PLASTIC WASTE DISPOSAL IN PAPER INDUSTRIES – A NEW APPROACH

By

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Papermaking produces significant residual waste streams.

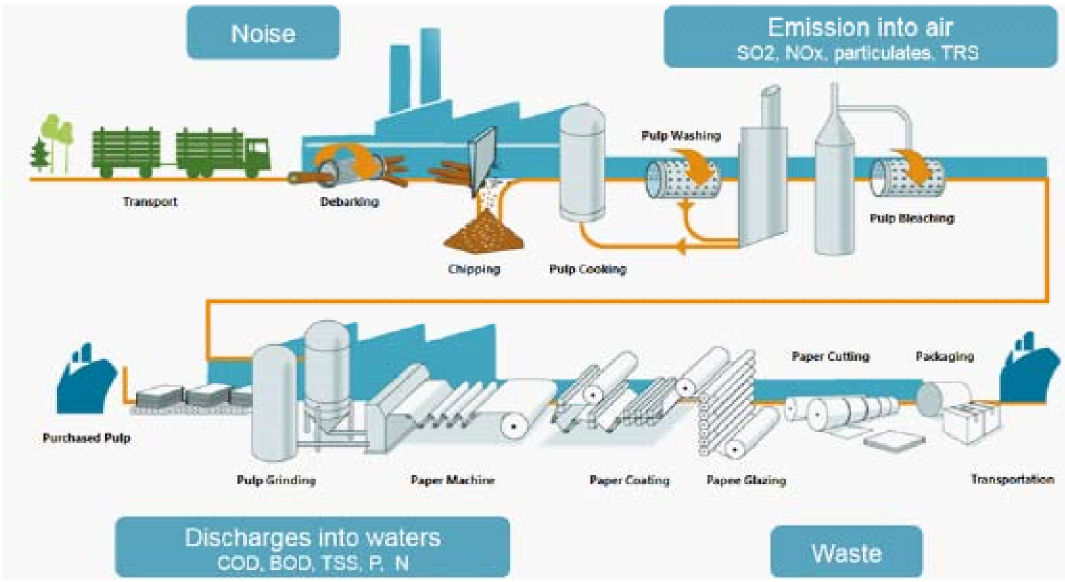
- Waste Water Generation - from Raw material section, Pulping and bleaching, Stock preparation and paper machine, Chemical recovery etc.
- Solid Waste Generation - Raw material handling, Rejects from screening and centri-cleaner, Primary and secondary sludges from WTP, Coal or boiler ash from steam and power generation, Lime sludges from causticizing sectionetc.
- Air Pollution - Gases from digesters, evaporators, recovery and gases emitted by different process units

Paper Mills use different technologies and treatment methods.

- Physical Methods - Sedimentation and Floatation
- PhysicoChemical Methods - Chemical flocculation, Activated Carbon Adsorption , Chemical Precipitation to remove colloids and color
- Biological Treatment Methods - Anaerobic Lagoons,Stabilization Ponds,Aerated Lagoons, Activated Sludge Process,Plastic Media Tricking Filters, Rotating Biological Contractor' Anaerobic Contact Filter
- Innovative Treatment Methods - Advance flocculation, Ozone/AOP technology,Membrane Technologies (Ultra Filtration, NF),Reverse Osmosis, Chemical Oxidation, Electro dialysis
- Solid waste management system – Fuel / Co-processing

Waste Plastics Generation from Waste Paper Recycle Paper Mills- Overview

The trend towards sustainability in the pulp and paper industry envisages waste



paper recycling. About 85% Paper mills inIndia use waste paper as primary fibersource for paper, paperboard and newsprint production, because of economical, energy savings and eco-friendliness benefits.

Paper recycling is the process of mixing **used/waste paper** with water and chemicals to break it down. This mixture is then chopped up and heated to break it down further into strands of cellulose called **pulp or slurry**. It is then strained through screens which remove any glue or plastic that may still be in the mixture. Finally it is cleaned, de-inked, bleached, mixed with water and then it can be made into new recycled paper.

