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Parametric Design & Analysis of Plastics Fuel Blend by using Taguchi Method in Diesel Engine

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ABSTRACT

Over the past two centuries, energy needs have risen dramatically, particularly due to the transportation and industry sectors. However, the main made fuels like (fossil fuels) are polluting and their reserves are limited. Governments & research organization work together for make the use of renewable resources a priority and reduce irresponsible use of natural supplies through increased conservation. The energy crisis is a broad is biggest problem in world. Most people don't realize to their reality unless the price of fuel at the pump goes up or there are lines at the fuel station.

Plastics waste fuel is sustainable and futuristic solution of fossil fuel as well as biggest problem of waste management of plastic waste can solve by this fuel. In thesis we prepare the plastic waste fuel by application of paralysis process in this process use low, medium and high grade of plastic and heated with limited amount of oxygen melt the plastic. The result of paralysis finds of liquid fuel and flammable gas. This fuel can be used as a blend in diesel with a proportion of B0D100, B10D90 B20D80, & B30D70 where B tent to blend of plastic fuel and D tend to diesel as if B0D100 means blend 0% and diesel 100%. These blend run diesel engine. The blends are in 10%, 20% & 30% plastic paralysis oil with standard diesel fuel. For experiment simultaneous optimization used a method called "Taguchi" used in the engine such as injection pressure and load condition. Taguchi Method of Optimization is a simplest method of optimizing experimental parameters in less number of trials.

***Keywords*—** Plastics Fuel, Pyrolysis, Blend

I. INTRODUCTION

India ranks sixth in the world in the term of energy demand accounting for 3.5 % of world commercial energy demand. It is expected to grow at 4.8% in next future. The demand of energy growth in all forms is expected to continue unabated owing to increasing urbanization, standard of living and increasing population with stabilization not before mid of the current century. The demand of diesel is grow from 52.33 million of tons in 2006-07 to 61.55 million of tons in 2009-10. As Indian concern crude oil production on basis of plan working group is estimated around 33-34 million metric tons per annum. The increasing gap between demand and domestically produced petroleum is a matter of serious concern.

1.1 Energy Crisis and Need for Alternate Fuel for IC Engines

Fossil fuels are one-time energy gift to the human race; once they are gone, they are gone forever, alternate non-petroleum fuels yield energy security and environment benefits. They have been with us in one form or another for more than one hundred years. Before the introduction of gasoline as a motor fuel in late 1800s, vehicles were often powered by what are now considered alternate fuels. The first Internal Combustion Engine designed, built and demonstrated by Rudolf Diesel at the 1900 Paris World fair ran on peanut oil. This was his dream to power an efficient Internal Combustion Engine with crude oil or vegetable oil.

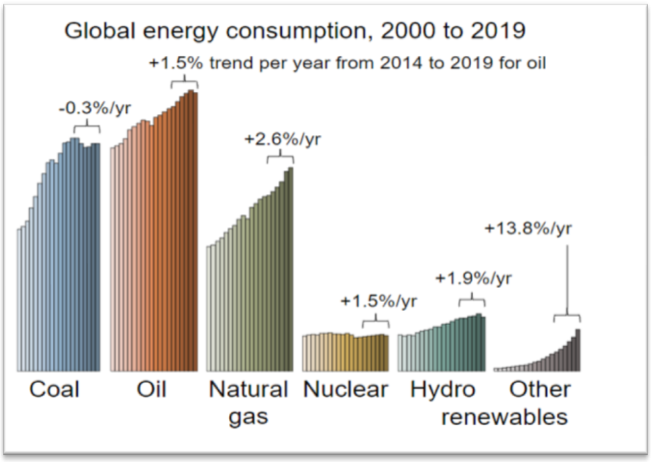

Figure 1.1: world wise energy consumption

Alternate Fuels

Thermodynamic tests, based on engine performance evaluation have established The feasibility of using a variety of alternate fuels such as hydrogen, CNG, alcohol; biogas producer gas and various types of edible and non-edible oils. However, in Indian context, the biomass-based fuels like alcohol, vegetable oils and biogas can contribute significantly to wards the problems related to fuel crisis.

