kinematic viscosity	1.968	2.311	2.64	2.421	3.2
Specific Gravity	0.749	0.779	0.81	0.81	.835
Flash point	<24	<24	50	40	75
Distillation temperature	100	100	100	100	250
Distillation temperature	161	174	221	211	300
Distillation temperature	272	286	333	325	350
Cetane index	40	40	55	51	64

CHAPTER 6: CONCLUSION

1. This initiative focuses on the innovative and developmental utilization of plastic waste.
2. Finding alternatives to plastic is challenging due to its diverse applications and characteristics. The demand for plastic is steadily increasing, leading to a corresponding rise in plastic waste.
3. The escalation in plastic waste contributes to further environmental issues.
4. As the accumulation of plastic waste intensifies, this compact method of waste management is swiftly gaining traction, providing an alternative solution for waste collection.
5. The byproducts of the resin pyrolysis process can be utilized as powders or synthetic substances, thereby mitigating the issue of plastic waste reduction.
6. In this study, waste plastic undergoes pyrolysis, as the use and creation of a catalyst are costly and complex.
7. Plastic pyrolysis results in a mix of gas and oil, with a minor amount of carbon residue. This process yields numerous potential outcomes and presents a viable solution for managing plastic waste and discovering alternative sources of diesel.
8. The recently disclosed information did not show that Accor's oil consumption has increased. Oil prices have continued to rise despite short-term demand growth during the global financial crisis. The continued growth in consumption has impacted AccorHotels and the industry more broadly. The company needs to find a balance between operating costs and sustainable growth as it struggles with rising oil prices. The global economic landscape remains strong and Accor's decisions regarding leverage will play a significant role in its future prospects.
9. Consequently, the existing gas and oil reserves could be depleted in a few years. Conversely, the use of plastics cannot be curtailed due to its extensive applications in the medical and pharmaceutical sectors, resulting in an increase in plastic waste.

10. Plastic pyrolysis oil is utilized as diesel fuel in diesel engines due to its economic viability and satisfactory fuel quality.
11. Moreover, the engine can be adjusted to accommodate the combustion conditions of plastic pyrolysis fuels.
12. Chemical recycling helps reduce the amount of plastic waste that is buried or burned. Th anks to chemical engineering, fossil materials used in chemical production can be replace d with materials recycled from plastic waste.
13. The waste is converted into secondary products such as pyrolysis oil or monomers. These raw materials can be used to make new plastics.
14. Chemical recycling supplements the existing recycling method and has the potential to revolutionize the environment by disposing of polymer waste that is currently challenging to recycle.
15. Allocating resources towards the advancement and infrastructure of chemical recycling technology will foster employment opportunities and safeguard the environment by diminishing CO2 emissions, thereby enhancing the total recycling capability of the EU.

CHAPTER 7 : ACHIEVED OUTCOMES & SOCIETAL RELEVANCE

7.1 Achieved outcomes

The process of converting 1 kg of plastic containers into diesel fuel can yield approximately 600-750 ml of fuel with minimal effort. This conversion of plastic to fuel has the potential to decrease CO_2 emissions by 80%, and burning 1 kg of plastic in open air results in the production of 3 kg of CO_2. This approach addresses both issues simultaneously. Furthermore, used waste oil emits fewer unbalanced hydrocarbons compared to diesel fuel. Our observations indicate that fuel derived from recycled plastic is more efficient than conventional fuels and costs 30% to 40% less to produce compared to other fuel production techniques or strategies.

7.2 Societal Relevance

1. **Environmental Sustainability**:
    - Our research focuses on converting plastic waste into alternative fuels, aligning with sustainable waste management practices.
    - By reducing plastic waste, we contribute to mitigating environmental pollution and minimizing its harmful impact on ecosystems.
2. **Energy Independence**:
    - Transforming plastic waste into fuel offers an alternative energy source.
    - Given the increasing energy demands, utilizing plastic waste for fuel production can enhance energy security and decrease reliance on fossil fuels.
3. **Health and Safety**:
    - Our study emphasizes using plastics that burn efficiently and have low water content for fuel production.
    - This approach reduces harmful emissions and ash, leading to better air quality and decreased health risks associated with waste incineration.

4. **Technological Adaptation**:
    - We highlight the necessity of adapting technology for plastic waste management.
    - By exploring mechanical and chemical recycling methods, we encourage innovation and efficient resource utilization.
5. **Community Impact**:
    - Our findings offer an eco-friendly solution for plastic waste disposal, benefiting local communities.
    - We stress evaluating fuel types and stove quality to maximize energy recovery while minimizing environmental impact.

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