In a waste paper based paper mill, the feedstock (used/waste paper) is in the form of different shape & sizes and of different qualities, consisting of

- o Paper & Board pieces
- o Cartons which are poly coated, plastic laminated or plastic coated
- o Impurities like pins, staples, non-metals, clothes & stone, etc

The details of the plastic waste generated from the waste paper based paper mill / De-inking plants are given below:

- o 3% plastic waste generated per ton of Paper
- o Plastic waste generated shall not be of any defined properties / characteristics. Its properties, characteristics, ingredients, moisture level, impurities varies a lot time to time.
- o Plastic generated shall contain
  - 50-60% of waste loose plastic
  - 40-50% of Impurities of pins, staples, non-metals, clothes & stone, etc
- o Plastic generated shall contain 30-50% Moisture approximately
- o Bailing process& Efficient storage (To be compacted &bailed, transported and stored in the yard)

Plastic waste that is generated during pulping process is then subjected for the bailing process. During bailing, the squeezing of the plastic waste takes-place and whatever water is there gets squeezed out and once the bale is properly squeezed and formed in the size, this is tied-up with the help of wire and taken out with the help of Forklift and stored in a yard.

Waste Plastics Problems faced by Papermills

Paper Mills face a huge problem in disposal of the Plastic waste (Residual Plastic) which is generated from their own Plant.

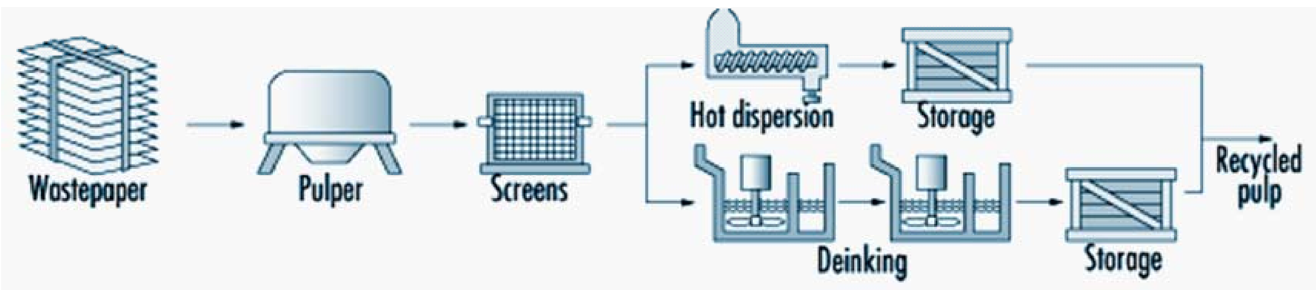
- Plastic waste isHazardous
- When plastics are burnt, harmful quantities ofdioxins, a group of highly toxic chemicals are emitted. Dioxins can cause reproductive and developmental problems, damage the immune system, interfere with hormones and also cause cancer.
- Segregation of waste plastic is difficult as it is mixed with short fibers, pins, stones, denims clothes, cotton, fillers, ink particles, metals, non-metals etc.
- Plastic waste generated from the process is being stored onsite in loose condition (may be bailed) at the paper mill storage yard and thus requires significant space, additional manpower to handle & transport the plastic waste from generation to storage area
- Legal, statutory and Social Issues faced by the paper mill inn disposal of plastic wastes, shall have a direct impact on the mill productions and profitability
- Government rules "Plastic Waste Management Rules, 2016" further tightens the role of plastic waste generating companies in mitigating it too.

Options for Plastics Waste Management & Eco-friendly Emerging Techniques

Conventional methods of waste plastic disposal are land filling and incineration. Paper Mills waste plastics shall be mitigated using emerging techniques and methodologies depending upon the type of plastics, associated impurities, wetness etc. As the waste plastic does not have a defined properties / characteristics, a suitable technology / methodology to be adopted. Some of the emerging techniques are

- PLASTICS RECYCLING THROUGH ENVIRONMENTALLY SOUND MANNER :

- o Recycling of plastics should be carried in such a manner to minimize the pollution during the process and as a result to enhance the efficiency of the process and conserve the energy. Plastics recycling technologies have been historically divided into four general types -primary, secondary, tertiary and quaternary.



Primary recycling involves processing of a waste/scrap into a product with characteristics similar to those of original product.

Secondary recycling involves processing of waste/scrap plastics into materials that have characteristics different from those of original plastics product.

Tertiary recycling involves the production of basic chemicals and fuels from plastics waste/scrap as part of the municipal waste stream or as a segregated waste.

