

Experimental Investigation of Diesel Engine Operating Parameters for A Mixture of Acetylene and Turpentine Oil with Diesel by Design of Experiment

Solanki Chiragkumar Pravinkumar

PG Student

*Department of IC & Automobile Engineering
Silver oak college*

Prof. Akash A. Bhavsar

Assistant Professor

*Department of Mechanical Engineering
Silver oak college*

Abstract

With modernization and increase in the number of automobiles worldwide, the consumption of diesel and gasoline has enormously increased. As petroleum is nonrenewable source of energy and the petroleum reserves are scarce nowadays, there is a need to search for alternative fuels for automobiles. Turpentine oil has been used in direct injection CI engine as an alternate fuel has similar properties as that of diesel. Acetylene is also a very good alternate fuel. In the present work, blend of different proportion of turpentine and diesel use in the diesel engine in which Acetylene was also introduced through intake manifold at a point closer to the intake valve by a non-return valve arrangement through a flame trap. The flow of acetylene was controlled 3 liters per minute by needle valve and was measured by a calibrated gas flow meter. The experiment run set was prepared by design of experiment in which L9 orthogonal array used for the experiment where different blend proportion, injection pressure and the load are the variable parameters and FC, SFC and Brake thermal efficiency are the output parameters. In this work optimization parameter run set is identify and validation test will also performed on this run set for the validation.

Keywords: acetylene, Turpentine oil, Tri-fuel

I. INTRODUCTION

Depleting petroleum reserves and increasing cost of the petroleum products necessitates an intensive search for alternative fuels which can wholly or partially replace petro-fuels. Biofuels are tested from times and they prove to be very good substitutes for the existing petro-fuels. They require 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 inducted into the engine along with the air coming into the engine. The gaseous fuels are used in dual fuel mode in IC engines. Since gaseous fuels have high auto they are normally used in DF mode. The dual fuel engine is the modified diesel engine in which usually a gaseous fuel called the primary fuel is inducted with air. The gaseous fuel ignites as it has a high self-ignition temperature. A small 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 spark or source for the ignition 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 part of CI engine and the compression of charge and propagation of flame is the part of SI engine. With the use of acetylene, the HC, CO, CO₂ and smoke emissions were less as compared to diesel baseline engine. But the NO_x emissions are increased significantly.

II. LITERATURE SURVEY

Premanand et.al. (2009). This paper presents the results of experimental work carried out to evaluate 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. Conventional vegetable oil in use today needs to be converted into biofuel, whereas turpentine oil can be directly used in diesel engines. Turpentine is a yellowish, opaque, sticky, volatile, combustible mixture of hydrocarbon isomers obtained either from pine gum or pine wood. Turpentine has a minimum alpha – pinene content of 40 % by weight. It consists chemically 58–65% gamma – pinene along with beta – pinene and other isometric turpentine. 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 operate existing diesel engine. However, this

could be admissible along with diesel fuel in the form of blends. Keeping this in mind experiments have been conducted using blends of turpentine and diesel fuel to study its replaceability, performance and emission 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 work. This method requires 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 optimization. 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 behavior 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 NO_x 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. With the advent of latest technologies, the above barriers are eliminated. One such technique is timed manifold injection (TMI) of the gaseous fuel, which is controlled electronically to precisely monitor the induction of fuel to overcome the pre-ignition problem in the intake. In the present investigation, acetylene was injected in the intake manifold in a single cylinder diesel engine, with a gas flow rate of 240 g/h, start of injection time is 10 At TDC and 90 CA (9.9ms) duration, operated in dual fuel mode. In order to decrease the NO_x emissions from acetylene-diesel engine, cooled EGR was employed. The cylinder pressure, brake thermal efficiency and emissions such as NO_x, 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.al. Turpentine 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 NO_x (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. Diesel engines are being used as one of the vital prime movers for generating power and electricity in many industrial and agricultural applications. Reports emanating from research studies on alternate or renewable fuels unanimously predict an unprecedented demand for petroleum fuels by 2030 and the repercussions of this have been already felt by the sudden surge in petroleum prices. In addition to this petroleum fuel demand, its use is also associated with increased environmental problems. Considering the future energy security, sustainability and environmental damage, the study on various alternate, clean and renewable sources of fuel has grabbed the interest and attention of many researchers. Among which, biodiesel is one of the most commonly used alternative fuel for diesel engine. 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].M.Parthasarathy (2014). India has enormous potential for production of biofuels like Biodiesel that can be derived from various vegetable oils. It is oxygenated, sulphur-free, renewable fuel and biodegradable can be utilized in conventional diesel engines without major modification. The use of biodiesel as a fuel in conventional diesel engines causes high smoke emission and low thermal efficiency due to their more viscosity compared to neat diesel. Various methods are used to encounter this problems [7].T.

