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INORGANIC WASTE RECYCLING BY USING PYROLYSIS PROCESS AS AN ENERGY RESOURCE

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Abstract -

As per the Annual Report of 2019-20 on implementation of Plastic Waste Management Rules, 2016 CPCB has estimated plastic waste generation in Maharashtra state is approximately 4,43,724 TPA. The same scenario is in Wardha which generates 0.45 metric tonnes per day as stated in the District Environment Plan by MPCB and Environment Department, Government of Maharashtra. Currently, a study is going on the plastic waste management whose fresh example is five plastic patches in oceans. We're dealing with solid waste management through pyrolysis. Whereas pyrolysis is the thermal degradation of plastic in absence of oxygen which gives 70 to 80% of fuel, and 30 to 20% of gases and char. the reactor, Condenser and, Shredder are the main required elemental setup for this process. In this project we're conducting this process in a cylindrical reactor witan h electric heater as a source of heat and a condenser, maximum feedstock inserted in the reactor is 0.4kg. We are mainly focusing on PETE and HDPE plastic. And using a batch reactor for our experiment, during the process we have to analyses the composition of gas and oil and look at its various properties.

Key Words: *Plastic Waste, CPCB, MPCB, PETE, HDPE*

1.INTRODUCTION

Plastic plays an important role in improving our lifestyles in numerous sectors such as healthcare, construction, packaging, electronics, automotive, and many more. The rise of the world population has caused the demand for commodity plastics to further increase. According to statistics, the global production of plastic has reached about 359 million tons in 2018. And in India plastic production was 1.799 million metric tons. Since most of the plastics were thrown out after a single use, the amount of plastic waste accumulated in the environment each year was at an alarming level. We are aware of its consequences and its properties. According to reports only 9 to 10% of total waste plastic is recycled, according to the CPCB report- richer states produce as much as 37g to 60g per capita per day. If we look at statistics, we'll get more landfills rather than any other treatment to be implemented, thus waste dumped in the landfill is high and it occupied a large space. Besides, the degradation of plastics may take up billions of years, thus the continuous disposal of plastic i.e., landfill would affect the environment negatively. In order to this infinitely remaining plastic its management is very important. Government, and local administration are & is trying their level best to provide all basic amenities to the population. Pyrolysis provides a several advantages over other conventional waste plastic management approaches. For instance, most waste plastics during recycling are down-cycled plastics are used in producing articles of lower quality and application. This is because the plastic tends to lose properties such as clarity, strength and flexibility as they are recycled again and again. The introduction of the "modern" self-compacting concrete (SCC) is associated with the drive towards better quality of concrete pursued in Japan in late 1980's Self compacting concrete is a kind of high fluidity concrete without vibration, also known as high-performance concrete and self-consoldating concrete.

Plastic waste poses enormous threats to animals, birds, plants, humans, and the environment. When burned gases are released, which poses a challenge of climate change and global warming to the world. Many animals and birds die because of swallowing plastics. One of the examples is the report published by BBC News on 5th December 2021 discussing the "Great Pacific Garbage Patch". Dealing with plastic waste is must, waste cannot just stop using plastic but we can manage in a it proper way such that we can get effective results. In India sanitation come the into limelight in 2014 from initiative taken by PM Shri.N. Modi making Swachh Bharat Abhiyan a mass moment. Its introduction into concrete mixes serves to densify the microstructure, significantly improving mechanical and durability characteristics. Silica fume particles, being several times finer than cement particles, effectively fill the voids within the concrete matrix, enhancing packing density and reducing permeability. Its introduction into concrete mixes serves to densify the microstructure, significantly improving mechanical and durability characteristics. Silica fume particles, being several times finer than cement particles, effectively fill the voids within the concrete matrix, enhancing packing density and reducing permeability.

1.1 The utilization of silica fume in concrete admixtures contributes to the following key advantages:

Strength Enhancement: Silica fume's pozzolanic reaction with calcium hydroxide generated during cement hydration leads to the formation of additional calcium silicate hydrate (CSH) gel, bolstering compressive and flexural strengths.

Durability Improvement: The densification of concrete microstructure, coupled with reduced pore size distribution, enhances resistance against aggressive chemical attacks, such as chloride ion ingress and sulphate exposure, thereby prolonging the service life of concrete structures.

Mitigation of Thermal Cracking: Silica fume's ability to reduce the heat of hydration and control thermal differentials within concrete minimizes the risk of thermal cracking, particularly in massive pours and high-strength concrete applications.

