History of The Invention: Zadgaonkars Process

Introduction

Principals involved

All plastics are polymers mostly containing carbon and hydrogen and few other elements like chlorine, nitrogen etc. polymers are made up of small molecules called as monomers which combine and form single large molecule called polymer.

When this long chain of monomers breaks at certain points or when lower molecular weight fractions are formed this is termed as degradation of polymer. This is reverse of polymerization. If such scission of bonds occurs randomly it is called as 'Random De-Polymerization.

In the process of conversion of waste plastic into fuels random De-Polymerization is carried out in a specially designed Reactor in absence of oxygen & in the presence of coal and certain catalytic additive. The maximum reaction temperature is 350°C. There is Total conversion of waste plastic into value added fuel products.

Laboratory Scale/Bench Scale

Inventor Prof. Mrs. Alka Zadgaonkar started the basic research work for elimination of polymer waste in the year 1992. After five years of rigorous research, in the year 1999, 300 gm of plastic waste was successfully converted into liquid hydrocarbons. The reaction parameters viz. temperature, pressure and time for a batch were extremely high in initial stages. Subsequently these parameters were brought down to feasible level by formulating improved catalytic additives.

Inventor was quite aware of the fact that many laboratory scale inventions miserably failed after scaling up. Considering this important fact, inventor decided to scale up the lab-scale unit by 100 times and thus 30 Kg bench scale apparatus was designed.

The Bench Scale Batch Process set-up

The equipment was upgraded and designed with the controls, feedback and data generation devices for 30 kg of mixed waste plastic as batch feed, which could be conveniently operated in a laboratory setup. A number of experiments were carried out on this set up and the data generated was analyzed for further development. Assorted plastics and coal along with catalyst is heated to about 400 °C and distilled products are collected.

The brief description of the equipment is as follows-

Particulars	Description
Reactor	This is an insulated stainless steel cylindrical reactor heated by electrical heating coils to achieve a maximum heating temperature of 500 °C. The necessary provision is made on the reactor for mounting the gadgets for measuring pressure, temperature and collection of hydrocarbons from the
Condenser	The gaseous output from the reactor is passed through a double walled condenser with inlets and outlets for cooling water. The gaseous hydrocarbons at a temperature of around 350 °C are condensed to around 30-35 °C
Receiver	The condensed hydrocarbon in the liquid form is collected in the receiver. The provision is made for collecting the uncondensed gases in to gas collector. The arrangement to measure the volume & rate of flow of distillate continuously or intermittently at any point of time in each batch operation
Control Panel	The complete process is controlled from the control panel. Optionally the process can also be controlled from a Computer. The continuous feedback of the process parameters is available on the Control Panel and the Computer. The data generated is stored in the computer

Output Yield Data

The major process parameters and product yields are given in Table below. The evolved vapors are condensed to collect gas and liquid products.

Feed	**Assorted waste plastic**

Catalyst	0.1 wt% on feed
Temperature	300-400 °C
Pressure	Atmospheric
Batch cycle time	3-4 hrs
The product yields	Quantity (wt%)
Gas	10-20
Liquid hydrocarbons	60-80
Coke	7-10

Typical analysis of the gaseous product is given in the following table-

No.	Component	Quantity
1	Methane	6.6
2.	Ethane+ethylen	10.6
3.	Propane	7.4
4.	Propylene	29.1
5.	Iso-butane	1.9
6.	n-Butane	0.9
7.	C4	25.6
8.	Iso C5-n-C5	0.1
9.	C5+higher	15.3
10.	Hydrogen	2.5
11.	CO/CO2	< 400 ppm

NB: The gas analysis was done after removal of chlorine as HCl

Typical analysis of the liquid product is given in the following table

No.	Carbon	Quantity (wt%)
1	Upto C10	61.0
2	C10 to C13	2.4
3	C13 to C16	8.5
4	C16 to C20	4.1
5	C20 to C23	7.6
6	C23 to C30	16.4

Certified Observations and Conclusions from Indian Oil Corporation (R&D Centre)

Following are the major observations and conclusions from the experiments by INDIAN OIL CORPORATION LIMITED (RESEARCH & DEVELOPMENT CENTRE)

- All the types of plastic waste including PVC & PET are converted into gases & liquid hydrocarbons.
- The catalyst enhances the conversion of waste plastic in to hydrocarbons thereby improving quality & quantity of hydrocarbon gas and liquid products. Negligible Conversion was observed in absence of invented catalytic additives
- Increase in the temperature and rate of heating increases the gas yield.
- Introduction of feed at higher temperature substantially reduces the process cycle time.
- Water from wet gas meter indicates presence of HCl in the gaseous fraction.
- Inorganic Chlorine is present in the gas and liquid products.