Lakshmanan et al. The diesel flow was measured by noting the time of fixed volume of diesel consumed by the engine. In general, it may be noted that in the dual-fuel engines, the thermal efficiency decreases at low loads and increases above the base line at full load operation with addition of inducted fuels like LPG, CNG etc. However, acetylene, because of its wide flammability limit and high combustion rate, is an exception where efficiency is lower throughout the load spectrum. With high loads, the brake thermal efficiency falls because of high diffusion rate and faster energy release.

III. EXPERIMENTAL SETUP

Acetylene is a colorless and highly combustible gas with a pungent odor. If it is compressed, heated or mixed with air, it becomes highly explosive. It is produced by a straightforward chemical process in which calcium carbide reacts with water and generates acetylene gas and slurry of calcium carbonate. It needs no sophisticated apparatus or equipment and the reaction 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 produces 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 considered one of the promising alternative fuels to diesel engines.

Table – 1
Detail Engine specification

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

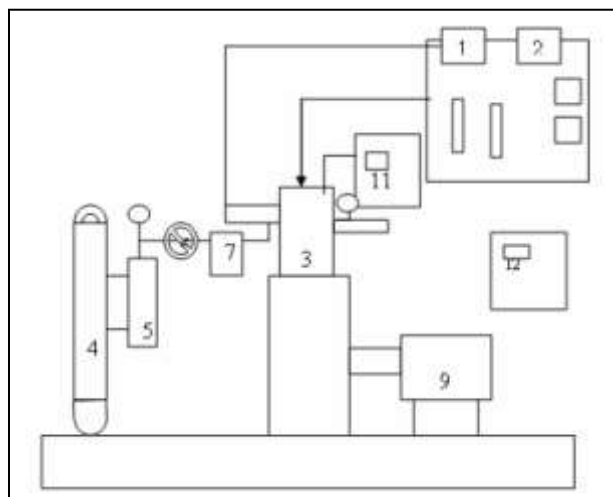


Fig. 1: circuit diagram for test setup

- 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 analyzer.



Fig. 2: Blend preparation of Diesel and Turpentine

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 °c	-43	74	38	-	32
Auto ignition temperature °c	300-450	250	300-330	572	305
Flammability limit % volume	1.4	1	0.8	.4	2.3

A. 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 tri-fuel 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)	HBP (kj/hr)	FC (kg/hr)	η_{Bthe} (%)
1	1531	0.847	1.81	0.29	1047	0.41	6.00
2	1486	0.847	9.07	1.41	5083	0.66	17.91
3	1467	0.847	16.33	2.51	9033	0.86	24.33
4	1509	0.763	9.07	1.43	5162	0.55	21.80

5	1470	0.763	16.33	2.51	9052	0.69	30.58
6	1527	0.763	1.81	0.29	1045	0.37	6.62
7	1474	0.679	16.33	2.52	9076	0.57	36.81
8	1514	0.679	1.81	0.29	1036	0.33	7.35
9	1502	0.679	9.07	1.43	5138	0.49	24.31