Sustainability: By repurposing an industrial by product, the incorporation of silica fume aligns with sustainable construction practices, reducing environmental impact and promoting resource efficiency. In summary, silica fume stands as a pivotal ingredient in contemporary concrete technology, offering a pathway to achieve high-performance, durable structures that meet the demands of modern construction practices while advancing sustainability goals.

2. OBJECTIVES

- To reduce plastic waste and prevent its consequences on animals and the environment.
- To make use of plastic (inorganic waste) to convert it into a useful product. So that it won't become hefty hills on land or floating patches in the ocean.
- To use pyrolysis process which will give fuel that can be used as an energy resource.
- To provide proper plastic waste management.

3. LITERATURE REVIEW

The production of plastic begins with a distillation process in an oil refinery. The distillation process involves the separation of heavy crude oil into lighter groups called fractions. Each fraction is a mixture of hydrocarbon chains (chemical compounds made up of carbon and hydrogen), which differ in terms of the size and structure of their molecules. One of these fractions' naphtha, is the crucial element for the production of plastics. Plastics are also produced from natural gas.

3.1 Karad RT, Havalammanavar S (2017) Waste plastic to fuel-petrol, diesel, kerosene (3) Naphtha is an intermediate hydrocarbon liquid stream derived from the refining of crude oil. It is the lightest liquid distillate product of crude distillation consisting of C5 to C10 hydrocarbons boiling in

the 38° to 155°C range. It is produced from the atmospheric distillation of crude oil and many secondary processing units in the refinery. Unlike other petroleum fuels such as kerosene, diesel, or fuel oil, naphtha is not a direct petroleum fuel however, it is used as a feedstock for the manufacture of plastics. The first unit process in a petroleum refinery is the crude oil distillation unit. The naphtha is a mixture of very many different hydrocarbon compounds it contains paraffin, naphthenic (cyclic paraffin's) and aromatic hydrocarbons.

3.2 Mohanraj Chandran, Chandrasekhar Murugeshan. Plastic Waste and Recycling ,2020 (6) Nowadays, converting the waste into valuable energy resource has been a brilliant way to fully utilize the waste in order to meet the increased energy demand. Plastic wastes can be turned into valuable energy since they are derived from petrochemical source called naphtha which having significant calorific value. The conversion can be made possible through several thermal treatments technologies. Pyrolysis is the most desirable process since the initial volume of the waste is significantly reduced, more energy can be recovered from the plastic waste by producing varieties of products, requires lower decomposition temperature and low capital cost.

3.3 Kundan Kumar Jha, T. T. M. Kannan, and Ashutosh Das. Fuel from Plastic Waste: A Review (4) There are many factors that affects and regulate this pyrolysis process, and taking an account of it can make the process more effective. The factors are temperature, plastic type, type of reactor, pressure in reactor, residence time. Where temperature varies according to thermal pyrolysis and catalytic pyrolysis, in case of thermal or non-catalytic pyrolysis at least 350°500°C temperature is required as seen in experiments.

3.4 Paper-4 : S D A Sharuddin , F Abnisa, W M A W Daud1 and M KAroua . Pyrolysis of plastic waste for liquid fuel production as prospective energy resource, 2018 (9) In case of catalytic pyrolysis temperature reduction takes place including less gas fraction that were obtained at high temperature. The zeolite and zeolite-based catalysts

have been the most successful and popular catalysts; operating at lower temperatures, they produce more liquid hydrocarbons. $BaCO_3$ and $CaCo_3$ are other catalyst that could be used.

4. PRODUTION INORGANIC WASTE RECYCLING BY USING PYROLYSIS PROCESS AS AN ENERGY RESOURCE

Using pyrolysis to recycle inorganic waste and produce energy can be an innovative and sustainable approach. While traditionally applied to organic materials like biomass, it can also be adapted for certain inorganic waste streams.

Here's a generalized approach to how pyrolysis could be utilized for recycling inorganic waste and generating energy:

4.1. Selection of Inorganic Waste: Identify inorganic waste streams suitable for pyrolysis. This could include plastics, rubber, certain metals, and other non-biodegradable materials.

4.2. Preparation and Sorting: The waste materials need to be sorted and prepared for pyrolysis. Contaminants should be removed to improve the efficiency and quality of the pyrolysis process.

4.3. Pyrolysis Process: The prepared waste is then fed into a pyrolysis reactor, where it undergoes thermal decomposition at high temperatures (typically between 300°C to 800°C) in the absence of oxygen. This process breaks down the complex molecules of the waste into simpler compounds, such as gases, oils, and char.

4.4. Energy Recovery: The gases and oils produced during pyrolysis can be utilized as an energy resource. These products can be combusted to generate heat or converted into other forms of energy such as electricity or biofuels.

