PLASTIC PETROL: SYNTHESIS AND PERFORMATIVE STUDY

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ABSTRACT

Waste plastics are mostly land filled or incinerated; however, these methods are facing great social resistance because of environmental problems such as air pollution and soil contamination, as well as economical resistance due to the increase of space and disposal costs. In a long term neither the land filling nor the incineration solves the problem of wastes, because the suitable and safe depots are expensive, and the incineration stimulates the growing emission of harmful and greenhouse gases, e.g. NOx, Sox, COx etc. Accordingly, recycling has become an important issue worldwide. This method can be classified as energy recovery, material recycling and chemical recycling. Among them one of the prevalent alternative methods is the production of converted fuel and chemicals by means of the thermal or catalytic degradation of polymers.

A research work for systematic decomposition of waste plastic has been carried out by using liquid bed technique and the product is fractionated to obtain petrol, diesel and liquid bed. The product petrol is then subjected to load test in petrol rig to have performative study.

Key words: Break thermal power efficiency, Environment, Load test of petrol, Management of plastic waste, Plastic waste, Recycling of plastic waste,

INTRODUCTION

In 'western' countries, plastic consumption has grown at a tremendous rate over the past two or three decades. In the 'consumer' societies of Europe and America, scarce petroleum resources are used for producing an enormous variety of plastics for an even wider variety of products. Many of the applications are for products with a life-cycle of less than one year and then the vast majority of these plastics are then discarded. In most instances reclamation of this plastic waste is simply not economically viable.

[7,8,9,10,11,12]One of the method to deal plastic waste is the chemical recycling. The chemical recycling processes can be classified into three main areas:

1. Recycling to fuels [gasoline, liquefied petroleum gas (LPG) and diesel oil],
2. Recycling to monomers,
3. Recycling to industrial chemicals.

MATERIALS AND METHODS

[13,14,15]The main aim of this research work is to obtain fuel from waste plastic and to carry out the performative study of this petrol in petrol rig. The waste plastic selected was the polystyrene. Polystyrene is used to manufacture disposable cup and plates, fast food boxes, thermocol, etc. The technique used for conversion of waste plastic into fuel is the liquid bed technique. As the primary experimental studies shows that this technique is able to give high quantity of fuel product and also recover the liquid bed. The experiment is carried out in the laboratory by using glass reactor. This reactor having an arrangement to record the reaction mass temperature as well as temperature of product vapor's going for condensation. Thus this arrangement is able to give decomposition and fractionation at desired temperature in a single step. In this work the liquid bed adopted is the kerosene with boiling range 200–250^{0}C. Here electrical heating device is used to provide high temperature and dimmerstate is used to control and maintain temperature of reactor. For proper coiling, two stage condensation system is used.

[16,17]Testing methods used for characterization of product liquid, liquid bed are as follows:

1. Specific gravity, API gravity and density determination,
2. Flash point determination,
3. Viscosity determination,
4. Acid value determination,
5. Saponification value determination,
6. Conradson carbon residue determination,

7. Aniline point determination,
8. Copper corrosion test,
9. Determination of water content,
10. Color inspection.

OBSERVATIONS

The observations for various tests for feed liquid bed, product liquid bed and product petrol and diesel are as shown below:

S. N.	Properties	Petrol	Kerosene (Product bed)	Diesel	Feed Liquid Bed
1	Specific gravity, at 38^0C	0.7751	0.8076	0.9411	0.7928
2	API gravity	33.59	43.979	18.8479	47
3	Viscosity, cst (40^0C)	1.0658	1.3209	2.9747	---
4	Aniline point, ^0C	Below 1.5^0C	54^0C	31^0C	63^0C
5	Flash point, ^0C	---	72^0C	108^0C	72^0C
6	Conradson carbon residue, wt%	0.01614	0.02288	0.0187	0.0059
7	Refractive index at 27^0C	1.5003	1.4582	1.5376	1.4491
8	ASTM distillation IBP ^0C 10% 30% 50% 90% FBP^0C MAX. Recovery (ml)	 145 150 154 159 209 215 98	 192 200 211 220 250 253 97	 251 256 274 296 310 365 97	 190 200 208 216 245 256 97
9	Moisture content % Ppm Mg of H_2O	 0.03028 302.79 2.5454	 0.01494 149.43 1.1818	 0.02412 241.29 2.227	 0.019260 192.6040 1.5000
10	Copper strip corrosion at 50^0C, 3 hours	Not worse than no. 1	Not worse than no. 1	Not worse than no. 1	Not worse than no. 1

[18]To study the petrol obtained is really workable or not, the load test of product petrol is carried out in petrol rig and data obtained is compared with the mineral petrol data at identical conditions.

