RECYCLING OF PLASTIC WASTE INTO FUEL

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Plastic Waste, Pyrolysis, Alternative Fuel, Waste Management, Environmental Sustainability.

Introduction:

Increasing population levels, booming economy, rapid urbanization and the rise in community living standards have greatly accelerated the municipal solid waste (MSW) generation rate in developing countries. Plastics have become an indispensable part of today's world. Due to their light weight, durability, energy efficiency, coupled with a faster rate of production and design flexibility, these plastics are employed in entire gamut of industrial and domestic areas Plastics are non-biodegradable polymers of mostly containing carbon, hydrogen, and few other elements such as chlorine, nitrogen etc. Due to its non-biodegradable nature, waste management is a common problem for both developed and developing countries, because of the fact that as the population increases, the quantity of waste generated also increases. Waste collection, segregation and disposal have been a long-standing unresolved problem and will remain a problem in the future if there is no initiative made to solve it. Mismanagement of waste will result to serious environmental problems such as surface and ground water contamination, flooding, air pollution and climate change. The Example of above problems as shown in the figure 1.1. Plastic debris, laced with chemicals and often ingested by marine animals, can injure or poison wildlife. Floating plastic wastes, which can survive for thousands of years in water, serve as mini transportation devices for invasive species, disrupting habitats. Plastic buried deep in landfills can leach harmful chemicals that spread into groundwater plastic waste in landfill and in badly managed recycling systems could be having an impact from the chemicals contained in the plastic. Plastic is generally derived from petroleum and when placed in landfills becomes carbon sink and if incinerated it increases carbon emissions. Since incineration is less accepted and the cost of landfill facility is unaffordable

Figure 1: Plastic waste in the watercourse

Objectives:

1. To reduce the amount of plastic garbage that ends up in landfills and to extract energy from it.
2. To Utilize plastic waste as a raw material to convert into liquid fuel.
3. To Analyse the fuel properties.

Methodology:

Different types of plastic waste

- Fly ash
- Pyrolysis reactor
- LPG gas
- Collection unit.

Plastics are a wide range of synthetic or semi-synthetic materials made from polymers, which are long chains of molecules that can be moulded or shaped into various forms. Thermoplastics can repeatedly soften and melt if enough heat is applied and hardened on cooling, Thermosets or thermosetting can melt and take shape only once.

Thermosets or thermosetting can melt and take shape only once. They are not suitable for repeated heat treatments; therefore, after they have solidified, they stay solid.In most of the situations, plastic waste recycling could also be economically viable, as it generates resources, which are in high demand. Plastic waste recycling also has a great potential for resource conservation and GHG emissions reduction, such as producing diesel fuel from plastic waste. This resource conservation goal is very important for most of the national and local governments, where rapid industrialization and economic development is putting a lot of pressure on natural resources. Pyrolysis is one of the technologies available to convert liquid plastic to an intermediate liquid product. This is the heart of the pyrolysis process and consists of an insulated reactor or retort where material decomposition takes place. Weight of the container: 5800 gm.

RESULTS AND CONCLUSION:

Density test using Hydrometer:

This test method covers the laboratory determination of the density, relative density (specific gravity) of a plastic liquid fuel products using a glass hydrometer. The fuel density was analysed according to IS-1448.16.1990. The sample was contained in a measuring cup of 250 ml, weighed under room temperature 26^{0}C**.**

Figure 2: Hydrometer

Result:

Density of plastic liquid fuel at 26^{0}C is = 850Kg/m^3

Flash point and fire point by Cleveland open cup apparatus

The flash point of the oil is the lowest temperature at which the vapors of oil momentarily take fire in the form of a flash under specified conditions of test. The fire point is the lowest temperature at which oil gets ignited and burns under specified condition of test.

Fig 3: Flash point & Fire point

Table 1: Result of flash point & fire point

SL No	Temperature °C	Remarks
01.	23°C	No flash
02.	24°C	No flash
03.	25°C	Flash
04.	26°C	Flash
05.	27°C	Flash

Table 1 shows the flash point of the liquid is 25^{0}C and fire point of the liquid is 27^{0}C which shows that the liquid fuel having fast rate of fire catching property. Which satisfy according to IS code- 1448.16.1990

Redwood Viscometer

Viscosity is the property of fluid. It is defined as “The internal resistance offered by the fluid to the movement of one layer of fluid over an adjacent layer”. It is due to the Cohesion between the molecules of the fluid.

