Plastic Waste Management

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Abstract: As man's life is becoming more luxurious, the consumption of diesel, commercial fuel and plastics is leading to the "severe energy crisis". Of all the above materials, plastics occupy a great place in causing environmental threat. The main reason behind it is the improper management of waste plastics which is a major challenge to the environmental engineers. Waste plastics which are polymers of high molecular weights tend to have "versatile properties of strength, lightness, durability, and cost". These things make them highly favourable in both domestic and industrial applications. But the extreme drawback of plastics is that "they are Non-disposable and Non-biodegradable". Hence a new method of producing diesel fuel from waste plastics has come into light which stands as a remedy to those burning problems. Tail Gas Reactive pyrolysis (TGRP) is the process of rapidly heating biomass from wood, plants and other carbon-based materials at high temperatures without oxygen. Using pyrolysis to break down tough feedstocks produces three things: biochar, a gas, and bio-oils that are refined to make "green" gasoline (and diesel fuel substitutes). Tail Gas Reactive Pyrolysis (TGRP), removes much of the oxygen from bio-oils without the need for added catalysts. This process is very eco friendly and cost effective as compared to the processes already available.

Keywords: Plastics, Tail Gas Reactive Pyrolysis (TGRP), Thermo fuel, Hydrocarbons

1. INTRODUCTION

Today it is very much essential to use alternative fuel because of energy security, environmental concerns and socio-economic reasons. Over the last few years biodiesel has gained importance as an alternative fuel for diesel engines. The world's annual consumption of plastic materials has increased from around 6million tons in 1950's to nearly 100 million tons in recent times, resulting in a significant increase in the amount of plastic waste generation. Most of times, post-consumer waste either messed all around or is disposed of by landfilling. It causes reduction in soil fertility, emission of toxic gases, pollution of ground water due to leaching of chemicals from these waste products.

1.2 OBJECTIVE

The objective of this study is to have knowledge about post-consumer plastic waste and proper understanding about how to use them, so that we will come to know about the future strategies to reduce their problems by having proper methods.

2. MATERIALS AND METHODS

2.1 RAW MATERIALS

- Polyethyleneterephtalate (PET)
- High density polyethylene (HDPE)
- Low density polyethylene (LDPE)
- Polypropylene (PP)
- Polystyrene (PS)

Out of these raw materials,PET is commonly recycled and has the No.1 as its recycling symbol.

3. EXPERIMENTAL DESCRIPTION:

TAIL GAS REACTIVE PYROLYSIS:-

Pyrolysis is the process of rapidly heating biomass from wood, plants and other carbon based materials at high temperatures without oxygen. Using pyrolysis to breakdown tough feedstocks produces three things: biochar, a gas and bio-oils that are refined to make “green” gasoline.