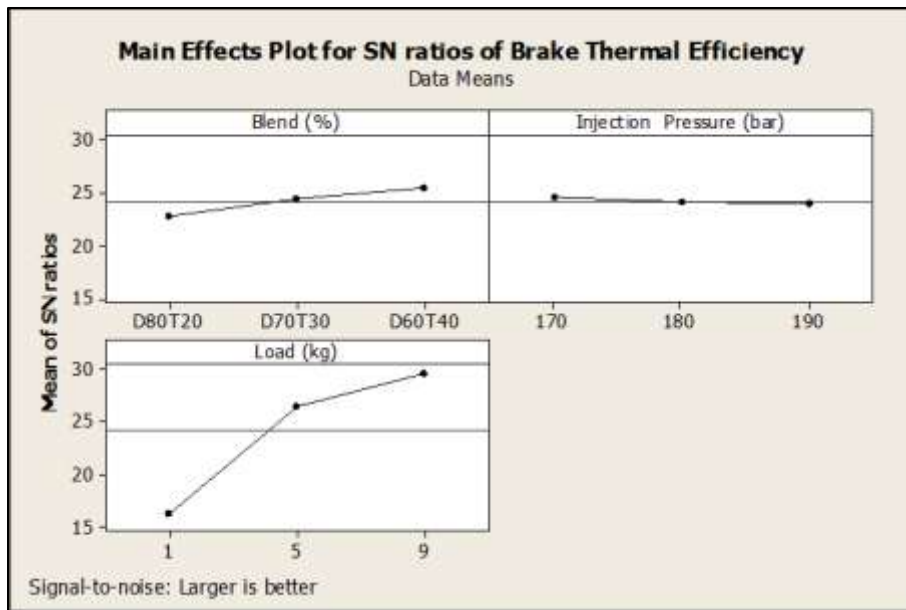


Fig. 3: Main Effects Plot for S/N ratio of BTE

Table – 5
Taguchi Analysis for Brake Thermal Efficiency

Level	Blend (%)	Injection Pressure (bar)	Load (kg)
1	16.080	21.537	6.657
2	19.66	18.613	21.340
3	22.823	18.420	30.573
Delta	6.743	3.117	23.917
Rank	2	3	1