4.5. Char Utilization: The solid residue, known as char or biochar, can be utilized in various ways. It can be used as a soil amendment to improve soil quality and fertility, or it can be further processed to extract valuable materials.

4.6. Emissions Control: Proper emission control systems should be in place to mitigate any harmful byproducts released during the pyrolysis process, such as particulate matter or toxic gases.

4.7. Environmental Impact Assessment: Before implementation, a thorough assessment of the environmental impact should be conducted to ensure that the process is environmentally sustainable and complies with regulations.

5. Benefits Of Using Pyrolysis For Inorganic Waste Recycling And Energy Production Include:

• Resource Recovery: Pyrolysis allows for the recovery of energy and valuable materials from waste streams that would otherwise be landfilled or incinerated.

• Energy Generation: The gases and oils produced can be used to generate heat or electricity, providing a renewable energy source.

• Waste Reduction: Pyrolysis reduces the volume of waste and helps alleviate pressure on landfill capacity.

• Environmental Sustainability: By recycling waste and producing energy from it, pyrolysis contributes to reducing greenhouse gas emissions and dependence on fossil fuels.

However, it's important to note that pyrolysis may not be suitable for all types of inorganic waste, and the economic feasibility of such a process depends on various factors such as the composition of the waste, market demand for the end products, and the cost of implementing and operating the pyrolysis facility. Additionally, proper management of any potential environmental and health risks associated with the process is crucial.

6. FACTORS INFLUENCING INORGANIC WASTE RECYCLING BY USING PYROLYSIS PROCESS AS AN ENERGY RESOURCE

1. Feedstock Composition: The composition of inorganic waste being used as feedstock greatly affects the efficiency and output of the pyrolysis process. Different materials have different decomposition temperatures and produce varying amounts and types of byproducts.

2. **Pyrolysis Temperature**: The temperature at which pyrolysis is conducted affects the yield and quality of the products. Higher temperatures generally result in more complete decomposition but may require more energy input.

3. **Pyrolysis Residence Time**: The duration for which feedstock is subjected to heat in the pyrolysis chamber affects the extent of decomposition and the characteristics of the resulting products.

4. **Catalysts**: The use of catalysts can enhance the efficiency of pyrolysis processes by lowering the required temperature and reducing the residence time. Catalysts can also influence the composition of the resulting products.

5. **Process Conditions (Pressure, Atmosphere)**: Altering pressure and atmosphere conditions can modify the reaction kinetics and product distribution in pyrolysis. For example, vacuum or inert gas atmospheres may be employed to control reactions and prevent unwanted side reactions.

6. **Heat Transfer Mechanisms**: The method of heat transfer (e.g., conduction, convection, or radiation) within the pyrolysis reactor affects the uniformity of temperature distribution and overall process efficiency.

7. **Product Utilization and Market Demand**: The availability of markets and demand for the products obtained from pyrolysis can significantly influence the economic viability of the process. Understanding the potential applications of the pyrolysis products is essential for successful implementation.

8. **Regulatory Environment and Policy Support**: Government regulations, incentives, and policies related to waste management, renewable energy, and emissions control can impact the feasibility and attractiveness of pyrolysis-based recycling initiatives.

9. **Technological Advancements**: Ongoing research and development efforts aimed at improving pyrolysis reactor design, process optimization, and product upgrading can enhance the efficiency and competitiveness of inorganic waste recycling through pyrolysis.

10. **Economic Considerations**: Factors such as capital investment, operational costs, and revenue generation from product sales influence the economic viability of pyrolysis-based recycling projects.

11. **Environmental Impact**: The environmental footprint of the pyrolysis process, including emissions, energy consumption, and waste disposal, is crucial for assessing its sustainability and acceptance by stakeholders and regulatory bodies.

7. RESULTS

Table1 - Temperature variation during run-3 of process

Time	Temperature (°C)	Time	Temperature (°C)
3.33	77	4:32	166
3.36	83	4:35	173
3:39	87	4:38	186
3:42	90	4:41	196
3:45	94	4:44	211
3:48	97	4:47	221
3:52	102	4:50	244
3:55	105	4:56	233
3:58	110	4:59	244
4:02	118	5:02	256
4:05	122	5:05	269
4:08	125	5:08	284
4:11	129	5:11	297
4:14	133	5:14	311
4:17	138	5:17	323

Table 2- Temperature variation during run-1 of the process

Time	Temperature (°C)
4:57	44
4:58	51
4:59	59
5:00	69
5:01	78
5:02	90
5:03	110
5:04	128
5:05	150
5:06	190
5:07	221
5:08	235
5:09	268
5:10	309
5:11	324

8. CONCLUSIONS

From our experiment, we taken the three runs of the process and we get results as discussed below,

Run1: In the first run, we take PETE bottles of 250 grams where we got wax of 20 ml. We did fastheating by allowing dimmer stat at 260V and then reducing to 240V. Our run has taken 30 minutes.