The **essential steps** in the pyrolysis of plastics involves:-

1. Evenly heating the plastic to a narrow temperature range without excessive temperature variations.

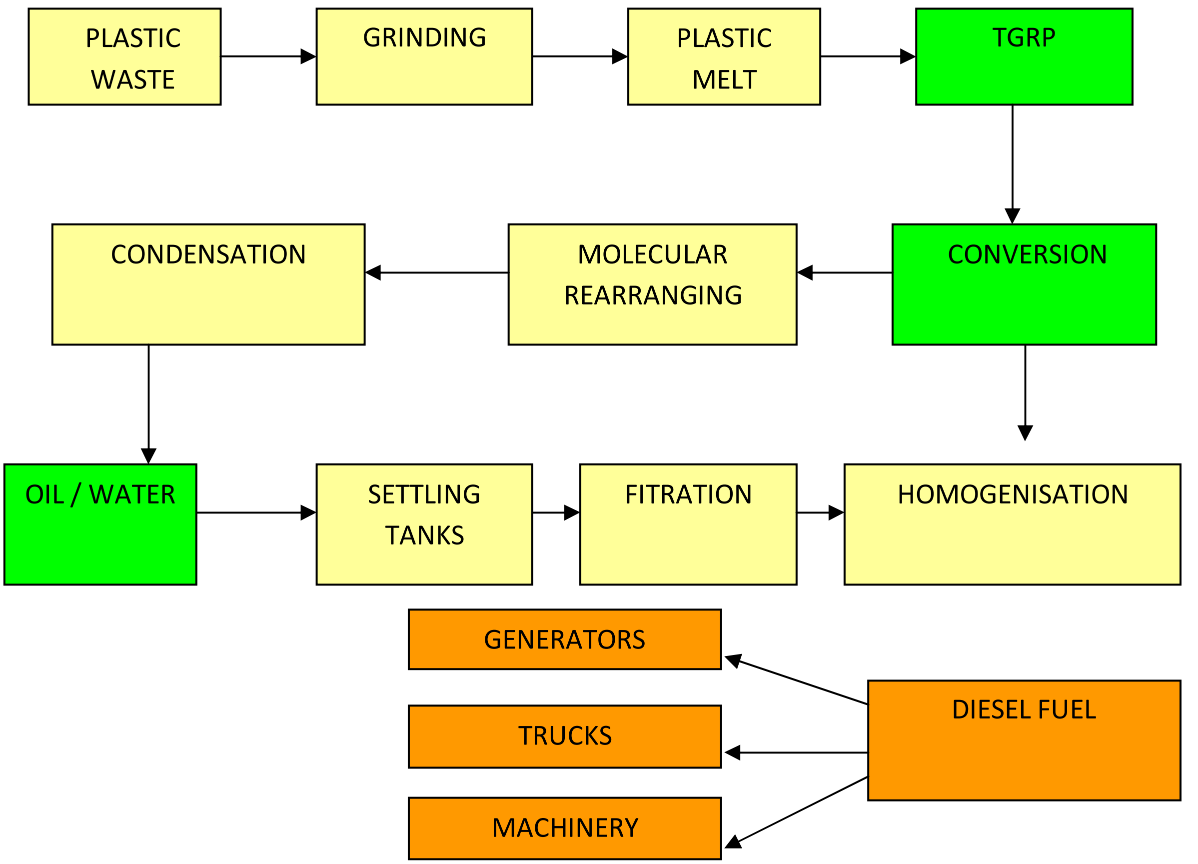
2. Cleaning oxygen from pyrolysis chamber, managing the carbonaceous char by-product before it acts as a thermal insulator and lowers the heat transfer to the plastic careful condensation and fractionation of the pyrolysis vapours to produce distillate of good quality and consistency.

Bio-oils are high in oxygen making them acidic and unstable. But oxygen can be removed by adding catalysts during operation. Although this adds to costs and complicates the process. Therefore, a new pyrolysis process came into research that removes most of the oxygen from bio-oils without the need for added catalysts. This new process is called TGRP (tail gas reactive pyrolysis). TGRP removes most of the oxygen from bio-oils using three types of bio feed stocks with different characterstics: oak, switchgrass and pressed pennycress seeds.

4. STRUCTURE OF THE SYSTEM

The system consists of stock in feed system, pyrolysis gasification chamber, catalytic converter, condensers, centrifuge, oil recovery line, off-gas cleaning, and adulterant removal. Waste plastics are loaded via a hot-melt in feed system directly into main pyrolysis chamber. The chamber can generally be filled within 30min. When the chamber temperature is raised, agitation commences to even the temperature and homogenize the feedstock's. Pyrolysis then commences to the point of product gasification. Non-plastic materials fall to the bottom of the chamber. The gas goes through the (patented) catalytic converter and is converted into the distillate fractions by the catalytic cracking process. The distillate then passes into the recovery tank after cooling in the condensers. From the recovery tank, the product is sent to a centrifuge to remove contaminants such as water or carbon. The cleaned distillate is then pumped to the reserve tank, then to the storage tanks.