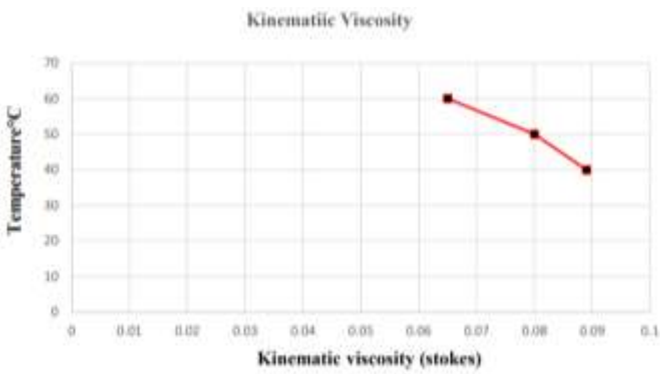
Figure 4: Redwood viscometer

Table 2: Result of redwood viscometer

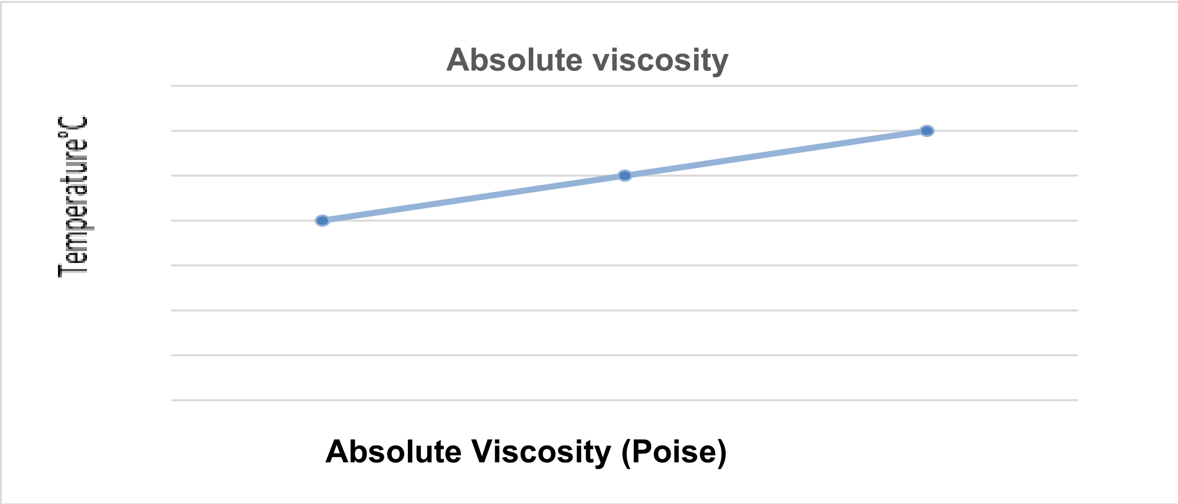
Trial no	**Sample volume**	**Temperature °C.**	**Time for flow of 60CC of oil (Sec)**	**Kinematic viscosity**	**Density (gram (cc))**	**Absolute viscosity (poise)**
01.	60ml	40°C	48.63	0.089	19.427	0.0045
02.	60ml	50°C	46.01	0.08	17.808	0.0049
03.	60ml	60°C	41.6	0.065	24.404	0.0026

Table 2: shows the time required for 60 cc of oil to flow through the viscometer decreases as the temperature increases. This indicates that the oil becomes less resistant to flow at higher temperatures, as expected for most fluids.

Graph 1: Kinematic Viscosity test of the fuel



Above graph shows that kinematic viscosity of the liquid fuel having gradual decrease rate of liquid at high temperature. Which satisfy according to IS Code-1448.16.1990



Graph 2: Absolute Viscosity test of the fuel

Above figure shows that absolute viscosity of the liquid fuel having gradual increase rate of liquid at high temperature. Which satisfy according to IS Code-1448.16.1998.

CONCLUSION

- The plastic fuel project demonstrates a promising approach to address two major global challenges; plastic waste management and the demand for alternative energy sources. By converting plastic waste into fuel through processes pyrolysis, this project highlights an innovative method to reduce environmental pollution while generating usable energy.
- The results indicate that plastic-derived fuel can be a viable substitute for conventional fossil fuels, offering comparable energy output and efficiency. However, challenges such as emission control, process optimization, and economic feasibility must be addressed for largescale implementation.
- Overall, this project reinforces the potential of plastic-to-fuel technology as a sustainable solution for waste-to-energy conversion. Further research and advancements in refining processes can enhance its efficiency, making it a valuable contribution to circular economy initiatives and environmental conservation.

Project Outcome & Industry Relevance

- The project “Recycling of Plastic Waste into Low-Cost Fuel” demonstrates a sustainable and innovative method for addressing two major global concerns: plastic waste management and the growing demand for alternative energy sources. By employing pyrolysis, a thermal decomposition process in the absence of oxygen the project effectively converts plastic waste into usable liquid fuel. This fuel shows properties comparable to conventional fuels, as confirmed by tests for density, flash point, fire point, and viscosity.

