DUAL FUEL OPERATION OF PERFORMANCE AND EMISSION CHARACTERISTICS OF LINSEED BIODIESEL USING ACETYLENE GAS

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ABSTRACT – *As we know all demand of petroleum products are increasing day by day due to population, motor bike, truck etc to overcome that we were preferred linseed biodiesel and acetylene gas as an alternative fuel. In this experiment performance, emission and combustion characteristics were evaluated such as brake specific energy consumption, P-θdiagram and CO_2 content. The acetylene gas was inducted at various pressures 0.5 bar, 0.8bar and 1 bar. Acetylene gas produced from limestone ($CaCo_3$) is renewable in nature and exhibits similar properties to these hydrogen. Based on the combustion, performance and emission parameters the pressure of induction was optimized which was L0.5 bar. Dual fuel operation results in lesser brake thermal efficiency when compared to pure diesel operation. This acetylene gas reduces smoke, soot formation and exhausts temperature and increase NO_X emission. The emission of carbon monoxide and carbon dioxide was lower under all operation condition when compared to diesel operation.*

Key Words: Diesel, Linseed Biodiesel, Acetylene, Different Pressure.

1 .INTRODUCTION

The enormous growth of the world's population during the last decade, technical developments and increase in standard of living in the developed nations led to the twin crisis of fossil fuel depletion and environmental degradation resulting local air pollution to global warming, climatic changes and sea level rise. The search for an alternative fuel promises a harmonious correlation with sustainable development, energy conservation and management, efficiency and environmental preservation. Therefore, any attempt to reduce the consumption of petroleum based possible alternative fuels will be the most welcome. Continuous use of them causes shortage of food supply and proves far expensive to be used as fuel at present. So far few types of non-edible vegetable oils have been tried on diesel engine leaving a lot of scope in this area. Testing of diesel engines with preheating, blending with diesel and blending with preheating improves the performance and reduces the emissions compared to neat vegetable oil. It also reduces the filter clogging and ensures smooth flow of oil. Linseed oil also known as flaxseed oil. Acetylene is the chemical compound with the formula C2H2. It is an unsaturated hydrocarbon and the simplest alkynes. An acetylene molecule is composed of two carbon atoms and two hydrogen atoms. The two carbon atoms are held together by what is known as a triple carbon bond having CH bond angle of 180 deg. This bond is useful in that it stores substantial energy that can be released as heat during combustion. However, the triple carbon bond is unstable, making acetylene gas very sensitive to conditions such as excess pressure, excess temperature, static electricity, or mechanical shock. Acetylene is a flammable and colourless gas.

1.1 Fuel Characterization

Table1.1 shows the values of different properties such as density, kinematic viscosity, flash point, fire point and calorific value of diesel and Linseed biodiesel. Table 1.2 shows comparison of other liquid fuels.

Table1.1 Properties of Diesel and Linseed biodiesel

Fuel Properties	Diesel	Linseed biodiesel	Apparatus used
Fuel density 15°C in $\frac{kg}{m^3}$	830	895	Hydrometer
Kinematic viscosity at 40°C in cst	4.6	6.00	Redwood viscometer
Flash point in °C	51	160	Ables apparatus
Fire point in °C	57	100	Ables apparatus
Calorific value in $\frac{kJ}{kg}$	42000	39,539	Bomb calorimeter

Table1.2: Comparison with Other Fuels

Physical and Combustion Properties of fuels	Acetylene	Hydrogen	Diesel
Fuel	C2H2	H2 C8	C20
Density kg/m3 (At 1 atm & 20 °C)	1.092	0.08	840
Auto ignition temperature (°C)	305	572	257
Stoichiometric air fuel ratio, (kg/kg)	13.2	34.3	14.5
Flammability Limits (Volume %)	2.5 – 81	4 – 74.5	0.6 – 5.5
Flammability Limits (Equivalent ratio)	0.3 – 9.6	0.1 – 6.9	------
Lower Calorific Value(kJ/kg)	48,225	1,20,000	42,500
Lower Calorific Value (kJ/m3)	50,636	9600	-------
Max deflagration speed(m/sec)	1.5	3.5	0.3
Ignition energy (MJ)	0.019	0.02	--------
Lower Heating value of Stoichiometric mixture (kJ/kg)	3396	3399	2930

2. EXPERIMENTATION

Engine components:

The various components of experimental, photograph of the experimental set up is shown in Fig2.1, table2.1 shows engine specification. The important components of the experimental set-up are

- The engine
- Dynamometer
- Smoke meter
- Anemometer
- Pressure Gauge

Fig.2. 1: Photograph of experimental setup

Table 2.1: Kirloskar diesel engine specification

Sl. No	Parameters	Specification
01	Manufacturer	Kirloskar oil engines Ltd. India
02	Model	TV-SR, naturally aspirat
03	Engine	Single cylinder, DI
04	Bore/stroke	87.5mm/110mm
05	C.R.	16.5:1
06	Speed	1500 RPM, constant
07	Rated power	5.2KW
08	Working cycle	Four stroke
09	Response time	4 micro seconds
10	Type of sensor	Piezo electric
11	Crank angle sensor	1-degree crank angle
12	Injection pressure	200bar/23 def TDC
13	Resolution of 1 deg	360 deg with a resolution of

3. RESULT AND DISCUSSIONS

This section consists of three types of experimental analysis of performance characteristics like brake thermal efficiency, specific fuel consumption, against brake power, emission characteristics like carbon monoxide (co) unburned hydrocarbon(HC), NOx, exhaust gas temperature against brake power and finally combustion characteristics like pressure, heat release rate, mass fraction burned against crank angle.

3.1 Performance characteristics:
Brake thermal efficiency:

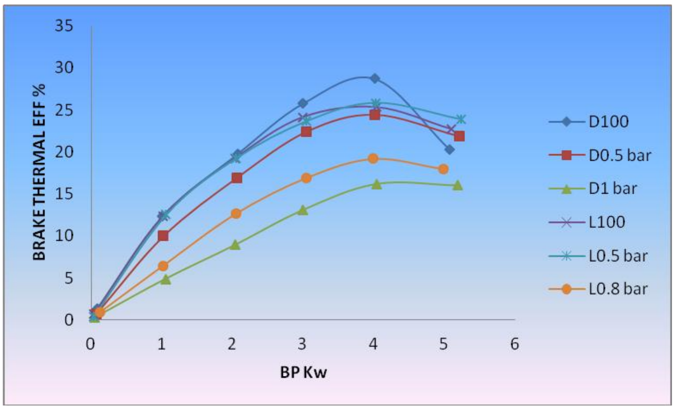

FIG.3.1.1: variation of brake power vs brake thermal efficiency

The above graph shows variation of brake power vs brake thermal efficiency in fig3.1.1, as BP increases the BTH is also increases. The BTH is higher for pure diesel i.e.28.74% at full load without use of acetylene gas due to time consumption of fuel is more. When diesel+ acetylene gas, linseed+ acetylene gas is used the BTH decreases due to high combustion rate and rapid energy release. As the acetylene gas D0.5 bar and D1bar pressure increased the BTH is decreased as compare to pure diesel. Similarly increasing pressure of L0.5 bar and L0.8 bar acetylene gas the BTH is decreased as compare to pure linseed biodiesel. The BTH is optimum for L 0.5 bar as compare to other pressure.

Brake specific fuel consumption:

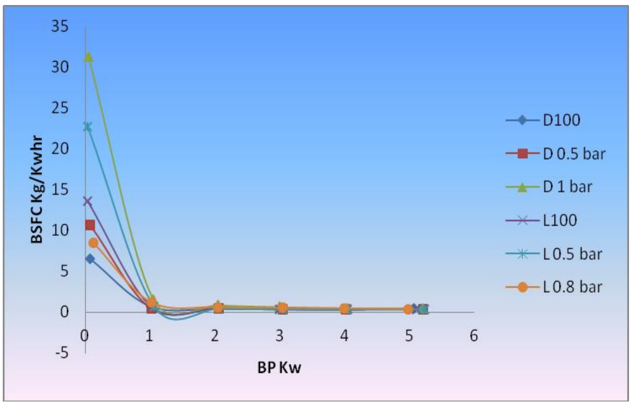

FIG.3.1.2: variation of brake power vs BSFC

The above graph shows variation of BP vs BSFC in fig.3.1.2, as the BP increased BSFC is also decreased. The BSFC is defined as sum of mass of fuel and gas i.e. (mf+ mg) to the BP. The combination of diesel+ acetylene gas at 0.5bar and 1 bar gives decreases in BSFC and is maximum at infinity. The combination of linseed +acetylene gas at 0.5bar and 0.8bar leads to decrease in BSFC and is minimum at full load of L0.5