Run 2- In the second run we have again taken PETE of 200 gm by weight. We again got wax as a product where we come to know waxes are forming due to increased resident time of the gas in coiled type condenser hence, we have replaced coiled type condenser to straight type in run 3.

Run 3- In this run we have used 150 grams of HDPE plastic as a feed and a given slow heating by initiating a dimmer state at 80 volts then increasing to 100 volts than 120 volt and 180v this process has taken to 2 hrs and got fuel at 371°C that is after 1 hour 40 minutes the fuel was about 10 ml hence got an efficiency of 7%. The efficiency was so because the condensable gases were not coming out directly from the outlet to the condensation unit. If we have used fluidizing gas the efficiency had been increased.

After experimenting on Abel's closed cup for determination of flash point and fire point and from S.D.A. Sharfuddin[7] and T.Karad[2] we get to know about the properties of fuel from waste plastic as shown in table-3

Table-3: Measured and referred values of fuel property

Properties	HDPE Fuel	Diesel	Gaseline
Viscosity(mm2/s)	5.08	1.9-4.1	1.17
Fire point (℃)	41(measured)	55	-
Flash point (℃)	48(measured)	52	42
Density(g/cm3)	0.08	0.735-0.807	0780
Pour point(℃)	-5	6	-
Calorific Value (MJ/kg)	40.5	43.0	42.5

9. FUTURE SCOPE

The According to the current data, there is a continuous increase in crude oil consumption and thereby an increase in the price of crude oil, although that is a temporary decline in demand growth due to the international financial crisis and Covid19. In future we can use pyrolysis fuel in proportions. According to scientific report by Sambandam Padmanabhan [9] at maximum loads, CO emissions from 20:80 is 13.41% lesser than diesel. The blends of 20:80, 30:70, and 40:60 showed significant CO reductions of 13.41%, 6.21%, and 3.73%, respectively. In the period of 2020–2021, the ethanol blending E20 programme. Ethanol is also less polluting and cheaper than fossil fuels. In two-wheelers, the CO emission drop was 50%, and in four-wheelers reduction up to 30%. Also, blends of ethanol and gasoline lower hydrocarbon emissions by 20%, but in Vidarbha like area it is not possible to appreciate the practice of sugarcane farming.

Thus, implementing pyrolysis set-up in Vidarbha can beneficial. • Pyrolysis can also help in managing plastic waste by reducing waste volume. & estimate by ministry of petroleum and natural gas suggest that the annual per capita consumption in India would be 20.1 kg by 2022. But as per our study we can say that pyrolysis is a good option for managing this plastic waste problem. Technological Advancements: Future research and development efforts will likely focus on improving the efficiency, scalability, and cost-effectiveness of pyrolysis technologies.

This includes advancements in reactor design, process optimization, catalyst development, and integration of pyrolysis with other waste treatment technology Integration with Renewable Energy Systems:

There is potential to integrate pyrolysis systems with renewable energy sources such as solar or wind power to enhance energy efficiency and reduce environmental impact. This integration can help create more sustainable and resilient waste-to-energy systems.

Waste-to-Chemicals Conversion: Pyrolysis can be further explored for the production of valuable chemicals and materials from inorganic waste streams. Research into catalytic pyrolysis and product upgrading techniques could enable the production of higher-value chemicals and materials, expanding the economic viability of pyrolysis based recycling.

Circular Economy Initiatives: Pyrolysis plays a crucial role in transitioning towards a circular economy by recovering energy and resources from waste materials. Future initiatives may focus on developing closed-loop systems that promote the efficient use and recycling of inorganic waste, reducing dependence on finite resources and minimizing environmental impacts. Urban Mining: With the increasing scarcity of natural resources, pyrolysis technologies can facilitate "urban mining" by extracting valuable metals and minerals from inorganic waste streams. Future developments in pyrolysis-based metal recovery processes could help address resource shortages and reduce the environmental footprint of metal extraction. Policy and Regulatory Support:

Governments and regulatory bodies may implement policies and incentives to encourage the adoption of pyrolysis technologies for waste recycling and energy recovery. This includes subsidies, tax incentives, and regulations that promote sustainable waste management practices and incentivize investment in pyrolysis infrastructure. Public

Awareness and Acceptance: Educating the public about the benefits of pyrolysis for waste recycling and energy recovery is crucial for its widespread adoption.

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