FLOWSHEET OF THE EXTRACTION OF DIESEL



4.1. OPERATIONS:

The heart of the pyrolysis system is the prime chamber, which performs the essential functions of homogenisation, controlled decomposition and out gassing in a single process. The process requires minimal maintenance apart from carbon residue removal, and produces consistent quality distillate from mixed and low-grade plastic waste. The key to an efficient pyrolysis process is to ensure the plastic is heated uniformly and rapidly. If temperature gradients develop in the molten plastic mass then different degrees of cracking will occur-and products with a wide distribution of chain lengths will be formed. Another important aspect of pyrolysis is to use a negative pressure (or a partial vacuum) environment. This ensures that oxidation reactions are minimised and that gaseous pyrolysis vapours are quickly removed from the process chamber thereby reducing the incidence of secondary reactions and the formation of undesirable by-products. The polymer is gently 'cracked' at relatively low temperatures to give predominantly straight chain aliphatic hydrocarbons with little formation of by-products. These hydrocarbons are then selectively condensed and cleaved further catalytically to produce the average carbon chain length required for distillate fuel.

4.2. OPERATING FEATURES OF THERMO FUEL:

The system is safe, efficient, easy to operate and highly economical.

4.2.1. SAFETY:-

Thermo Fuel operates under normal pressure; it is fully computer controlled and has numerous operating safety features built in as part of the design.

4.2.2. MAINTENANCE:-

Coking occurs in the chamber when the pyrolysis of the waste plastics is almost complete. However, Thermo Fuel is designed to minimise coking by stabilising heat conductivity within the pyrolysis chamber. The chamber requires cleaning every second process, and takes just 30 minutes.

4.2.3. PRE-TREATMENT:-

Generally, input feedstock plastics do not require washing or sorting. The plastics can be shredded and/or granulated prior to being fed through a melt in feed system into the chamber so almost any shape or size of waste plastics can be handled.

4.2.4. POLLUTION:-

We are extremely conscious of potential air pollution through the operation of any of our waste treatment systems. ThermoFuel produces extremely low level of emissions, due to the capture of almost all of the output, both liquids and gases, inside the system. The ThermoFuel process is designed to meet all EU legislation.

4.2.5. NOISE OR VIBRATION:-

The system has very few moving parts, and accordingly there is no excessive noise or vibration.

4.2.6. FOREIGN MATTERS:-

Foreign matters such as soil, said or papers arc often adherent matters attached to waste plastics. Our system is designed to cope with these foreign materials up to approximately10% by weight or volume.

4.2.7. PYROLYSIS GAS:-

Pyrolysis of plastics tends to occur on irregular basis hence the carbon chain lengths of the pyrolytic gases vary between1-25. Most of the gas is liquefied in the condensers but some remains as gas. Hydrocarbons with carbon count of 4 and lower remain as a gas under room temperature. This high calorific gas contains methane, ethane, propane, butane, etc. Though volume of the gas differentiates, depending upon the types of the plastics, it is generally just 2-5%. This gas is reused to heat the pyrolysis chamber.

4.2.8. PRODUCT YIELD AND CHARACTERISTICS:-

Plastics are separated into oil, gas and char residue by pyrolysis. Recovery ratio and characteristics of the product distillate differs depending on the types of plastics or decomposing temperature and is discussed in detail below. As a rule of thumb, approximately 950ml of oil can be recovered from 1kg of plastics such as Polyolefins including Polyethylene (PE) and Polypropylene (PP), or Polystyrene (PS).

4.2.9. PLASTICS SUITABILITY FOR TREATMENT:-

ThermoFuel can process commingled and miscellaneous waste plastics such as:

Plastic packaging scrap from material recovery/sorting facilities oil and detergent bottles off-cuts/trimming from nappy production, mulch film and silage wrap, mixed post-consumer plastics, caps/labels/rejected bottles from bottle recycling operations, commercial stretch and shrink wrap, multi layer film and laminates.

