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CONVERSION OF WASTE PLASTIC TO FUEL FOR THE DI-CI ENGINE

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ABSTRACT

Plastics are rush into our daily lives and now pose tremendous threat to the environment. Over 100 million tones of Plastics are produced annually worldwide, and the used products have become a common feature at overflowing bins and landfills. The long bio-degradability time of plastics create environmental problems. As an alternative, waste plastic oil is receiving increasing attention as fuel for the Diesel engines. As a part of our project work, we extracted the hydrocarbon fluid from the same type of waste plastic (medical saline bottles). Later characterization, Chromatographic and mass spectrographic analysis carried out, and to implement as fuel for DI-CI engine, the characteristics of plastic HC fluid compare with the Petroleum diesel.

Keywords: Plastic HC, Saline Bottles, GC-MS.

I. INTRODUCTION

Today the plastic waste is a big problem for the entire world, due to its too long bio degradability time. The disposal of plastic waste improperly leads to several problems. On the other hand plastic is polymer of hydrocarbons. All the fuels are composed of hydrocarbons. Hence the non bio-degradable plastics subjected to de-polymerization leads to production fuel. With this concept many researchers put their efforts to extract the plastic hydrocarbon fluid (HC) from different types of plastics. The percentage of extraction of hydrocarbon fluid is depending on operating temperature of the reactor, heat distribution across the plastics, condenser temperature, and the chemical composition of the plastic. The operating temperature of the furnace is near to 500^0C the percentage of extract is higher. The length of the condenser, the mass of the water circulated per hour and the annular distance in between hot gas pipe and outer pipe are influencing the rate of condensation of the hydrocarbon fluid. Hence while designing the condenser these parameters need to consider. While melting the plastic condensable and non condensable gases are produced. Escaping of non-condensable gas directly to the outside environment is not preferable, because those gases are harmful to the health. Plastic is melting in the absence of the oxygen. The generated gases have rapid oxidation tendency, which need to burn immediately.

When a Plastic HC fuel is adopted for an existed engine, calorific value, flow ability, cetane number, oxidation index, acid value, percentage of carbon residue, saturated hydrocarbons of the fuel are need to compare with the conventional fuel. If the adopted fuel has less calorific value than the existed fuel, the rate of fuel consumption will be more. The extracted HC fluid should have the near viscosity to the petro-diesel; otherwise it leads to low flow rates in the fuel lines and choking of the injector. When the viscosity of the HC fluid is higher than the petro-diesel, atomization, vapourization and homogenization inside the combustion chamber are not proper during the combustion. Cetane index is the other parameter which influences the knocking tendency. If the HC fluid is acidic vibration tendency increases. It also accelerates the corrosion tendency. When the carbon residue is higher the formation of soot during the combustion will be higher. Hence while adopting the HC fluid one need consider the all above properties. Otherwise either fuel or engine modifications are required. Blending of the plastic HC fuel with petro-diesel, methanol, adding of high cetane number fuels etc. are the fuel modifications which improves the combustion efficiency. Increasing of injector pressure, changing of injection timing using of retro-fittings are the engine modifications which improve the adoptability of plastic HC as a fuel for compression ignition engine.

In our project, by considering the above literature survey we developed the reactor and condenser for the extraction of plastic HC fuel, characterization and Gas Chromatography & Mass Spectrograph (GS-MS) analysis performed on the extracted HC fuel to put into diesel engine as fuel.

