PERFORMANCE CHARACTERISTICS OF AIR COOLED SINGLE CYLINDER FOUR STROKE ENGINE FUELED WITH DIESEL-KEROSENE BLENDS

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ABSTRACT

In the fastest growing economy like India, need of various transportation systems (operated by conventional fuels) is increasing every day while conventional fuels like diesel and petrol are vanishing gradually with time. Therefore in today's scenario we must have the alternative to conventional fuels. Researchers have found that up to 30% of kerosene blend with diesel can be used in diesel engine without any modification.

This paper presents the experimental analysis of diesel engine fueled with diesel and diesel-kerosene blends to find out the performance characteristics of diesel fuel and kerosene blends with diesel in a single cylinder four stroke engine. An experimental study was conducted on Gunt HAMBURG made single cylinder four-stroke diesel engine (CT 100.22). Two levels 5% and 10% of kerosene (by volume) blended with diesel fuel designated as K5 (5% Kerosene+95%Diesel) and K10 (10% Kerosene+90% Diesel) respectively are used, while normal diesel was considered as a baseline fuel and designated as D100. Performance parameters like mechanical efficiency, mechanical power, brake thermal efficiency and specific fuel consumption are investigated and compared by using D100, K5 and K10.

After analysis it is found that performance of engine is improved by using K10 as compared to K5 and D100. Therefore from this research it is concluded that by blending kerosene with diesel, performance of the engine will increase and dependency on diesel fuel will decrease.

KEYWORDS: *Brake thermal efficiency (BTE), Mechanical power, Mechanical Efficiency, Specific fuel consumption (SFC), Air cooled single cylinder four strokes Diesel Engine, CT 100.22, Diesel-Kerosene Blends.*

I. Introduction

Diesel engines are extensively used worldwide for transportation, decentralized power generation, agricultural applications and industrial sectors because of their high fuel conversion efficiency, ruggedness and relatively easy operation. One of the important characteristics of a diesel fuel is its ability to auto ignite. A characteristic that is quantified by the fuel's cetane number or index, a greater cetane number or index means that the fuel ignites more quickly. The cetane number of a fuel indicates the self-igniting capability of the fuel and has a direct impact on ignition delay. The higher the cetane number, the shorter the ignition delay and vice versa. High cetane number fuel encourages early and uniform ignition of the fuel. Since these properties are comparable to a blend of diesel and kerosene, therefore this blend can be used in the engine without modifying it [1,2&9].

[1] O. Obodeh analyzed and compared the performance characteristics of diesel-kerosene blends with diesel fuel in a direct ignition (DI) diesel engine. He found that mixing kerosene with decreases Specific fuel consumption with increase in engine load.

[2] A. Hafiz found that Mechanical efficiency (η_{mech}) and Brake thermal efficiency (η_{BTE}) insignificantly increases with increase in the concentration of kerosene in kerosene-diesel blends as compared with pure diesel fuel.

[3] K.R. Patil performed experiment up to 15% blending of kerosene (by volume) with diesel fuel. The reduction of lubricity was one of the reasons for keeping less than 10% kerosene (by volume) in the blends, apart from the effect of reduced viscosity on the spray. However, there is a problem of friction in the diesel engine due to blending kerosene with diesel, the kerosene-diesel blend increases the cold flow properties of the diesel fuel such as cold filter plugging point (CFPP), pour point (PP), cloud point (CP) and flash point which determine the combustion characteristics of the diesel fuel.

[4]Asfar and Hamed, [5] Shyam et al, [6] Cookson et al and [7] Chicurel also addressed that combustion of fuel blends can improve the combustion process.

[8]. Naseer Salman Kadhim studied the influence of blending kerosene (by different volume) with diesel fuel on the performance of a single cylinder 4-stroke air cooled DI diesel engine and concluded that Brake thermal efficiency slightly increases with kerosene.

[9] Bilal A. Akash conducted an experiment and found that addition of 25% of diesel to kerosene resulted in a significant improvement in the combustion process than burning of diesel or kerosene separately.

[10]. Saario et al. have studied combustion behavior of heavy fuel oil in a cylindrical furnace.