Quaternary recycling retrieves the energy content of waste/scrap plastics by burning / incineration. This process is not in use in India.

- o Steps Involved in the Recycling Process Selection:

The recyclers / reprocesses have to select the waste / scrap which are suitable for recycling /reprocessing.

Segregation: The plastics waste shall be segregated as per the IS Codes

\Processing: After selection and segregation of the pre-consumer waste (factory waste) shall be directly recycled. The post-consumer waste (used plastic waste) shall be washed, shredded, agglomerated, extruded and granulated

• CO-PROCESSING BY CEMENT INDUSTRY

- o One of the most effective methods of recycling of plastics waste for recovery of energy is its use as an alternative fuel in cement kilns
- o Co-processingplantsshallbedesigned, equipped, built and operated in such a way that the gas resulting from the co-processing is raised in a controlled and homogeneous fashion and even under the most unfavorable conditions, to a temperature of 950°C for two seconds. For hazardous wastes with a content of more than 1% halogenated organic substances (expressed as chlorine), the temperature has to be raised to 1100°C.
- o Co-processing plants shall have and operate an automatic system to prevent waste feed: I. at start up, until the temperature of 950°C or 1100°C as the case may be. II. Whenever the temperature of 950°C or 1100°C as the case may be is not maintained. III. Whenever emission monitoring show that any emission limits value is exceeded due to disturbances or failures of air pollution control devices.
- o Co-processing plants shall be designed, equipped, built and operated in such a way as to prevent emission into the air giving rise to significant ground level air pollution; in particular; exhaust gases shall be discharged in a controlled fashion and in conformity with ambient air quality standards by means of a stack, the height of which is calculated in such a way as to safeguard human health and the environment.
- o The management of the co-processing plant shall be in the hands of a skilled person, competent to manage the hazardous waste in an environmentally sound manner.

• FUEL/ENERGY BY PLASMA PYROLYSIS

- o Controlled Pyrolysis Process - oxygen starved with a reactor temperatures above 1,500°C

o Plasma Pyrolysis is a technology, which integrates the thermochemicalproperties of plasma with the pyrolysis process. The intense and versatile heat generation capabilities of PPT enable it to dispose off all types of plastic wastes including polymeric, biomedical and hazardous waste in a safe and reliable manner.

o Plasma Pyrolysis Technology : In plasma pyrolysis, firstly the plastics waste is fed into the primary chamber at 850 Deg.C through a feeder. The waste material dissociates into carbon monoxide, hydrogen, methane, higher hydrocarbons etc. Induced draft fan drains the pyrolysis gases as well as plastics waste into the secondary chamber, where these gases are combusted in the presence of excess air. The inflammable gases are ignited with high voltage spark. The secondary hamber temperature is maintained at around 1050 Deg.C. The hydrocarbon, carbon monoxide and hydrogen are combusted into safe carbon dioxide and water. The process conditions are maintained so that it eliminates the possibility of formation of toxic dioxins and furans molecules (in case of chlorinated waste). The conversion of organic waste into non toxic gases (CO2, H2O) is more than 99% . The extreme conditions of Plasma kill stable bacteria such as Bacillus stereothermophilus and Bacillus subtilis immediately. Segregation of the waste is not necessary, as very high temperatures ensure treatment of all types of waste without discrimination.

• FEED STOCK FOR BITUMINOUS ROAD CONSTRUCTION

- o Polymer Coated Bitumen Road is a technology, in which the plastic is heated to 170-180 Deg.C and mixed with the hot semi-liquid bitumen & Aggregates and thus forms a plastic coating.
- o A Government order in November 2015 has made it mandatory for all road developers in the country to use waste plastic, along with bituminous mixes, for road construction. This is to help overcome the growing problem of plastic waste disposal in India. The technology for this was developed by the 'Plastic Man' of India, Prof RajagopalanVasudevan, Professor of Chemistry at Thiagarajar College of Engineering, Madurai
- o Polymer coated aggregate bitumen mix performs well compared topolymer modified bitumen mix.
- o Higher percentage of polymer coating improves the binding strength of the mix.Foam plastics have better binding values.