II. EXPERIMENTAL SET UP FOR THE EXTRACTION OF HC FLUID:

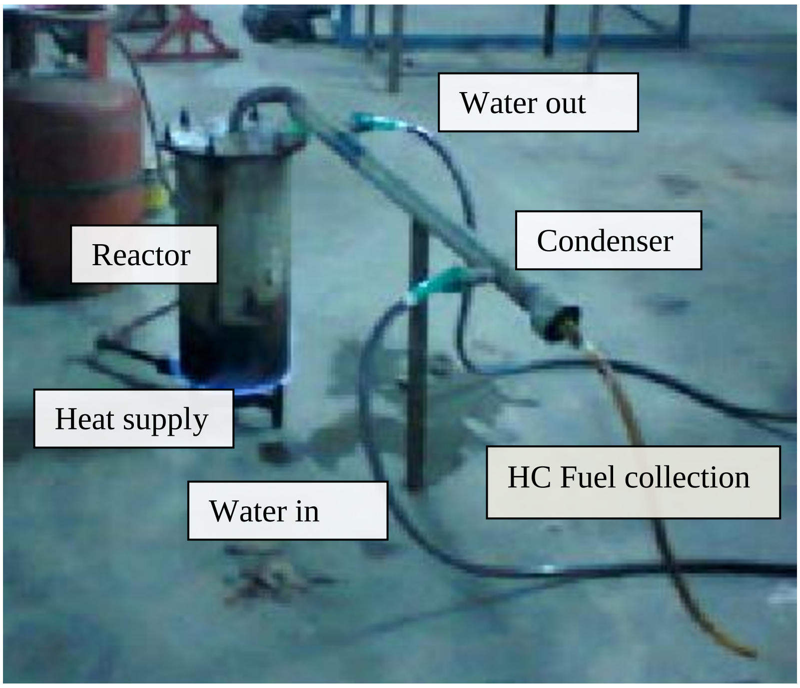

Figure.1 Experimental Set Up for the Plastic Hydrocarbon Fuel.

As shown in Fig.1 the experimental setup consists of heat source, reactor, condenser and fuel collection pipe. To supply the heat energy liquid petroleum gas with burner used for the experiment. Controlling of the gas and availability of the heat energy is high in this case. The energy balance calculation not included in this paper. The work mainly concentrated on extraction and characterization. Counter flow shell and tube type heat exchanger used as condenser. The center pipe carries the hot gases and annular pipe carries the cool water. Hence the condensate is formed in the central tube, and it is collected into bottles. Non condensable gases also released during the experiment. These gases are separated and burned. The reactor height is ten times more than the diameter. Hence the separation of gaseous phase and the liquid phase perfect and no liquid phase is entered into the condenser. The quality of the condensate is improved due to high length to diameter ratio for the reactor.

To conduct the experimentation the chips of saline bottle placed in the reactor chamber. The chamber is filled upto 50% with the chips. The quantity of the chips weighed after that it is placed in the reactor. The reactor cap is fixed after placing the gaskets to arrest the leakage of the gases. The cap directly the condenser in let pipe is connected as shown in fig.1. Heat supplied from the bottom of the reactor. The total time of the heat supplied also considered, to calculate the heat input. In this experiment 85% of the hydrocarbon fluid is collected.

Further the collected fluid is subjected to the fractional distillation to extract the good quality of the fuel at different temperatures.

III. CHARACTERIZATION AND GC-MS ANALYSIS

Table:1 Properties of the HC Fuel:

S.No	Parameter	Units	Plastic HC fuel	Petro-diesel	Test method
1	Kinematic Viscosity @40^{0}C	cSt	1.04	1.5.-2.0	ASTM D 445
2.	Iodine value		5.59	--	AOAC Ch.41
3.	Carbon residue	%	0.061	0.03	ASTM D 189
4.	Flash Point	^{0}C	30	55-60	ASTM D 93
5.	Fire Point	^{0}C	33	57-63	
6.	Moisture content	%	0.02	0.08	ASTM D 4377
7.	Density	gm/cc	0.7872	0.83-0.85	ASTM D 1298
8.	Sediment	%	0.06	--	ASTM D 893
9.	Gross Calorific value	kJ/Kg	37,867	43,700	ASTM D 240
10.	Cetane Index		42	45-50	ASTM D 976
11.	Saturated Hydrocarbons	%	18.6	--	GCMS Screening
12.	Unsaturated hydrocarbons	%	23.4		

From the above properties, one can observe the viscosity of the Plastic HC fuel is less than the Petro-diesel. Hence the flow ability in the fuel lines and injection quality very near to the petro- diesel. It supports the less modification of the existed engine. The cetane number of the Plastic HC and Petro-diesel also very near. Hence the knocking tendency is also very less. The calorific value is slightly less than the petro-diesel, which causes for more fuel consumption. By observing above physical and chemical properties the extracted plastic HC is suitable for implementing as fuel for the CI engine, in the blended form as well as in neat form.

3.1 GC- Ms Analysis

Gas chromatography and mass spectrographic diagrams are shown fig.2 & fig.3. Unsaturated hydrocarbons in the plastic HC fuel are 23.4%, the remaining components are Saturated hydrocarbons and aromatics which is favorable to implement as fuel for the diesel engines.