- The practical implications of this project are significant. It offers a dual benefit by reducing the burden on landfills and pollution caused by plastic waste, while simultaneously producing alternative energy that can reduce dependence on fossil fuels. In real-world settings, this technology could be adopted in waste management systems, fuel manufacturing sectors, and decentralized energy solutions, especially in developing nations. Industries such as transportation, construction, and even agriculture could utilize this fuel as a cheaper and cleaner alternative.

- Furthermore, the use of fly ash as a catalyst adds value to another industrial by product, enhancing fuel yield and quality. This project supports the goals circular economy and sustainable development, promoting a shift from waste to resource-based strategies in both local and global contexts.

Working Model vs. Simulation/Study

The project involved the development of a physical working model. It was not limited to theoretical study or simulation. The team successfully designed and implemented a working setup for converting plastic waste into liquid fuel using the pyrolysis method. The process included the collection and preparation of plastic waste, use of a pyrolysis reactor, application of catalysts (fly ash), and extraction of liquid fuel.

The report details the experimental setup, including the pyrolysis reactor, collection units, and measurement instruments (hydrometer, viscometer, Cleveland open cup apparatus). The extracted fuel was also subjected to practical testing to determine physical and chemical properties such as density, flash point, fire point, and viscosity.

This confirms that the project outcome was based on a functional prototype and hands-on experimentation, rather than just a simulation or conceptual study.

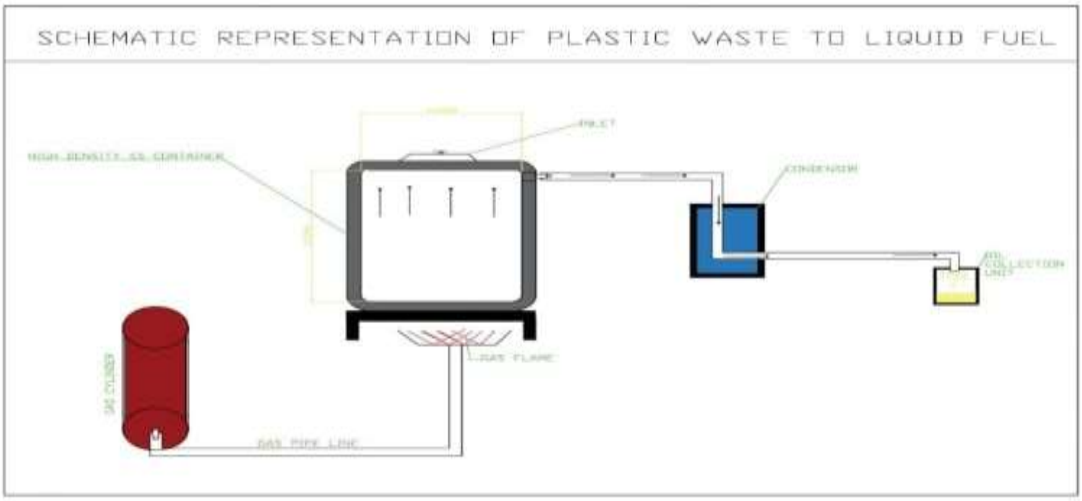


Fig 5: Working model

Project Outcomes and Learnings:

Outcomes

- Successfully developed a working pyrolysis setup to convert plastic waste (HDPE, LDPE, PP) into liquid fuel.
- Achieved extraction of usable fuel with a density of 850 kg/m³ and a flash point of 25°C, indicating its suitability as a combustible energy source.
- Demonstrated the use of fly ash as a catalyst, which enhanced the fuel quality and efficiency of the pyrolysis process.
- The fuel obtained showed properties comparable to conventional fuels, as verified through standard tests (IS-1448.16.1990).
- Provided a practical, eco-friendly solution for plastic waste management while offering an alternative energy source.

Learnings:

- Gained hands-on experience in building and operating a pyrolysis reactor and handling different types of plastic waste.
- Learned how catalysts (like fly ash) can improve chemical processes and increase output efficiency.
- Understood the importance of waste segregation and pre-processing for efficient fuel conversion.
- Improved knowledge of fuel property testing methods such as density, viscosity, flash and fire points.
- Realized the potential of engineering innovations to address environmental issues, and the challenges involved in scaling and optimizing such systems for industrial application.

Scope of study:

Pyrolysis, an energy-efficient, cost-effective, and environmentally friendly process, can convert various plastic wastes like HDPE, LDPE, and PP into valuable liquid fuels. This technology has the potential to improve the global economy and reduce dependence on fossil fuels. With continuous innovation and investment, it can convert waste plastic resources into effective commercial products, contributing to sustainable waste management systems and transitioning to green energy sources.