- ECO-FRIENDLY LIQUD FUEL BY THERMO-CHEMICAL DEPOLYMERISATION

o Plastics are organic polymers, most of them chains of carbon atoms alone or with oxygen, sulphur, or nitrogen. The conversion of waste plastics into fuel oil by thermochemical depolymerization involves using moderate heat in the absence or oxygen to break down the long-chain hydrocarbons into short-chain hydrocarbon gases and oil.

o This technology emerges as an efficient, safe, and cost-effective process.

Emerging Technologies – Plastics waste mitigation

- **Plasma PyrolysisTechnology**

- Pyrolysis Process - oxygen starved
- Mass-less heat created from plasma torch
- Uniform, reactor temperatures are maintained approximately 1,500°C ; Controlled processing atmosphere
- Lower volume of off gas
- Depending on waste composition treated, 2 to 4 times the thermal energy is generated than that it consumes
- No bottom or fly ashes generated
- Production of dioxins or furans is IMPOSSIBLE
- No secondary wastes, Recovers valuable products

- **Incineration Technology**

- Combustion –excess air required
- Heat value of waste required to maintain combustion reaction or supplementary fossil fuels required
- Operating temperatures around 1,000 °C
- Large volumes of off-gas generated
- "Cold" spots plus excess oxygen inside incineration chamber can result in Dioxins and furans
- Fly and bottom ash treatment and landfill disposal needed

- **Thermochemical Depolymerisation**

- oxygen starved Reaction &catalyticdepolymerisation of complex hydrocarbons
- Mass-less heat created from Burners (Oil / LPG)
- Uniform, reactor temperatures above 500°C - 600°C, Controlled processing atmosphere
- Products are Fuel Oil + off gas + Carbon Black
- Lower volume of off gas
- No bottom or fly ashes generated
- No secondary wastes, Recovers valuable products

CONCULUSION

Plasma Pyrolysis Technology & Incineration Technology releases a considerable quantum of offtake gases produced during this process, which contain residues that can pollute the environment. Thermochemical Depolymerisation is being considered as an Emerging New Technology that can be adopted in paper mills because the plastics are converted to mostly fuel and Carbon black and hence generate less offtake gas. This gas is also reused in the system as a closed loop and hence the gas released to atmosphere is almost nil. Also, this technology operates at a safe temperature range with efficiency and cost effectiveness. Paper Mills can consider Thermochemical Depolymerisation

o To suffice the requirements of stringent"Government Notifications on Plastic Waste Management Rules, 2016"

o To mitigate the waste plastic and protect the environmentas a Primary Focus

o Accomplishes CSR to Society

o Generate Zero Discharge

o Value added products/Fuel that contributes a part of R.O.I

o Moderate investment levels

o Plant Safety Assurance

o Value Addition

Thermochemical Depolymerisation Plants by Paterson Energy, India

About Paterson Energy

Paterson Energy Private Limited (Paterson Energy) has been established with a vision to mitigatewaste plastics and thereby to protect the Environment, Health & Safety of all living beings, prevailing on Planet EARTH.

- By Managing / Mitigating harmful Solid Wastes
- By implementing an Eco Friendly Green Technology Projects
- To venture jointly with Government / Private Partnership
- To convert waste plastic to Energy (Fuel / Power)

Paterson Energy

- Is an Indian Company headquartered atChennai.
- Promoted by AMARNATH MAITREYAN, who is the CEO of a India's most reputed Wealth Management Company & holding various positions in boards of Corporates & Stock Exchanges
- Propagation of the indigenously developed Thermochemical Depolymerisation plant with an aim to provide Green Solution.
- Has established a 3TPD continuous Thermochemical Depolymerisation plant in 2012, that converts Non-Biodegradable, Non-recyclable

Plastics waste to Fuel(Plastic Oil) and is operating successfully.

