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Optimization of Process Parameters of D.I Engine by Taguchi Method for Tri Fuel

R. B. Mandavia
Assistant Professor
Department of Mechanical Engineering
GEC, Bhavnagar

Abstract

With modernization and increase in the number of automobiles worldwide, the consumption of diesel and gasoline has enormously increased. In this experiment tri fuel concept was used according to that diesel and turpentine different proportion bled introduced in diesel engine and acetylene entre in the diesel engine through intake manifold in the diesel engine. Among the many process parameters, bled ratio, injection pressure and load was selected to perform the experiment and by using Taguchi techniques L9 orthogonal array run set prepared to perform the experiment and SFC was the output parameter in this experiment after run the experiment according to run set got the optimum set of SFC.
Keywords- Diesel Engine, L9 Orthogonal Array, Tri Fuel

I. INTRODUCTION

Depleting petroleum reserves and rising cost of the petroleum products demand a serious hunt for alternative fuels, which can wholly or partially replace Petro-fuels. Biofuels are tested from times and they prove to be very excellent substitutes for the existing Petro-fuels. They involve a little engine modification to be used in IC engines. Nowadays gases like LPG (liquefied petroleum gas), LNG (liquefied natural gas), acetylene, etc. are being used as substitute of diesel and gasoline in IC engines. These are invested into the engine along with the air getting into the locomotive. The gaseous fuels are used in the dual fuel mode in IC engines. Since gaseous fuels have high auto they are normally used in DF mode. The dual fuel engine as the modified diesel engine in which usually a gaseous fuel called the main fuel is inducted with air The gaseous fuel ignites as it delivers a high self-ignition temperature A diminished amount of diesel usually called the pilot, is injected as in a normal diesel engine, near the end of the compression stroke. The pilot diesel fuel auto ignites and acts as a discharge or a source for the kindling of the primary fuel-air mixture. The combustion of gaseous fuel occurs due to the flame that propagates through. Thus the dual fuel mode combines the feature of CI and SI engine. Fuel injection is the section of CI engine and the compression of boot and the propagation of flame is the component of SI engine. With the use of acetylene, the HC, CO, CO2 and smoke emissions were less as compared to the diesel baseline engine. But the NOx emissions are increased significantly.

II. LITERATURE SURVEY

Premanand et.al.(2009). This report gives the effects of experimental study carried out to measure the combustion performance and exhaust emission characteristics of turpentine oil fuel (TPOF) blended with conventional diesel fuel (DF) fuelled in a diesel engine. Turpentine oil derived from pyrolysis mechanism or resin obtained from pine tree dissolved in a volatile liquid can be used as a bio-fuel due to its properties. The test engine was fully instrumented to provide all the required measurements for determination of the needed combustion, performance and exhaust emission variables. Turpentine is also a bio fuel due its properties comparable to that of diesel.content of 40 % by weight. It consists chemically 58–65% gamma – pinene along with beta – pinene and other isometric terpenes. Test results showed that absolutely dry oil of turpentine absorbs a maximum volume of active oxygen at 100 C.[1].

Karthikeyan et.al generally, turpentine possesses moderate certain number which is not sufficient to run the existing diesel engine. Still, this could be admissible along with diesel fuel in the form of blends. Holding this in mind experiments has been conducted using blends of turpentine and diesel fuel to study its applicability, performance and discharge behavior. As the investigation involves three parameters such as blend proportion, injection timing and injection pressure, a simultaneous optimization method called Taguchi was used in the workplace. This method calls for fewer numbers of trials for fixing optimum levels. This is the primary advantage of this method. As per this method nine trials were experimented and its results were used for optimisation. In addition, an ANOVA was also performed for the parameters to evaluate its percentage contribution over the desired output. The results of the taguchi experiment showed that the 40T blend (40% turpentine and 60% diesel) performed better at 29°BTDC injection timing and at 180 bar injection pressure than other blends and had a capacity to cold start the engine. Using the optimum levels, a full range experiment was also conducted using 40T blend to compare its performance and emission behaviour with standard diesel operation. The results of the full range experiment showed that the 40T blend offered approximately