4.2.10. THE CHAR STREAM:-

The carbonaceous char forms in the chamber during pyrolysis. The char residue produced is generally about 5% of the output for relatively clean polyolefin feed stocks. Since the char passes acid leaching tests it can simply is land filled. The carbon matrix has a metal 'fixing' effect and binds lip the metal ions so that no leaching occurs after disposal.

4.2.11. ENERGY REQUIREMENTS:-

The chamber is heated by natural gas if and where available, or by using fuel or gas produced by the process itself.

4.2.12. OUTPUT FUEL PROPERTIES:-

the typical mass balance for one tonne of mixed polyolefin plastic entering the process is approximately 90% hydrocarbon distillate, 5% char, as well as 5% gaseous material known as non-condensable gases.

The non-condensable gas from the ThermoFuel plant is passed through a water scrubber and then fed into the natural gas flow for the burner, which heats the unit so there are no net, hydrocarbon emissions.

The hydrocarbon fraction in turn comprises approximately 75% distillate cut and 25% paraffin material.

The paraffin fraction is continuously cracked after the first condenser until it reaches the desired chain-length range and then added to the primary fuel stream. A comparison of the distillate produced from a commingled plastic mix compared with regular synthetic fuel has been conducted by gas chromatography, and shows good similarity between fuels.

4.2.13. ADVANTAGES AND DISADVANTAGES:-

Synthetic fuel (distillate) is principally a blend of hydrocarbon compounds called middle distillates that are heavier than gasoline but lighter than lubricating oil. It is not a 'pure' compound but a cocktail of straight-chain and branched alkanes, cyclic saturated hydrocarbons and aromatics.

BLENDING:-

ThermoFuel synthetic is blended from batch-to-batch to ensure homogeneity.

CETANE:-

Thermofuel produced synthetic fuel has a cetane number in the range of 57, similar to higher conventional synthetic fuel, which averages 51-54. Most engine manufacturers recommend synthetic fuels with a cetane number of at least 50.

EMMISSIONS:-

Fuels produced from 100% clean plastic feedstock's will reflect extremely low sulphur levels, generally under10ppm compared to current Australian and general international requirements of < 35 - 50ppm.

There are two types of sulphurs in potential contaminants, organic and in-organic, both of which can be removed within the ThermoFuel system process.

LUBRICITY:

Finally, it is important to emphasise that ThermoFuel fuel is extremely high in lubricity. In synthetic engines some components, including fuel pumps and injectors, are lubricated by the fuel, so good lubricity is key element in reducing wear on these parts.

5. RESULTS AND DISCUSSIONS

Plastic as a feed to the process is approximately 90% hydrocarbon distillate, 5% char, as well as 5% gaseous material known as non-condensable gases. The hydrocarbon fraction in turn comprises approximately 75% distillate cut and 25% paraffin material. Paraffin fraction is continuously cracked after the first condenser until it reaches the desired chain-length range and then added to the primary fuel stream. A comparison of the distillate produced from a commingled plastic mix compared with regular synthetic fuel has been conducted by gas chromatography, and shows good similarity between fuels. Approximately 950ml of oil can be recovered from 1kg of plastics such as Polyolefin's including Polyethylene (PE) and Polypropylene (PP), or Polystyrene (PS).

6. CONCLUSION

The purpose of this study is to investigate the possibility of using various plastic wastes containing high density polythene as polymer additives to other fuels or substances. ThermoFuel is a truly sustainable waste solution, diverting plastic waste from landfills, utilising the embodied energy content of plastics and producing a highly usable commodity that, due to its cleaner burning characteristics, is in itself more environmentally friendly than conventional distillate. Extraction of diesel from waste plastics is only a extension for the present need of fuel energy but not to replace the diesel completely.

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