The objective of this study is to determine the effect of kerosene blends on diesel engine performance characteristics. Engine performance characteristics govern the suitability of a fuel. Kerosene is also an alternate fuel for modern internal combustion engines that has similar properties as diesel fuel such as calorific value, density, etc. Kerosene can be easily blended with diesel because of its homogeneous nature. Kerosene can also be blended with diesel fuel to improve winter cold flow operability of the engine. The boiling range of kerosene and diesel is shown in Figure 1.

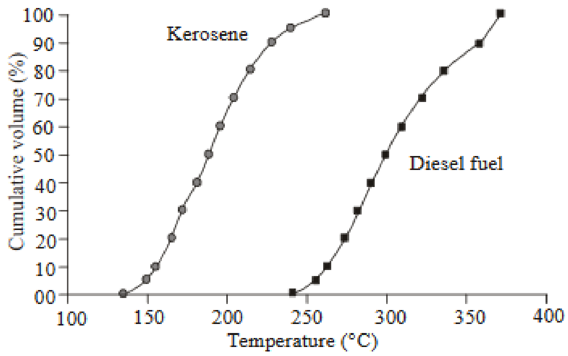

Figure 1: Boiling range curves of kerosene and Diesel [9]

After conducting the experiment following parameters are analyzed.

1. *Mechanical Power*
2. *Mechanical Efficiency (ε_m)*

   Mechanical efficiency is defined as the ratio of brake power (delivered power) to the indicated power(power provided to the piston). It can also defined as the ratio of brake thermal

   efficiency to the indicated thermal efficiency.

$$\varepsilon_m = \frac{Brake\ Power}{Indicated\ Power} \ldots\ldots\ldots\ldots..1$$

3. *Brake Thermal Efficiency (BTE)*

   Brake thermal efficiency is the ratio of energy in the brake power to the input fuel energy in appropriate units.

$$BTE = \frac{Brake\ power}{Mass\ flow\ rate\ of\ fuel \times Calorific\ value\ of\ fuel} \ldots\ldots\ldots\ldots\ldots 2$$

4. *Specific fuel consumption (SFC)*

It is defined as the amount of fuel consumed for each unit of brake power per hour; it indicates the efficiency with which the engine develops the power from fuel. It is used to compare performance of different engines.

$$SFC = \frac{Fuel\ consumption\ per\ unit\ time}{Power} \ldots\ldots\ldots..3$$

II. Materials and Method

A. Fuels used

Properties of diesel and kerosene are shown in Table 1. Fuels used in this study are D100, K5 and K10, of which properties are shown in Table 2.

Table 1: Properties of Kerosene and Diesel

Fuel	**Diesel**	**Kerosene**
Formula	$C_{12}H_{23}$	$C_{10}H_{22}$
Calorific value (kJ/kg)	44500	45400
Cetane Number(CN)	40-55	35-40
Density at 15°C kg/m3	820- 845	791-795
Viscosity(cSt) at 39°C	2.7	2.2
Freezing point(°C)	-8.1	-40
Boiling Point Range (°C)	260 - 320	180 - 240
Flash Point (°C)	52-96	37-65
Flame Temperature(°C)	1715	1782
Sulphur content by(wt.%)	0.8	0.12
Self ignition temp.(°C)	725	640

Table 2: Properties of D100, K5 and K10 blends

Fuel Blend	**Density(kg/m3)**	**CV(MJ/kg)**	**kinematic viscosity(cSt)@40°C**
D100	836	43.24	2.45
K5	834.05	43.19	2.27
K10	832.10	43.13	2.24

B. Test Engine

The experiment is performed on CT 100.22 which is an air-cooled single cylinder four stroke diesel engine. To conduct the experiments, the engine is placed in the CT 110 Test Stand for Small Combustion Engine as shown in Figure 2. The experimental module contains a Diesel engine with a power output of approx. 5.5kW.