Brake specific energy consumption:

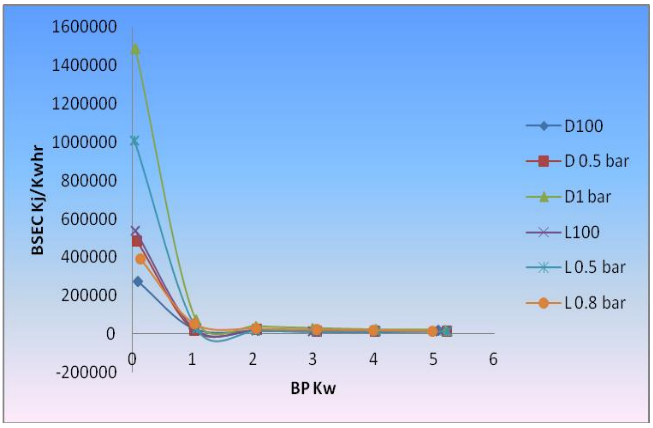

FIG.3.1.3: variation of brake power vs BSEC

The above graph shows changes of BP VS BSEC in fig3.1.3, as the BP is increased the BSEC goes down gradually. The BSEC is defined as the heat supplied to the brake power. The BSEC is Maximum at full load i.e. 17723.10 Kj/ kwhr for pure diesel. BSEC is Minimum at 5.23Kw of BP of L0.5 bar. Addition of acetylene gas provides more energy share compare to that of diesel so that the brake specific energy consumption increase at initial load. The BSEC decreases with increase in engine loads. The BSEC depends on fuel specific gravity, viscosity and calorific value. If the specific gravity increases and calorific value decreases and more amount of fuel is needed to produce the same amount of energy.

3.2. Emission characteristics

Carbon monoxide:

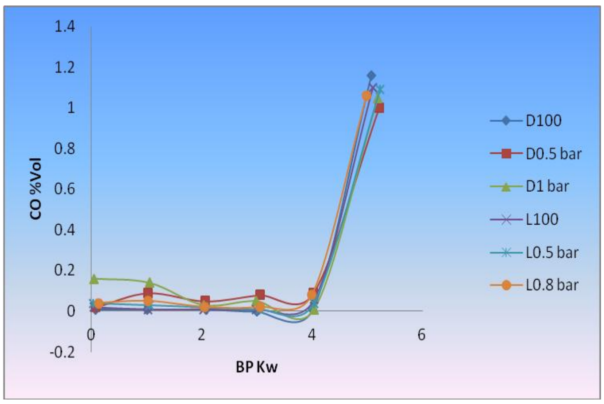

FIG.3.2.1: variation of brake power vs co emission

Carbon monoxide emission is due to unavailability of oxygen during the combustion process. Poor mixing and incomplete combustion are also responsible for CO emissions. The graph shown in fig.3.2.1 is drawn between CO emission (%Vol.) and BP Kw applied. By induction of acetylene, results show less CO emissions at all brake powers when compared to pure diesel operation due to complete combustion of fuel. CO is Maximum for pure diesel at full load i.e. 1.16 % Vol.

Carbon dioxide:

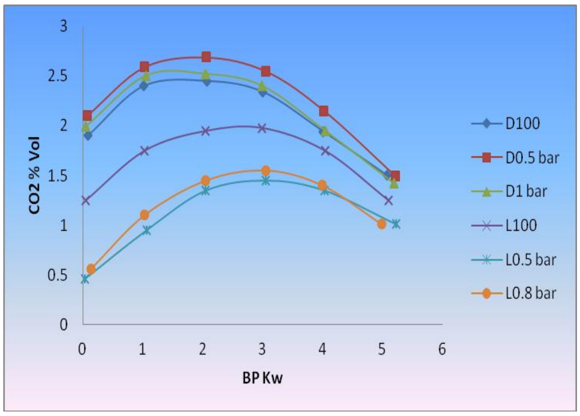

FIG. 3.2.2: variation of brake power vs co_2 emission

The above graph shows variation of brake power vs carbon dioxide in fig.3.2.2, as the CO_2 is higher for pure diesel i.e. 1.5% Vol due incomplete combustion. When diesel +acetylene gas is used CO_2 is decreased and similarly for linseed biodiesel+ acetylene gas is used CO_2 decreased due to complete combustion of linseed biodiesel. Increase in CO_2 emission may be due to the higher combustion temperature and there by reduction in cylinder heat transfer.