2.5% higher brake thermal efficiency than diesel baseline operation without much worsening the exhaust emission. The results showed that the mixing of turpentine with diesel fuel up to 40% increases brake thermal efficiency by 1-2 % from the reference fuel. Taguchi method of optimization predicted optimum level of parameters within 9 trials and the 40T blend found working satisfactorily at optimum setting. A slighter increment in NOx emission was found while working with 40T blend at optimum setting. Approximately 50% smoke reduction was achieved with 40T operation. A smaller on shoot of CO was found with 40T operation at full load. The results also proved that the blending of turpentine with diesel fuel up to 40% increases the engine performance without much worsening its emission [2].

T. Laxmanan (2011) et al.Interest in employing gaseous fuels to internal combustion (IC) engines whether for stationary or mobile automotive applications has gained importance because of the economical, sustainable and environ-mental technical features associated with their usage. In order to decrease the NOx emissions from acetylene diesel engine, cooled EGR was employed. The cylinder pressure, brake thermal efficiency and emissions such as NOx, smoke, CO, HC, CO2 and exhaust gas temperature were studied. Use of gaseous fuel in diesel engines that use dual fuel concept is more economical with environmental advantage [3].

T.Lakshamanan (2011) et.alTurpentine is a biofuel that is one of the alternative fuel additive to petro fuel because it is a renewable bio-based resource and provides the potential to reduce consumption of the petro fuels and particulate emissions in spark ignition engines. It can be produced from plentiful, domestic, cellulosic biomass resources such as woody plants, agricultural and forestry residues, and a large portion of municipal solid waste and industrial waste streams. Production of turpentine from biomass is one way to reduce consumption and cost of crude oil imported by some countries, and also environmental pollution. The turpentine is an environmentally friendly alternative liquid fuel, which can be used in any spark ignition (SI) engine as an additive to the gasoline. It was used in early engines without any modification. However, abundant availability of petro fuels stopped the usage of turpentine in internal combustion engines [4].

R. vallinayagam, et al. (2013).A new type of biofuel, pine oil, is introduced in this work for the purpose of fuelling diesel engine. The viscosity, boiling point and flash point of the reported oil are lower, when compared to that of diesel. Also, the calorific value of pine oil biofuel is comparable to diesel. As a result, it can be directly used in diesel engine without trans-esterifying it. Pine oil biofuel and their blends of 25%, 50%, and 75% with diesel were tested in a single cylinder, four-stroke, direct injection diesel engine and the combustion, emissions and performance results were compared with diesel. The results show that at full load condition, 100% pine oil reduces CO (carbon monoxide), HC (hydrocarbon) and smoke emissions by 65%, 30% and 70%, respectively. The brake thermal efficiency and maximum heat release rate increase by 5% and 27%, respectively. However, the NOx (oxides of nitrogen) emission is higher than that of diesel fuel at full load condition. The experimental work reveals that 100% pine oil can be directly used in diesel engine and potential benefits of pine oil biofuel have been reaped. Apart from biodiesel, researchers have conceived the idea of using alcohol and emulsion fuels in diesel engine as an alternative fuel [5].

S.Bruscaetal.It is well known that acetylene is a high flammable and explosive compound. In comparison with commercial liquid fuels, very wide flammability limits and a low Octane Number have relegated the acetylene into the “iperdetonat” fuels category. Thus, it is impossible to run an internal combustion engine on acetylene without a detonation phenomenon control system. The current paper deals with a theoretical and experimental analysis of an internal combustion engine running on acetylene and alcohol. A standard 8 kW spark ignition engine with carburetor was modified with electronic injection control system (ECU) and two standard commercial injectors: one for the acetylene and one for the alcohol. The two injectors were installed using a modified engine intake system [6].