Figure 2: Testing engine setup

Specification of test engine is given in Table 3

Table 3: Specification of Test engine

Company	Hatz IB30-2
Engine Manufacture	Gunt
Fuel Type	Diesel for CT100.22
Cooling System	Air cooled
Number of cylinders	1
Dimensions	370 mm x 330 mm x 450 mm
Bore	80 mm
Stroke	69 mm
Compression ratio	22 : 1
Output power at 3500 per minute	5.5 kW

C. Methodology

The system is drained initially and refilling with normal diesel fuel (D100) before commencing test requires, for warming up, the engine run without load for some time (say 5 minutes). The speed of the engine was increased to maximum at the same load until the engine becomes stable, which is being determined from the exhaust temperature. To record the output power curve related to the full load characteristic curves, with the engine running the speed regulator is set to the maximum amount of fuel.

Using the dynamometer on the CT 110 test stand, the engine is then loaded by turning the speed potentiometer to maximum. By reducing the speed set on the potentiometer in steps, torque values are displayed on the CT 110 test stand from which the output power curve can be drawn up.

The data required in the analysis was obtained with the help of Electronic Data Acquisition System connected to the test engine at varying load values by using an Electrical Dynamometer. Following cases are experimented.

Case-I: Experiment using normal Diesel (D100) fuel

First of all experiment was conducted by using normal diesel fuel (D100) and outcomes are shown in Table 4.

Case-II: Experiment using K5 (5% Kerosene+95%Diesel) Blend fuel

Second time experiment was conducted by using K5 fuel and outcomes shown in Table 5.

Case-III: Experiment using K10 (10% Kerosene+90 %Diesel) Blend fuel

Finally experiment was conducted by using K10 fuel and full load as well as partial load characteristics are recorded as shown in Table 6.

III. Results and Discussions

The performance characteristics of diesel-kerosene blends, i.e K5 and K10 fuels are investigated and compared with baseline fuel that is normal diesel (D100). At different speed and load conditions performance characteristic curves, brake thermal efficiency (BTE), mechanical power, mechanical efficiency and specific fuel consumption (SFC) are plotted as shown in figure 3, 4, 5 and 6 respectively.

It is evident from figure 3, that the BTE increasing with load for all types of fuel tested. Brake thermal efficiency is always found to be higher with increasing the kerosene blends as compared with baseline diesel fuel, this is because of the fuel properties such lower viscosity, density, and higher calorific value of blends K5 and K10. The higher BTE value was 36.9% registered by blend fuel K10 at full load while diesel fuel and K5 fuel were registered the highest 34.18%, 34.80% respectively at the same load and speed. The lowest BTE value was 6.89% registered by using diesel fuel at low load and engine speed 1500 1/min, while when using fuel blends K5 and K10 the BTE values were 7.92% and 11.58% respectively at the same load and speed.

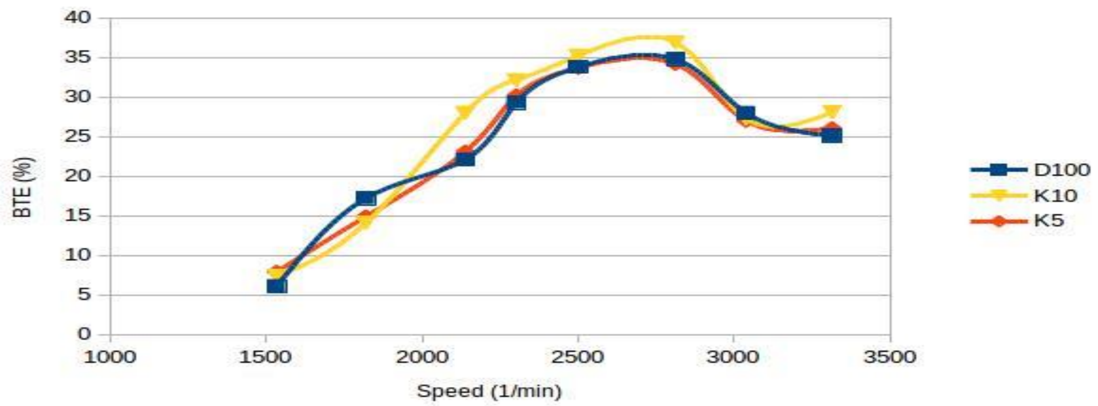

Figure 3. Brake Thermal efficiency versus speed

Figure 4 illustrates the variation of mechanical power with rated speed. Mechanical power is increasing with increase in engine load for all fuel blends. The mechanical power at 100% rated load was 0.6% higher at 10% kerosene blend as compared with that obtained when the engine was run on diesel fuel and K5 fuel.