Unburnt hydrocarbons:

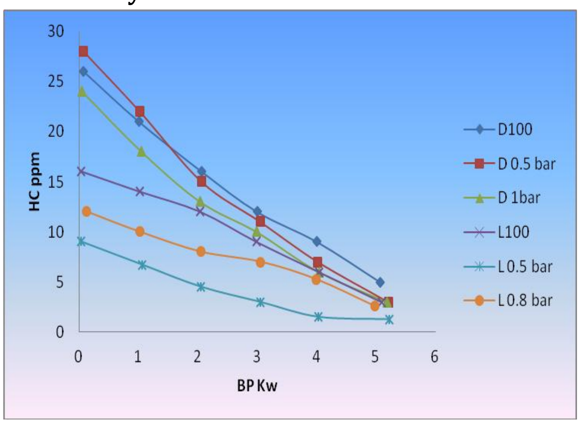

FIG.3.2.3: variation of brake power vs HC

The change in HC emission with BP is shown in the fig.3.2.3.There is an increase in un-burnt hydrocarbon emissions with the addition of acetylene because of decrease of oxygen % inhaled. Due to less oxygen present in the charge intake it leads to improper combustion. The HC value for diesel operation at full load is 26ppm and for D0.5, D1, L0.5 and L0.8bar of acetylene values are 28ppm, 24ppm, 9ppm and 12ppm respectively.

Oxides of nitrogen:

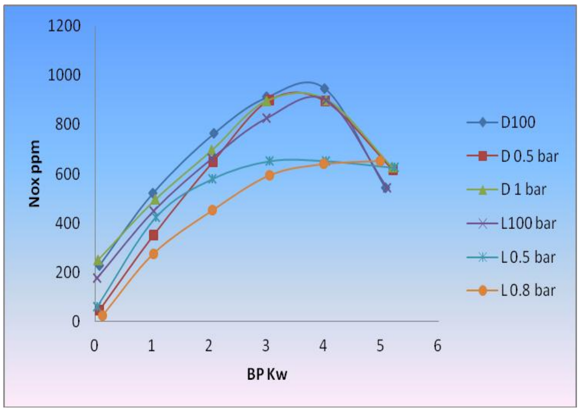

FIG.3.2.4: variation of brake power vs NO_x

The graph showed in fig.3.2.4 is in between NOx emission and BP for neat diesel and all acetylene blends .NOx values in emission depend upon reaction temperatures and peak cylinder pressures. As the flow rate of acetylene gas increases the reaction temperatures and peak cylinder pressures are increases accordingly that results higher NOx emissions. NOx emission for the diesel operation at full load is 543ppm and for different pressure of acetylene induction D0.5, D1, L0.5, and L0.8bar are 615ppm, 625ppm, 625ppm and 653ppm respectively.

Exhaust gas temperature:

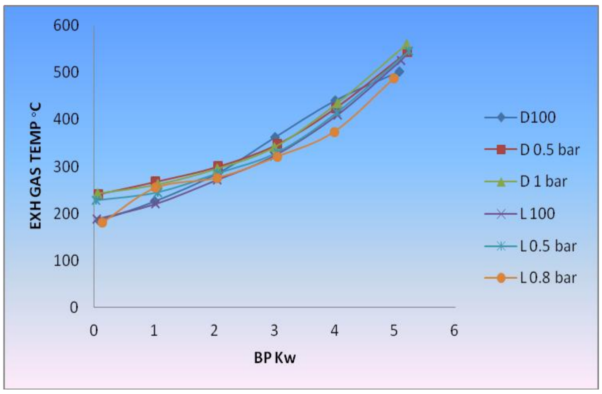

FIG.3.2.5: Variation of brake power vs exhausts gas temperature

The exhaust gas temperature is increasing with acetylene induction when compared to diesel operation may be due to more energy input with acetylene gas. The graph shown in fig.3.2.5 is drawn between exhaust gas temperature and BP. The EGT is in the range of 184°C to 502°C for neat diesel operation and 241°C to 560°C for acetylene at various pressures at compression ratio 18:1. The EGT reached to 560°C while acetylene was inducted at 1bar and it is more when compared with other pressure at full load. So EGT graph is useful for optimizing the pressure at which acetylene gas can be inducted in the in air manifold along with air.