Observation and data given:

1. Cylinder bore (D) = 52 mm,
2. Stroke length (L) = 51.8 mm,
3. Water density (□w) = 1000 kg/m^3,
4. Calorific value of sample (mineral petrol) = 42000 KJ/kg

5. Acceleration due to gravity (g) = 9.81 m/s^2,
6. Air density (□a) = 1.2 kg/m^3,
7. Room temperature (T_1) = 34^0C

A] For Mineral Petrol:

1. Density of petrol sample (□f) = 0.7 kg/litre,
2. Calorific value (C.V.) = 42000 KJ/kg

Observation table for mineral petrol sample:

S.N.	h_1	h_2	RPM	Load (kg)	Time (sec.)	Exhaust Temperature (^{0}F)
1	15	– 20	2500	0.5	59	535
2	15	– 20	2500	1.0	51	545
3	15	– 20	2500	1.3	44	548
4	15	– 20	2500	1.5	42	552

B] For Plastic Petrol:

1. Density of petrol sample (□f) = 0.77 kg/litre,
2. Calorific value (C.V.) = 39570 KJ/kg

Observation table for plastic petrol sample:

S.N.	h_1	h_2	RPM	Load (kg)	Time (sec.)	Exhaust Temperature (^{0}F)
1	15	– 20	2500	0.5	63	535
2	15	– 20	2500	1.0	56	545
3	15	– 20	2500	1.3	49	548
4	15	– 20	2500	1.5	46	552

CALCULATIONS

1. Air mass flow rate (Ma): Kg/hr.

a) Area of orifice = $\frac{\pi}{4}$ x d^2

Where, d = Orifice diameter = 0.01525 m, A_0 = 1.8256 x 10^{-4} m^2

b) **Manometer head (Ha):**

$$Ha = \frac{\frac{hw}{100} \times \rho w}{\rho a}$$

$hw = h_1 - h_2 = 15 - (-20) = 35$ cm

$\rho w = 1000\ kg/m^3$

$\rho a = 1.2\ kg/m^3$

Ha = 291.66 m

c) **Mass flow rate of air:**

$Ma = A_0 \times C_d \times 3600 \times \rho a \times (Ha \times 2 \times g)^{0.5}$ kg/hr

Here C_d = constant for engine = 0.62

$Ma = 2.2344 \times (Ha)^{0.5}$

= 38 kg/hr.

2. Break Power:

$$BP = \frac{(2\pi \times N \times W \times R \times g)}{60000} \times \eta d$$

$$BP = \frac{(w \times N)}{4599}$$

Where, W = Load shown in spring balance in kg,

R = Torque arm = 0.18 meter,

ηd = Efficiency of eddy current dynamometer = 0.85,

N = Engine speed in RPM,

3. Specific fuel consumption (SFC in kg/kw-hr):

$$SFC = \frac{TFC}{BP}$$

4. Air fuel ratio A/F:

$$A/F = \frac{Ma}{TFC} = \frac{38}{TFC}$$

ρ_f = 0.7 kg/liter, CV = 42000 KJ/kg

5. Total fuel consumption (TFC in kg/hour):

$$TFC = \frac{(10 \times 3600 \times \rho_f)}{(t \times 1000)}$$

Where, 10 = Fuel consumed in cc,

ρ_f = Fuel density = 0.7 kg/liter,

T = time for 10 c fuel consumed,

TFC = 25.2/t

6. Break thermal efficiency b%:

$$\eta b = \frac{(BP \times 100 \times 3600)}{\text{Heat supplied}}$$

Heat supplied = TFC x Calorific value

CV = 42000 KJ/kg

MATERIAL BALANCE

Feed	Petrol in ml	Kerosene in ml	Diesel in ml	Residue in gram	Gases
Waste plastic 100 gm and Liquid Bed 100 ml	22.5	101	75	7.3252	Traces