Shaik Khader Basha et al. People have been working seriously in the search for best alternative fuels to safeguard the environment ever since the transportation and industrial fields started growing widely. Among such alternatives acetylene has proved to be a better fuel for internal combustion engines due to its low cost, simplicity in manufacturing and excellent combustion characteristics. Moreover it has less carbon content compared to other fuels, which plays a central role in environmental degradation. However the fuel must be safe and environmentally friendly and also readily usable in existing engines without any significant design modifications. Acetylene is produced in parallel to the engine operation taking proper care to avoid back firing. We propose in the present study that acetylene be the safe and appropriate fuel for a compression ignition engine. Diesel engine is selected with a subsidiary mixing box for a homogeneous mixture of air and acetylene. The experiments are conducted with fixed acetylene flow rates from 0.1Lit/min to 5Lit/min with an increase of 0.5Lit/min in every step. The engine is tested at various loads, keeping track of combustion performance to find out the optimum fuel flow rates and also to have reduced emissions. The results show that the performance of the Acetylene enriched engine is nearer to the pure diesel engine with reduced emissions. It is concluded that acetylene could be the better alternative fuel without compromising brake thermal efficiency and safe operation with a moderate increment of smoke and NOx.[7]

III. EXPERIMENTAL SETUP

Acetylene is a colorless and highly combustible gas with a pungent odor. If it is pressed, heated or mixed with air, it becomes highly volatile. It is developed by a straightforward chemical process in which calcium carbide reacts with water and generates acetylene gas and slurry of calcium carbonate. It requires no sophisticated apparatus or equipment and the response is spontaneous It was widely used in acetylene lamps, to light homes and mining tunnels during 1980s. It is a gaseous hydrocarbon highly combustible and unstable. It also brings on high flame temperatures ranging from 30000 C to 54000C. Turpentine oil derived from pyrolysis mechanism or resin fraction obtained from the pine tree dissolved in a volatile liquid is believed one of the promising alternative fuels for diesel locomotives.

Table 1: Detail Engine Specification

Engine type	*Single cylinder, 4 strokes, multi fuel, water cooled, research engine*
Rated power	*3.5 kW @ 1500 RPM*
Cylinder diameter	*87.5 mm*
Stroke length	*110 mm*
Connecting rod length	*234 mm*
Dynamometer	*Type eddy current, water cooled, with loading unit*

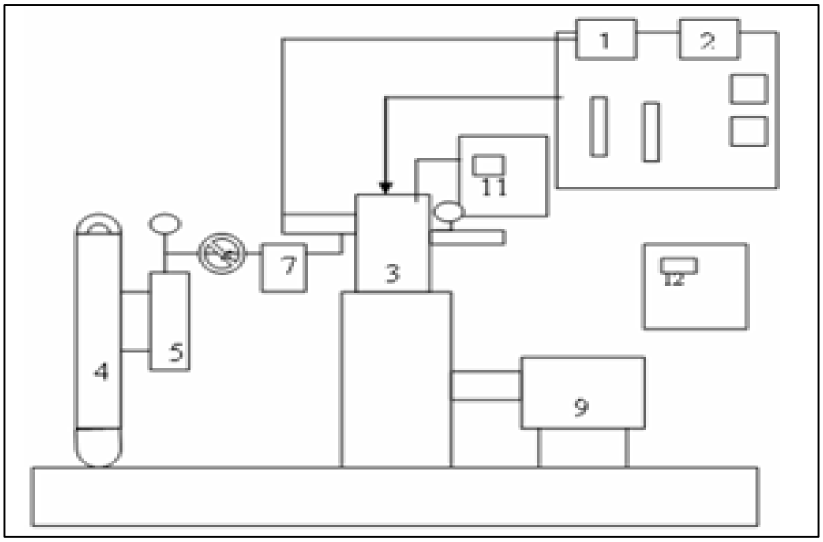

Fig. 1: Circuit Diagram for Test Setup

1) Air flow meter
2) Diesel fuel tank
3) Diesel engine
4) Acetylene generator
5) Flame trap
6) Flow control valve
7) Gas flow meter
8) Intake manifold
9) Dynamometer
10) Control panel
11) Oscilloscope
12) Gas analyser