1.2.1 Bio-Fuel

Bio-fuel offer several distinct advantages over petroleum diesel. Since plants, capture Carbon dioxide when they are growing and release when the oil is burnt. Vegetable oil fuels are nearly CO neutral, an important characteristic in the effort to

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combat greenhouse gas emissions. Biofuel are virtually free of sulfur and will not run out ever while other sources of energy are finite and will be depleted Bio-diesel is an eco-friendly, alternative diesel fuel prepared from domestic renewable resources i.e. vegetable oils (edible or non- edible oil) and animal fats. These natural oils and fats are made up mainly of triglycerides. These triglycerides when react with striking similarity to petroleum derived diesel and are called "Bio-diesel". As India is deficient in edible oils, non-edible oil may be material of choice for producing bio diesel. For this purpose, Jatropha crops considered as most potential source for it. Bio diesel produced by trancesterification of oil obtains from the plant

Bio-Diesel

Biodiesel consists of mono alkyl esters produced from vegetable oils, animal or old cooking fats. Coconut biodiesel is fuel alternative produced from soybean oil. Biodiesel contains no petroleum diesel, but it can be blended with petroleum diesel**.** Biodiesel is a clean burning, Eco friendly natural fuel obtained from tree born oils by alchemical transformation process called Transesterification carried out in a Chemical Processing Plant. Transesterification is an age-old chemical process and is a time-tested method of Transforming Vegetable oils or fats into Biodiesel (Alkyl Esters of Fatty Acids) and Glycerin plus some soaps etc. The chemistry lies in transforming the fatty acid chains into Alkyl Esters of respective fatty acids present in different feed oils used and isolation of glycerol present in the Triglyceride molecule in the oils and fats. Industrial production of Biodiesel consists of the following three distinct processing phases and three basic Equipment lineups.

II. METHODS OF CONVERTING PLASTIC TO FUEL

Pyrolysis or Thermal Degradation

Pyrolysis is a process of thermal degradation of a material in the absence of oxygen. Plastic is fed into a cylindrical chamber. The pyrolytic gases are condensed in a specially designed condenser system, to yield a hydrocarbon distillate comprising straight and branched chain aliphatic, cyclic aliphatic and aromatic hydrocarbons, and liquid is separated using fractional distillation to produce the liquid fuel products. The plastic is Pyrolysis at 370◦C–420◦C. The essential steps in the Pyrolysis of plastics involve (Figure 1):

1. Evenly heating the plastic to a narrow temperature range without excessive temperature variations,
2. Purging oxygen from Pyrolysis chamber,
3. Managing the carbonaceous char by-product before it acts as a thermal insulator and lowers the heat transfer to the plastic,
4. Careful condensation and fractionation of the Pyrolysis vapors to produce distillate of good quality and consistency.

Identify applicable funding agency here. If none, delete this text box.

Table 1: Main operating parameters for Pyrolysis process

Parameters	Conventional	Fast	Flash
Pyrolysis temperature	(K) 550–900	850-1250	1050-1300
Heating rate (K/s)	0.1–1	10–200	>1000
Particle size (mm)	5–50	<1	<02
Solid residence (s)	300–3600	0.5–10	<0.5

Catalytic

Degradation In this method, a suitable catalyst is used to carry out the cracking reaction. The presence of catalyst lowers the reaction temperature and time. The process results in much narrower product distribution of carbon atom number and peak at lighter hydrocarbons which occurs at lower temperatures. The cost should be further reduced to make the process more attractive from an economic perspective. Reuse of catalysts and the use of effective catalysts in lesser quantities can optimize this option. This process can be developed into a cost-effective commercial polymer recycling process for solving the acute environmental problem of disposal of plastic waste. It also offers the higher cracking ability of plastics, and the lower concentration of solid residue in the product

III. EXPERIMENTAL SETUP

A rope brake dynamometer arrangement with a brake drum coupled with Kirloskar AV1 type single cylinder engine, 1500 rpm and provided with a cooling water arrangement and spring balance. The load can be varied by rope tension on the brake drum with moving the hand wheel provided on the frame Fuel tank and measuring arrangement is also consist on stand the fuel goes to the engine through 50ml burette. Suitable pipe fitting arrangement is provided for circulation the cooling water into the engine water jacket. For measuring the rate of flow cooling water meter is provided. With this entire arrangement, one can find the heat carried away by cooling water. the inlet and outlet temperature of water can be directly read from the digital temperature indicator arrangement for measure the heat carried away by exhaust gases. Exhaust gas calorimeter consists of a centrally tube and an outer jacket. Exhaust gases passes through central tube and water circulate in outer jacket to get the maximum temperature difference of exhaust

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gases at inlet and outlet calorimeter. The volume of water circulation is measured with the help of water meter and stopwatch. Thermocouple are provided to get the inlet and outlet temperature of exhaust gases and water circulated. Engine is installed in Thermal Engineering Laboratory of Mechanical Engineering Department, to conduct experimental work for testing OF Waste plastics fuel blend With Diesel.