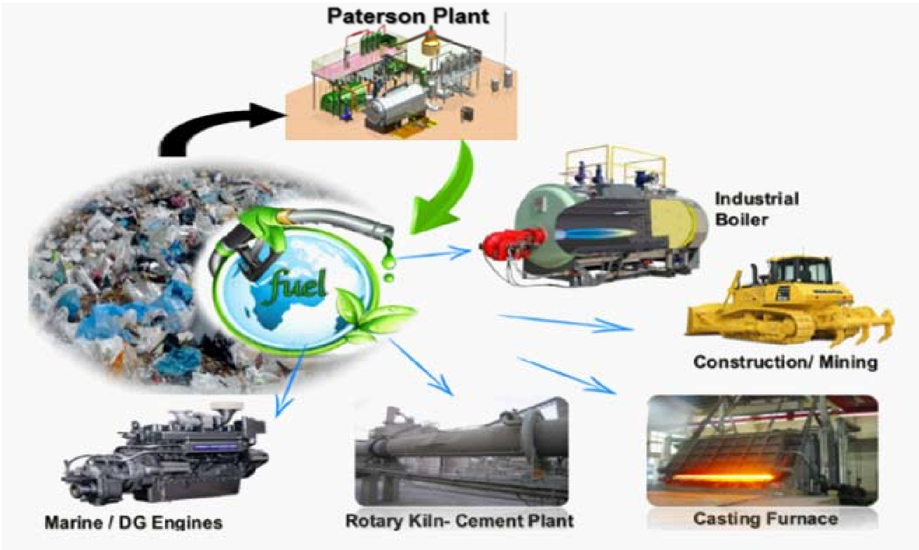
- After 4 years of successful operation and continuous R&D , an additional 7 TPD Thermochemical Depolymerisation plant has been installed in 2016
- Plastic oil is sold in open market for Industrial Boilers, Casting Industries, Diesel Generators etc
- Bagged project from Engineers India Limited, to install & Operate a 5TPD waste plastic to fuel(WTF)Plant at Mathura, U.P on BOO Basis under Swatch Bharat Scheme

The PO is used in Industrial Boilers, Furnaces, Hot Water Generators, Hot Air Generators, Thermal Fluid Heater, Electric Generators (50% diesel blending), Diesel Pumps(50% diesel blending)etc.

Paterson De-polymerisation Plant-features

Paterson Energy has in-depth experience and expertise in supplying high performance continuous waste plastic to oil Thermochemical Depolymerisation plant to clients like Engineers India Limited (A government of India Enterprise) and abroad. The salient features of our plants are

- Standardised Plant Plastic Processing Capacity of 3TPD (Tons per day), 6TPD, 10TPD and 20TPD
- Continuous type Thermochemical Depolymerisation technology for high efficiency and safety
- Production cost of less than Rs 20 (USD 0.22) per liter of Thermochemical Depolymerisation oil.
- Upto 95% conversion of waste plastic into Thermochemical Depolymerisation oil.
- Advanced catalyst -Improves efficiency, reduce coke yield, increases oil yield and quality



- Advanced technology to manufacturing high quality Thermochemical Depolymerisation oil without distillation
- Multi-discipline Design Engineering Team& Professors from external Universities.
- Indigenous Technology
- Machinery plant capacity and emission performance guarantees
- Robust and easy to operate and maintain plant design
- Advanced Thermochemical Depolymerisation Plant Technology
- Completely automated plant operation – Low operational manpower
- Zero effluent / Zero discharge plant