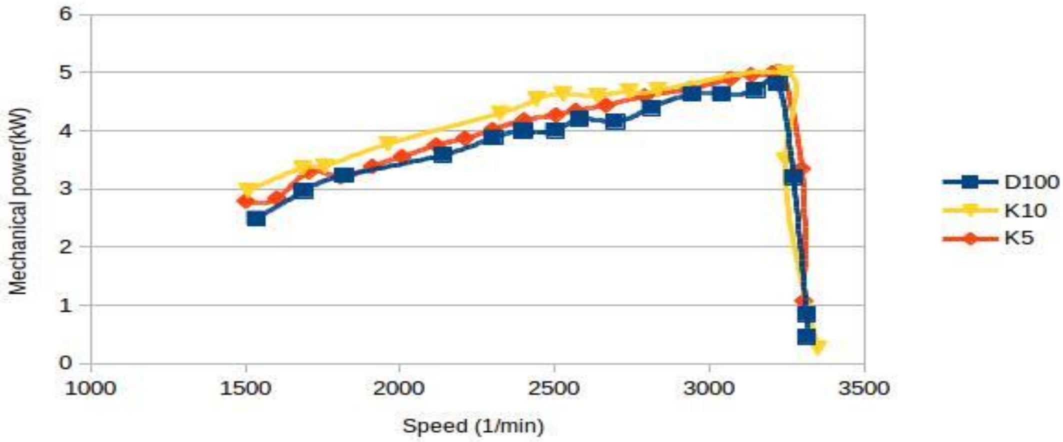

Figure 4. Mechanical Power versus Speed

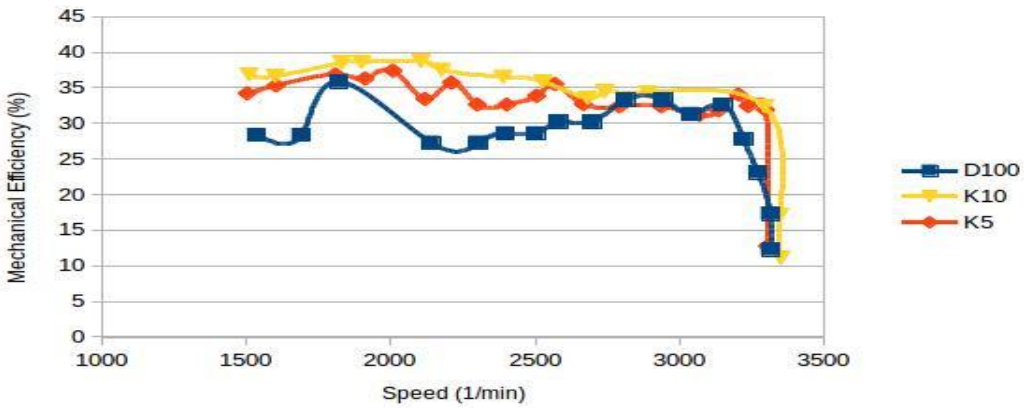

Figure 5: Mechanical Efficiency versus Speed

Fig 5 shows the effect of fuel type on Mechanical Efficiency at different speeds. It evident from the figure that mechanical efficiency is always found to be higher with increasing the kerosene blends as compared with baseline diesel fuel, this is because of the fuel properties such lower viscosity, density, and higher calorific value of blends K5 and K10. The higher mechanical efficiency value was 38.46% registered by blend fuel K10 at full load while diesel fuel registered the lowest 36.443% at the same load and speed. The lowest mechanical efficiency value was 12.86% registered by using diesel fuel at low load and engine speed 1700 1/min , while when using blends fuel K5 and K10 the mechanical efficiency values were 12.75% and 11.13% respectively at the same load and speed.
Fig. 6 demonstrates the variations of specific fuel consumption (SFC) of various blends of diesel-kerosene fuels as a function of rated load. Specific fuel consumption decreasing with increase in engine load which can be attributed to the higher calorific value of kerosene as compared to diesel fuel. In other words, less quantity of fuel is needed in order to produce the same amount of energy. Decrease in SFC of the blended fuels was caused by faster evaporation and combustion of the blend particles as compared with diesel fuel. It was observed that SFC at 100% rated load was 12.897g/kWh