Technical Specification

Diesel Engine

Make	Kirloskar Oil Engine, Pune.
Type	Vertical, Totally Enclosed, Compression Ignition Four Stroke Cycle, Water Cooled Engine.
No. Of Cylinder	One
BORE	80 mm
STROKE	110 mm
CUBIC CAPACITY	62 cc
COMPRESSION RATIO	16.5: 1
RPM	1500
RATE OF OUTPUT	3 HP
Diameter of orifice (D0)	0.017m
Diameter of cylinder (D)	0.08m
Length of stroke (L)	0.11m
Diameter of brake Drum (d_B)	0.3m
Diameter of Rope (d_R)	0.012m
Number of cylinder (Nc)	1
Number of cycle (n)	2(for 4 stroke cycle
C_v	43500kj/kg
C_p	4.186kj/kg
C_d	0.64

IV. PRODUCTION OF PLASTICS WASTE FUEL

It is take some serious decision to reduce the plastic wastage day-to-day use in industries. Purdue University team give recent idea for method to convert a commonly used plastic into fuel oil. The process, suggested by American Chemical Society Sustainable Chemistry and engineering, is give more energy-efficiency than recycling or burning waste plastic, the researchers say. In the last 50 years About six billion tons of plastic waste has been generated around the world. But Very little this plastics waste is recycled, and 80 percent of it sits in landfills or in the natural environment, where it harms wildlife, leaches harmful chemicals, and emits greenhouse gases.

4.1 Raw Material

Plastic waste, also known as plastic-related pollution, it defined as "the buildup of plastic objects (such as plastic bottles and cans) in the Earth's ecosystem that has a negative impact on animals, wildlife habitat, and humans." It also takes into account the large amount of plastic that isn't recycled and ends up in landfills or, in the case of the developing world, unregulated dump sites. So much of what we consume is made of plastic (such as plastic bottles and food containers rapping material) because it’s inexpensive, yet durable. However, plastic materials is very slow to degrade due to plastics chemical structure, which presents a huge challenge.

4.2 Plastic in Our Daily Lives

The plastic has some special property likes cheap, strong, lightweight, and resistant to corrosion. Due this type of property the plastic cannot be replaceable The most common uses of plastic are in packaging of material and building components such as window table decorative materials, &piping. It is also used in medical industry, plastic is often key to contamination and infection control. in healthcare Syringes, pipettes and gloves used and biomedical research cannot be reused. While the excessive use of plastic packaging is of concern, some form of packaging is often necessary to maintain the hygiene or freshness of food, or to maintain product integrity during shipment. Small or travel-sized toiletries and personal hygiene products are sometimes seen as wasted, but they are vital in providing affordable sanitation options to some of our most vulnerable communities, such as the homeless or low-income families. With an estimated 70% of the world's population living on less than $10 a day, single-serve bag toiletries provide an affordable sanitation option in developing markets.

Figure 4.1: Plastics waste material water bottle

4.3 Thermocol

Thermocol is the expanded form of Polystyrene which is a plastic very commonly used in its hard form as well as expanded into a foam which is generically known as Thermocol. Polystyrene beads are pumped with Pentane gas (amongst other chemicals) to expand to 50 times their size in order to form this soft but strong foam called Polystyrene foam. This material finds wide usage in the packaging industry, model and craft industry as well as in the construction and insulation industry. A very useful material for sure but it comes with its set of hazards.

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Figure 4.2: Thermocol waste

Waste Polystyrene (thermocol): The waste Thermocol in form of disposed of packaging material was collected from the waste yard. The soft and high volume thermocol samples were first kept inside the tank at 300-450 °C for one hour resulting in a low volume hard brittle mass which was then ground to powder. The powdered sample was subjected to pyrolysis. The DSC of the waste sample is shown in the figure, the melting point of the waste sample is found to be 247°C, which ensures the samples to be polystyrene. Waste low density polyethylene (polyethylene bag): The fine cuttings of waste polyethylene shopping bags (made of LDPE) of 2 cm2 area were used for the pyrolysis experiments. The melting point of the waste sample is found to be 110 °C respectively, which ensures the samples to be low density polyethylene

4.4 Making of Plastics Fuel

- Waste material like Plastic, Thermocol, etc… was taken and kept close inside the Combustion chamber.
- A pipe was fitted onto the top part of Combustion chamber.
- The outlet of pipe was opened into the closed container containing half-filled distilled water.
- The combustion chamber was made to heat up to 450^0C.
- As the waste polyester material inside the chamber started heating; the hot gases started coming out.
- The hot gases were collected in the second container (filled half with distilled water).
- As the hot gases started condensing inside the second container got changed into liquid form of low density (as compare to distilled water) and came up the level of water.
- The liquid was collected in a bottle through a tap attached to the container.
- The liquid we got is the Resulting fuel we aimed for.