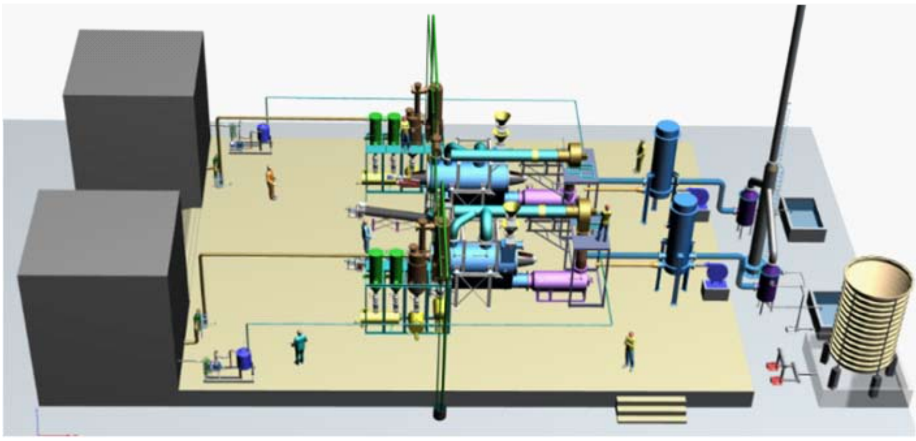
The Technology

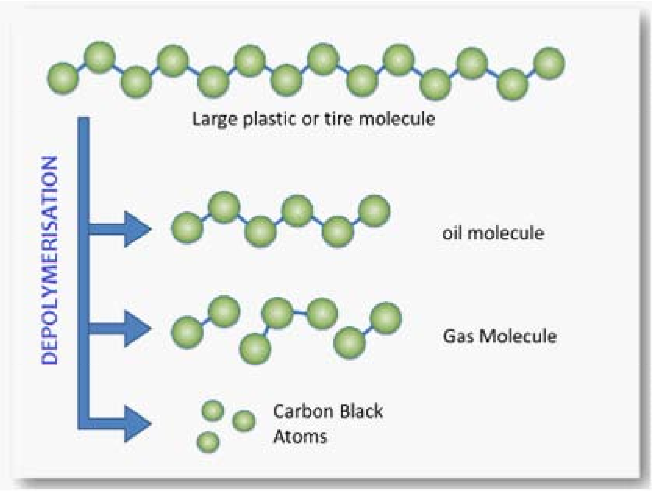
Paterson's technology deploys continuous Thermochemical Depolymerisation process to convert waste plastics to diesel grade fuels similar to diesel and gasoline. The technology uses a multi-staged thermal process to molecularly crack and re-arrange longer chain hydrocarbons found in plastics to shorter chain hydrocarbons found in petroleum fuels.

The Paterson Technology consists of the following operating systems and processes for the highly efficient and effective conversion of end of life plastics (Non Recyclable and Non Biodegradable) to useable liquid fuels. Suitable end of life plastics are preprocessed to size reduce and remove any contaminants or non-plastic materials from the feedstock at the first stage of the Paterson Technology. The

shredded plastics are then loaded via a hot melt in-feed system directly into main De-polymerisation Reactor. Agitation commences to even the temperature and homogenises the feedstocks.

De-polymerisation then commences and the plastic achieves a gaseous stage. Non-plastic materials fall to the bottom of the chamber. The gases from the Reactor passes into the contactor which knocks back the long chained carbons and allows the required condensable vapors to pass into the distillation column. The system diverts the non-condensable synthetic gas through a scrubber and then back into the furnaces to heat the Reactor.





The condensable gases are converted in the distillation column to produce lite oil and raw diesel. The light oil is put into storage. The raw diesel is passed to the vacuum distillation column to be further refined to produce diesel grade, kerosene grade and lite oil. The distillates are then collected in the recovery tanks.

Environmental-friendly : Paterson's technology

Emission Standard : Adopting special gas scrubbers to remove acid, gas and dust

smoke : Fully enclosed during the operation, there will be no dust.

Water pollution : NIL (Zero pollution)

Protection : Exhaust gas burning room, desulfurization & double-de-dusting system

Odorless : Odor Exhaust system

The Feed stocks (Waste Plastic)

Paterson's Technology process is specifically designed to manage most plastic waste feedstock in a single profitable process that is pertinent to the persistence of global plastic disposal issues.

Acceptable Plastic Feed stocks

- 2 HDPE (High Density Polyethylene). Examples: Crinkly shopping bags, freezer bags, milk bottles, bleach bottles, buckets, rigid pipes and crates.
- 4 LDPE (Low Density Polyethylene). Examples: Garbage bags, squeeze bottles, black Irrigation tubes, films and garbage bags.
- 5 PP (Polypropylene). Examples: Trays, potato bags, drinking straws, containers, tubs, plastic garden settings, baby baths and plastic boxes
- 6 PS (Polystyrene). Examples: Trays, yoghurt & dairy containers, vending cups and produce boxes.

Non-Acceptable Plastic Feed stocks

- 1 PET (Polyethylene Terephthalate). Examples: Soft drinks bottles, food grade packaging and trays
- 3 PVC (Polyvinyl Chloride). Examples: Pipes, window fittings, bottles and laminates
- 7 Other. Examples: Foams, nylons and fiberglass.