RESULT AND DISCUSSION

Result: The various values for TFC, SFC, A/F and Break Thermal Efficiency obtained for mineral petrol and plastic petrol are tabulated as follows:

Sample	Density (kg/lit.)	Calorific Value (KJ/Kg)	Load (kg)	B.P. (KW)	TFC (Kg/hr.)	SFC (kg/kW-hr)	A/F	Heat supplied (KJ/kg)	Break Thermal Efficiency
A	0.7	42000	0.5	0.2717	0.4271	1.57	80.67	17938.2	5.45
			1.0	0.5438	0.4941	0.9	76.90	20752.2	9.41
			1.3	0.7070	0.5727	0.81	66.35	24053.4	10.58
			1.5	0.815	0.6	0.73	63.33	25200	11.73
D	0.77	39570	0.5	0.2717	0.44	1.61	86.33	18480	5.33
			1.0	0.5438	0.495	0.91	76.76	20790	9.48
			1.3	0.7070	0.5657	0.8	67.17	23795.4	10.79
			1.5	0.815	0.6026	0.7393	63.06	25309.2	11.68

Discussion:

1. From above observation it is clear that the waste plastic able to give the liquid product which can fractionated into petrol, recover kerosene bed and diesel.
2. Here the fractionation was carried out by using ASTM distillation. The fraction with boiling point up to $200^{0}C$ is known as petrol. The fraction with boiling range 200 – $250^{0}C$ is known as liquid bed, and the fraction with boiling point range above $250^{0}C$ is known as diesel.
3. From the high specific gravity and low aniline point of product petrol and diesel as compared with IS specification (IS norms for specific gravity of petrol

is 0.70 – 0.72) indicate that the product petrol and diesel consists of high percentage of aromatic hydrocarbons.

4. Flash point value for product diesel is quite higher than the standard value of diesel. This is due to the boiling point range. Actually flash point is related to lower hydrocarbon (that is IBP to 10% range hydrocarbon). Here kerosene and diesel taken as higher range (kerosene 200 – 250^{0}C) and diesel more than 250^{0}C. Hence, there are higher value of flash point for kerosene and diesel.
5. **Break power:** As load increases break power also increases, but the break power is same for pure petrol and petrol obtained from plastic for respective load, because break power is the unusable power output of the engine which does not depend on power required to fuel.
6. **Fuel test time:** Fuel test time for 10 cc fuel decreases as load increases, but decrease in time is more for pure petrol than the petrol obtained from plastic.
7. **Total fuel consumption:** As load increases the total fuel consumption increases, but increase in total fuel consumption is more for pure petrol than petrol obtained from plastic for respective load.
8. **Specific fuel consumption:** As load increases the specific fuel consumption decreases, but the decrease in pure petrol is more than the petrol obtained from plastic for respective load.
9. **Air to fuel ratio:** As load increases the air to fuel ratio decreases, but for pure petrol air to fuel ratio decreases more than the petrol obtained from plastic.
10. **Break thermal efficiency:** As load increases the break thermal efficiency increases, but increase in efficiency is more in pure petrol than the petrol obtained from plastic.

CONCLUSIONS

1. From this work it is clear that the waste plastic able to give the high amount of liquid fuel range product by using liquid bed, which can be fractionated to petrol, diesel and recover kerosene bed.

2. Use of liquid bed able to give high yield of liquid fuel, 100 gm polystyrene waste able to give nearly 100 ml liquid product.
3. The product fuel i.e. petrol and diesel able to show all the characteristics prescribed for these fuels.
4. From the comparative performative data for mineral petrol and plastic petrol, we can conclude that the plastic petrol able to run the engine and have nearly same break thermal efficiency as that of mineral petrol.
5. Finally it can be concluded that the plastic petrol is workable and give the same performance as that of mineral petrol in all aspects.

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