Table 2: Physical and combustion properties of fuels

Properties	Gasoline	Diesel	Turpentin	Hydrogen	Acetylene
Formula	C4 to C12	C8 to C25	C10H16	H2	C2H2
Molecular weight	105	200	136	1	26.04
Density kg/m^3	780	830	860-900	0.08	1.092
Specific gravity	0.78	0.83	0.86-0.9	0.0696	0.92
Boiling point 0c	32-220	180-340	150-180	-252.8	-84.44
Latent heat of vaporization kj/kg	350	230	305	0.904	801.9
Lower heating value kj/kg	43,890	42,700	44,000	1,20,000	48,225
Flash point ^{o}c	-43	74	38	-	32
Auto ignition temperature ^{o}c	300-450	250	300-330	572	305
Flammability limit % volume	1.4	1	0.8	4	2.3

Experimental Procedure Single cylinder, vertical, water-cooled, self-governed diesel engine made by “kilorskar” is used for this experiment. Entire experiments have been conducted on engine for speed of 1500 rpm. In this experiment prepared the blend of trifuel diesel, turpentine and acetylene and by varying Blend, Load, and Injection Pressure. The stabilizer has been used to maintain constant Voltage. The experiment performed base on L9 orthogonal array in which fuel blend .load and injection pressure are the variable parameter which has been selected after the literature survey as these are the effective parameters and output parameter is brake thermal efficiency.

Table 3: Orthogonal Array

Ex. No.	Blend (%)	Injection Pressure (Bar)	Load (kg)
1	D80T20	170	1
2	D80T20	180	5
3	D80T20	190	9
4	D70T30	170	5
5	D70T30	180	9
6	D70T30	190	1
7	D60T40	170	9
8	D60T40	180	1
9	D60T40	190	5

Table 4: Brake Thermal Efficiency

Sr. No.	Speed (RPM)	Density (kg/liter)	Torque (N.m)	BP (KW)	H_{BP} (kj/hr)	FC (kg/hr)	SFC (KG/KWH)
1	1531	0.847	1.81	0.29	1047	0.41	1.45
2	1486	0.847	9.07	1.41	5083	0.66	0.58
3	1467	0.847	16.33	2.51	9033	0.86	1.12
4	1509	0.763	9.07	1.43	5162	0.55	0.56
5	1470	0.763	16.33	2.51	9052	0.69	1.58
6	1527	0.763	1.81	0.29	1045	0.37	1.56
7	1474	0.679	16.33	2.52	9076	0.57	0.23
8	1514	0.679	1.81	0.29	1036	0.33	1.25
9	1502	0.679	9.07	1.43	5138	0.49	0.25