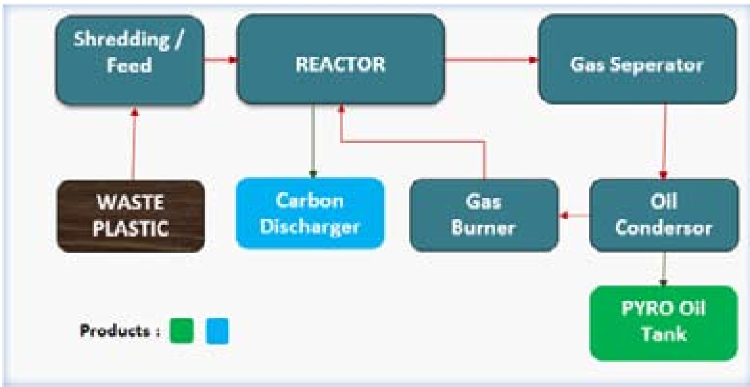
Other materials not suitable for the process (but are not limited to)

- Metals
- Wood
- Oil based paints
- Silicone based products
- Poisons and chemicals, herbicides, pesticides, fungicides
- Oxidizing agents, fertilizers, nitrates, chlorates,perchlorates,hypochlorite's, peroxides
- Prescribed wastes as listed in the Environment Protection Regulations
- Materials with moderate-to-high levels of nitrogen, chlorine or bromine
- Material containing Sulphur

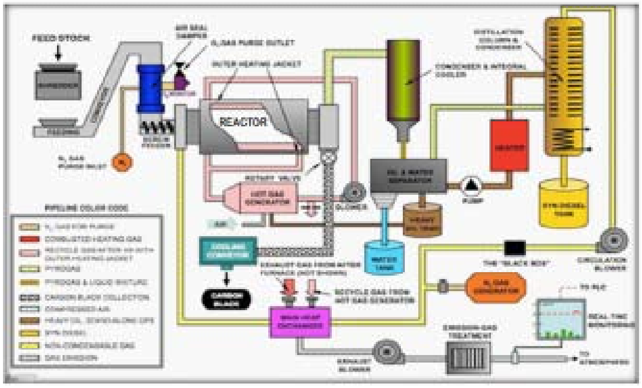
The Process

The Process is called Thermal Depolymerisation which is the chemical decomposition/degradation of organic and hydrocarbon substances/ polymers by heating. The technology is a thermal degradation process in which plastic waste is treated in a cylindrical reactor at 400 to 600 Degrees Centigrade, in the absence of oxygen at high reaction temperatures and in the presence of a Catalyst. Thermal Depolymerisation of waste plastic results in producing high-energy gas, oils and carbon black. The ratios of the first three products depend on process conditions, mainly on temperature.

Process flow diagram



Process Schematic diagram



The Product : Technical Specification (PO) *

S. No.	Characteristics	Indian Specifications	Oil Produced from our Machine
1	Acidity, inorganic	NIL	NIL
2	Ash, % wt. max.	0.1	0.1
3	**Density at 15^{0}C, g\ml, Max.**	**0.99**	**0.87**
4	**Flash point, (PMCC) ^{0}C, Min.**	**66**	**43**
5	Kinematics viscosity (CS)at 50^{0}C Max.	180	22
6	Sediment, % wt. max.	0.25	0.25
7	**Sulphur, total, % by wt., max.**	**2.5**	**0.5**
8	Water content, % by vol., max.	1	1
9	Pour point, 0C, maxes.	30	5
10	Carbon residue % by mass	20	18

Technical Specification (Char) *

Properties	Analysis Method	Rubber powdered carbon	Carbon black grades in US		
			HAF(N330)	SRF(N754)	MT(N908)
Iodine Adsorption Number,mg/g	ASTM D-1510	176	82	24	
DBP Absorption, cm3/100g	ASTM D-2414	78	92-102	50-65	26-44
CTAB Surface Area, m2 /g	ASTM D-3765	68	74-90	23-39	
pH – Value	ASTM D-1512	9	9	9	
Heating Loss, % max	ASTM D-1509	1.5	2.5	1.5	1.5
Ash Content, % max	ASTM D-1506	10	0.5	0.5	0.5
Average Particle Size, nm	MICROSCOPE	300 mesh			

Note :* means that the values provided in the table is for a specific sample of waste plastic analyzed at a specific instant/date. These values vary-widely tewith respect to the mixture of varieties of plastics, oil content, impurities level, wetness etc