IV. GRAPHICAL RESPONSE

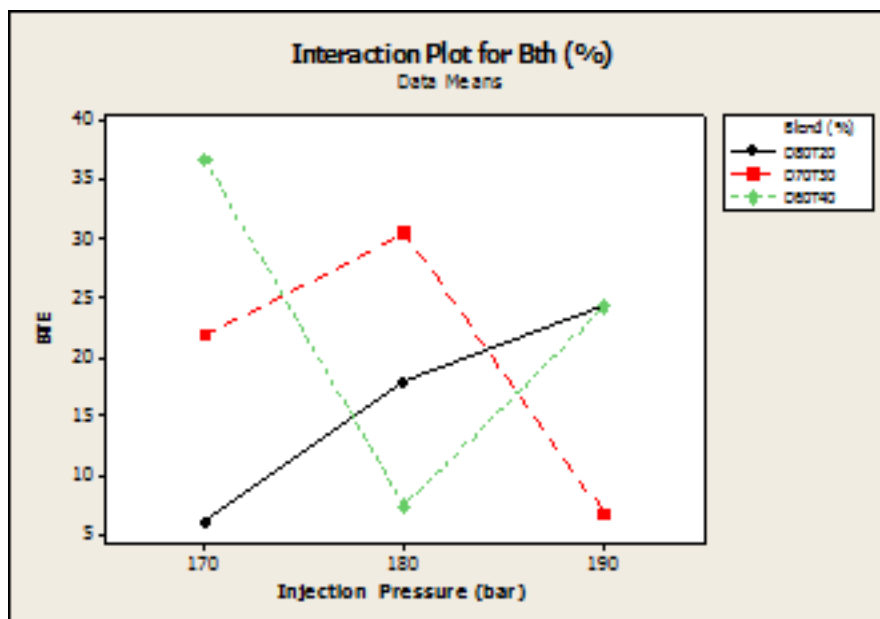


Fig. 4: Effect of Injection Pressure on BTE at different blend ratio

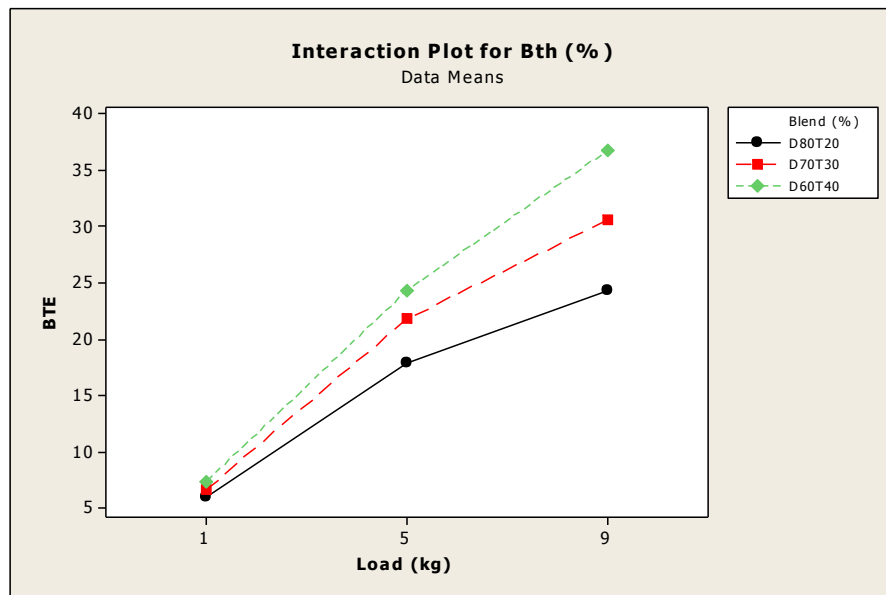


Fig - 5: Effect of load on BTE at different blend ratio

V. CONCLUSION

In this research work turpentine and diesel blend is used in the diesel engine where acetylene introduced 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 0.49kg/hr and specific fuel consumption is 0.35 kg/kwh at 60% diesel and 40% turpentine blend ratio (D60T40) at which injection pressure was 190 bar and load was 5 k.g. and 24.31% is the Brake thermal efficiency, 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. Parameters which has been predicted by Taguchi are blend ratio D60T40, injection pressure bar 190 bar and load 5kg and prediction value of brake thermal efficiency is 35.88 % and experiment performed on same range and after experiment got the 34.45% brake thermal efficiency and percentage of error is 3.99.

REFERENCES

- [1] B.premanand, C.G.saravanan. Performance and exhaust emission of turpentine oil powered direct injection diesel engine. Elsevier Ltd., oct.2009.
- [2] Karthikeyan, N. Nallysamy. Optimization of engine operating parameters for turpentine mixed diesel fuelled D.I. diesel engine using Taguchi method. dec.2010
- [3] T. Laxmanan, G. Nagarjun. Study on using acetylene in dual fuel mode with exhaust gas recirculation. Elsevier Ltd. April 2011.
- [4] T. Laxmanan, G. Nagarjun. Experimental investigation of port injection of acetylene in DI diesel engine in dual fuel mode. Elsevier Ltd. April 2010.
- [5] R. vallinayagam, S. Vedharaj. Combustion performance and emission characteristics study of pine oil in a diesel engine. Elsevier Ltd. July 2013.
- [6] S.Brusca, R.Lanzafame. On the possibility to run an internal combustion engine on acetylene and alcohol. Elsevier Ltd. Dec 2013.
- [7] M.Parthasarathy. Experimental study of acetylene enriched air in diesel engine powered by biodiesel and diesel blend. Journal of chemical and pharmaceutical science. Dec 2014.