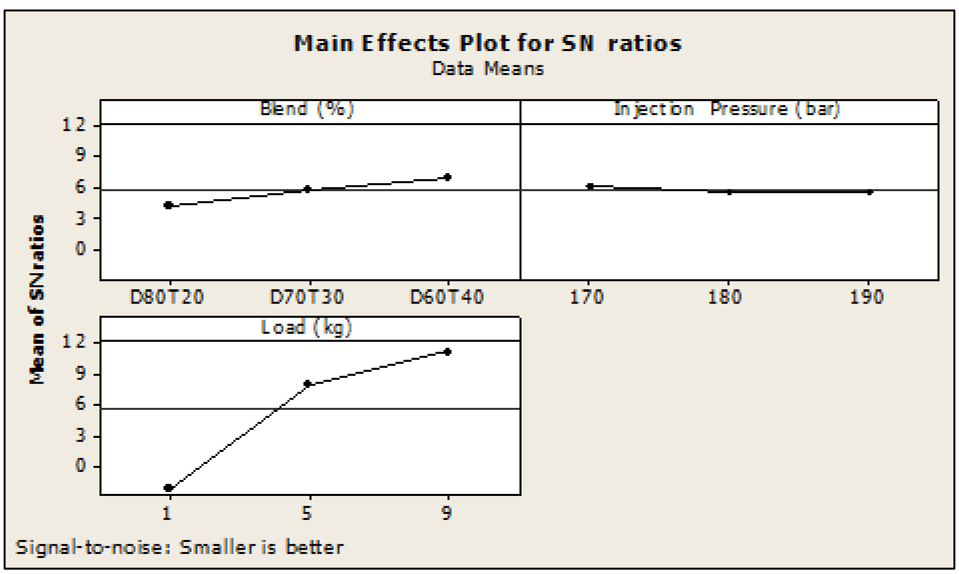

Fig. 3: Main Effects Plot for S/N ratio of SFC

In fig.3 shows the effect of process parameters according to that compiled the table no.5 in which show that load is the most effective parameters with 0.9828 delta and injection pressure rank is 3rd with 0.0443 delta value.

Table 5: Taguchi Analysis for Brake Thermal Efficiency

Level	*Blend (%)*	*Injection Pressure (bar)*	*Load (kg)*
1	*0.7365*	*0.6689*	*1.2640*
2	*0.6394*	*0.6246*	*0.3978*
3	*0.5672*	*0.6449*	*0.2812*
Delta	*0.1693*	*0.0443*	*0.9828*
Rank	*2*	*3*	*1*

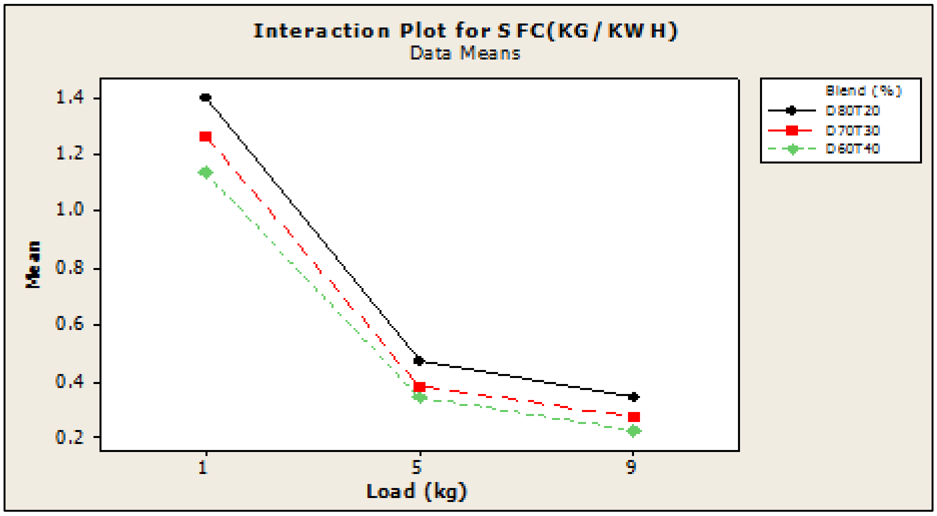

Fig. 5: Effect of load on SFC at different blend ratio

Fig 5. Shows the effect of load on SFC at different bled ratio. Bases on that can see the as the load is increasing SFC is falling but the bled ration D60T40 has given the good value compare to other blend ratio.

IV. Conclusion

In this research work turpentine and diesel blend is used in the diesel engine where acetylene introduce at 3 liters per minute at constant flow rate and performed the experiment based on design of experiment matrix (L9 orthogonal array), after performing the experiment according to run set got the value of FC is 0.25 kg/kwh at 60% diesel and 40% turpentine blend ratio (D60T40) at which injection pressure was 190 bar and load was 5 k.g. Confirmation experiment is also performed on the predicted result by Taguchi analysis to evaluate the Predictive capability of the Taguchi Method for Diesel engine performance, and after experiment got the 4.5% of error in the predicted and experimental value.

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