Fig. 4.3: Production of fuel

4.5 Optimization Method

The blends are in 10%, 20% & 30% plastic Pyrolysis oil with standard diesel fuel. A method known as “Taguchi” was used in the experiment for simultaneous optimization of engine such as injection pressure and load condition. Taguchi method is a simplest method of optimizing experimental parameters in less number of trials. In the experimental investigation the number of parameters involved in the experiment determines the number of trials required for the experiment. So we can use Taguchi method tried in the experiment to optimize the levels of the parameter involved in the experiment. This method takes an orthogonal array to study the entire parameter space with only a small number of experiments. This study uses four levels and three factors hence, an L16 orthogonal array was used for the construction of experimental layout (Table-2, column-1, 2,3&4). The L-16 has the parameters such as blend, injection pressure and load arranged in column 1, 2 and 3 &4as per this taken sixteen (16) experiments were designed and trials were selected at random manner, to avoid systematic error creeping into the experimental procedure. Brake specific fuel consumption was calculated in every trial and used as a response parameter. Taguchi method taken a parameter called signal to noise ratio (S/N) for measuring the quality characteristics. There are three type of signal to noise ratios are in practice. Of which we used the smaller-the-better S/N ratio was used in this experiment because this optimization is based on lower SFC. The taguchi method used in the investigation was designed by statistical software called “Minitab 19” to simplify the taguchi procedure and results.

V. RESULT AND DISCUSSION

This Experiment was conducted for selected sets of reading (parameters) byMinitab-19 software and determine brake specific fuel consumption(BSFC) for those sets of parameters by experiment.

Table 2: L16 Orthogonal array

Blend	Inj. Pressure	Load	Bsfc	Snra1	MEAN1
B0D100	160	1	1.50243	-3.5359	1.50243
B0D100	185	4	0.55982	5.03911	0.55982
B0D100	195	8	0.41202	7.7017	0.41202
B0D100	215	12	0.35865	8.90668	0.35865
B10D90	160	4	0.54277	5.30772	0.54277
B10D90	185	1	1.52829	-3.6841	1.52829
B10D90	195	12	0.35138	9.08451	0.35138
B10D90	215	8	0.20525	13.7545	0.20525
B20D80	160	8	0.39402	8.08959	0.39402
B20D80	185	12	0.24448	12.2352	0.24448
B20D80	195	1	1.43041	-3.1092	1.43041
B20D80	215	4	0.51504	5.76315	0.51504
B30D70	160	12	0.33879	9.40136	0.33879
B30D70	185	8	0.2924	10.6805	0.2924
B30D70	195	4	0.5122	5.81123	0.5122
B30D70	215	1	1.36452	-2.6996	1.36452

In this experiment, four levels for three parameters were considered. L16 single orthogonal array shown in table- 2(column-1,2 & 3) was selected for the experimental investigation. "Smaller-the-better" is use for as a quality characteristic, since the objective function is to maximize performance. Brake specific fuel consumption (BSFC) for those sets is given in table-2. The objective of Response curve analysis determining influential parameters and their optimum levels. It is make graphical representations of change in performance characteristics with the variation in different process parameter. The curve gives a various pictorial view of variation of each factor affective the process and describe what the effect on the system performance would be when a parameter shifts from one level to another. Calculation of S/N ratio for the performance curve at each factor level and average effects were determined by taking the total of each factor level and dividing by the number of data points in the total.

The results of the taguchi experiment identifies that Injection pressure 215 bar, blend P30D70 and engine load 12 kg are optimum parameter setting for lowest break specific fuel consumption. Engine performance is mostly influenced by engine load and is least influenced by injection pressure.

FUTURE SCOPE

For a greener future this is an extremely simple process. The plastic waste is placed on a conveyor belt where it is dried and shredded. Then it is put into an airtight thermal chamber for being decomposed. In the chamber, the granulated plastic melts into vapours that are distilled into a golden liquid chemically identical to regular fuel. However, the main difference between the fuel generated by this process and conventional fuel is that the former has fewer pollutants, and is much cleaner due to the low amount of sulphur present in plastic. This fuel is about 10 to20 percent cheaper than regular fuel due to the abundant supply of plastic waste, and the extremely low production cost.

Currently, this fuel has been approved for industrial use and is being researched and tested for vehicles. The results so far have been very promising, which gives us hope of a greener, cleaner future. The factory is capable of manufacturing close to 1,600 litres of fuel daily from the two metric tons of waste that they are provided with. In Manila city, there are approximately 10 million people who produce about 6,000 tons of trash every day, which is a whopping amount.

Plastic fuel technology isn't new. However, its implementation needs a boost. If the technology gets some backing, we could see an effective solution to one of the long-standing problems faced by mankind.

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