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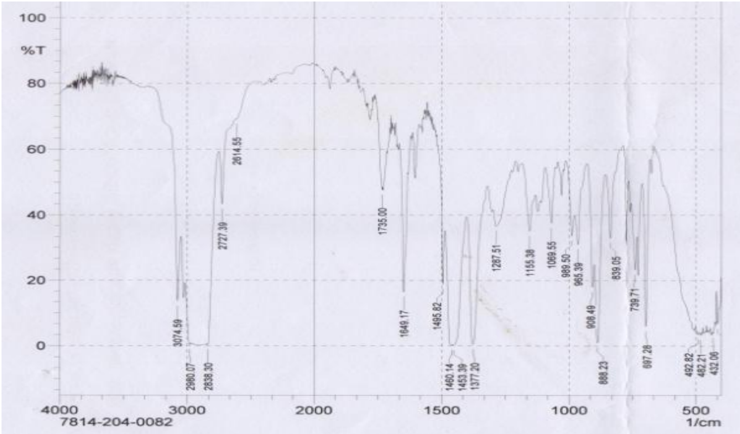

Figure.2 FTIR Spectrum of Plastic Hydrocarbon Fuel

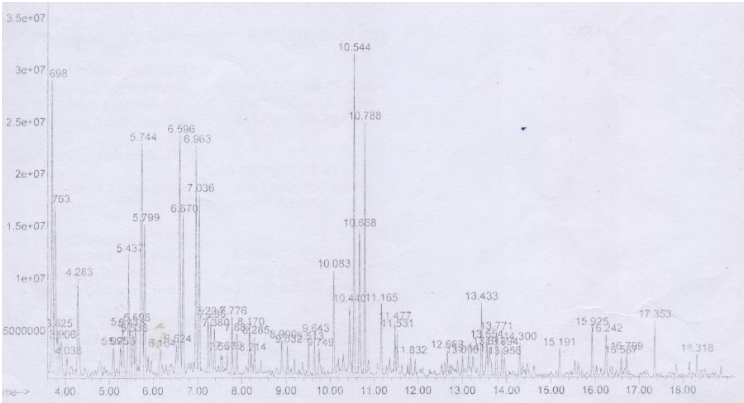

Figure.3 GCMS of Plastic Hydrocarbon Fuel

Table:2 Identification of Chemical Components in the Plastic HC Fluid from GC

PK#	RT	Area%	Name of the component	Mol. Formula
1	3.79	13.88	3-Pentanone,	$C_5H_{10}O$
2	4.16	3.27	1,6 –Heptadiene,2,3,6-trimethyl	$C_{10}H_{18}$
3	5.47	19.66	alpha.- Methyl styrene	C_9H_{10}
4	6.58	15.2	1-Ethyl-2,2,6- trimethylcyclohexane	$C_{11}H_{22}$
5	7.47	9.41	3,4-Dimethyl-3-heptene	C_9H_{18}
6	8.39	2.96	1-Dodecene	C12H24
7	9.48	2.76	3-methyl Hexane	C_7H_{16}
8	10.50	16.22	Cyclohexane,	C_6H_{12}
9	11.50	3.88	2,2-dimethyl-(E)-Heptane	C_9H_{20}
10	12.66	1.63	Dodecane	$C_{12}H_{26}$
11	13.54	6.3	octadecylester,	$C_{21}H_{40}O_2$
12	14.29	0.66	3,4-Dimethyl-3-heptane	C_9H_{18}
13	15.55	1.66	Benzene,	C_6H_6
14	16.51	1.04	4-tetradecene	$C_{14}H_{28}$
15	17.35	1.05	isobutyl trans-hex-3-enyl ester	$C_{14} H_{22}O_4$
16	18.31	0.42	2-methylpropyl ester.	$C_6 H_{12}O_2$

IV. CONCLUSIONS

1. From the above analysis one can observe that a plastic hydrocarbon fuel can be used as a fuel for the CI engine without modifications.
2. Instead of considering a variety of plastics as raw material for extraction of HC fluid, if same type of waste plastic, without any dye is considered for extraction of HC fluid, harmful components can be eliminated.

V. FUTURE SCOPE OF WORK

For the successful implementation of a plastic HC oil as fuel for the IC engines, in- addition to the above, further analysis in the area of Combustion of fuel, Heat release during the combustion, Exhaust gas of the engine , tribological properties of engine components, engine vibration and noise need to do.

VI. ACKNOWLEDGEMENTS

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