lower at 10% kerosene blend as compared with SFC value when the engine was operated on diesel fuel. So the blended fuel provides good fuel economy.

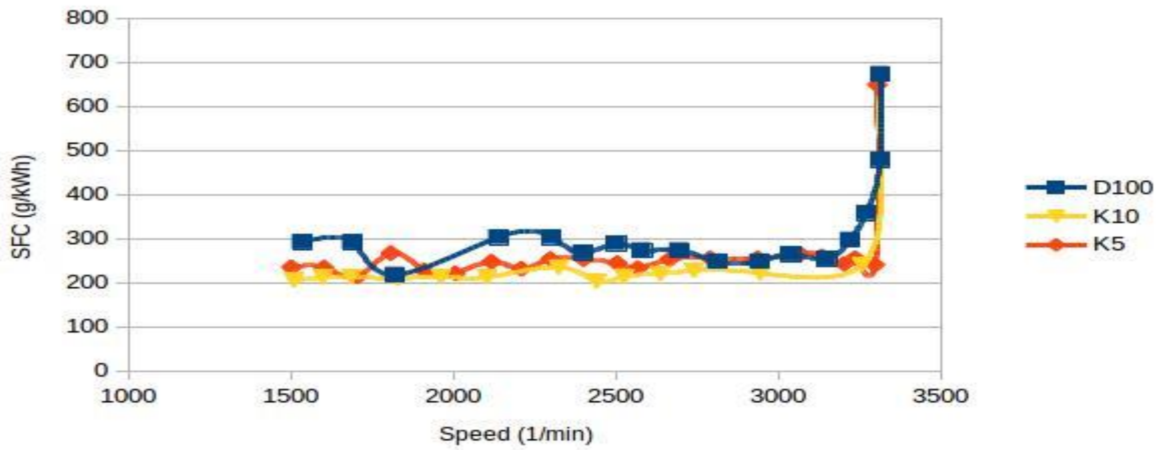

Figure 6: Specific fuel consumption versus speed

IV. Conclusions

From experimental investigation following conclusions are inferred.

1. Mechanical power increased with increase in percentage concentration of kerosene in the kerosene-diesel blends as compared with pure diesel fuel for all load conditions.
2. Brake Thermal Efficiency & Mechanical efficiency slightly increased with increase in the concentration of kerosene in kerosene-diesel blends as compared with pure diesel fuel.
3. The Specific fuel consumption (SFC) decreased with increase in percentage concentration of kerosene in the kerosene-diesel blends as compared with pure diesel fuel.

The other important reason for blending diesel fuel with kerosene was to improve cold flow operability. Kerosene has a better cold filter plugging point (CFPP) than diesel fuel, which means it can be successfully passed through a filter at a lower temperature than an untreated diesel fuel. This kerosene-diesel blended fuel can be used in winter time to avoid cold start problems in the diesel engine.

From the results, it can be concluded that diesel-kerosene blends are quite successful in replacing normal diesel in direct injection diesel engine. Results clearly show that there is a decrease in Specific fuel consumption, increase in Mechanical efficiency. So from the curves it is seen that 10% kerosene blended diesel,i.e K10 fuel is the best choice for use in the existing diesel engines without any modification to improve engine performance.

V. Future Work

In future, blend percentage can be increased up to 30% at different levels and number of parameters (like compression ration, load etc.) can be increased along with speed. After tabulating these parameters with respect to levels an orthogonal array can be formulated. This orthogonal array would help in optimizing the performance parameters of the engine by Taguchi Technique.

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