3.3 Combustion characteristics

Pressure crank angle diagram:

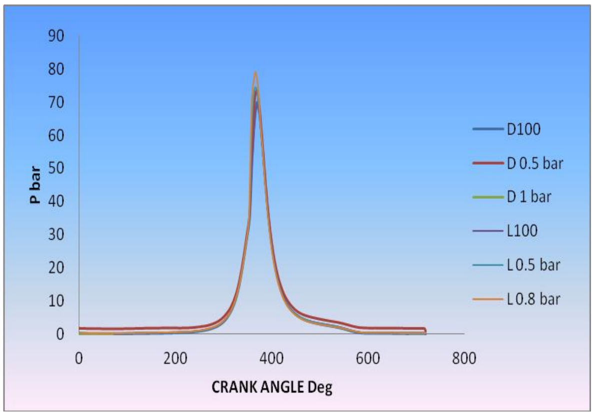

FIG.3.3.1: variation of crank angle vs cylinder pressure

Fig.3.3.1 shows the measured cylinder pressure versus crank angle variation at full load for diesel operation and acetylene pressures of D0.5, D1, L0.5 and L0.8bar at compression ratio 18:1 of the engine. The maximum cylinder pressure for diesel operation at full load is 69.90bar and for acetylene at different pressures, it is 73.55 bar, 73.44bar, 74.52bar and 78.97 bar. The cylinder pressure is raised by acetylene induction due to increase in ignition delay and high heat release by acetylene. The peak cylinder pressure for acetylene induction at L0.8bar is 78.97bar and it is higher among that of all other pressures.

Net heat release rate:

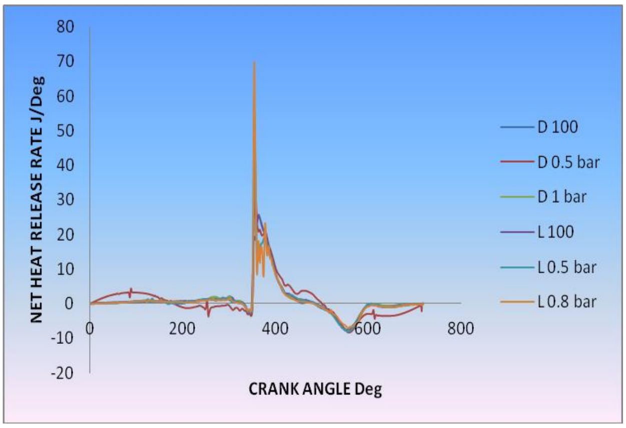

FIG.3.3.2: variation of crank angle vs net heat release rate

The graph drawn for the net heat release rate for diesel operation and acetylene inducted at different pressure with crank angle for compression ratio 18:1 is shown in fig.33.2. The maximum heat release rate for diesel and linseed biodiesel operation at full load is 25.15 J/deg CA and 25.55 J/deg CA respectively. For acetylene induction at L0.5bar and L0.8 bar the rate of heat release is marginally decreased to 14.73 J/deg CA and 13.05 J/deg CA.

Cumulative heat release rate:

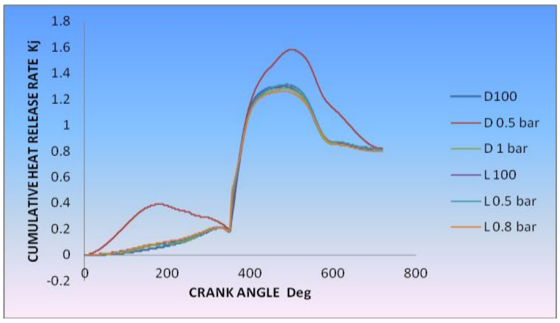

FIG.3.3.3: crank angle vs cumulative heat release rate

The graph drawn for the net heat release rate for diesel operation and acetylene inducted at different pressure with crank angle for compression ratio 18:1 is shown in fig.3.3.3. The maximum heat release rate for diesel operation at full load is 1.3 Kj CA and for acetylene induction at L0.5bar the rate of cumulative heat release is marginally increased to 1.32 Kj CA.

Mass fraction burnt:

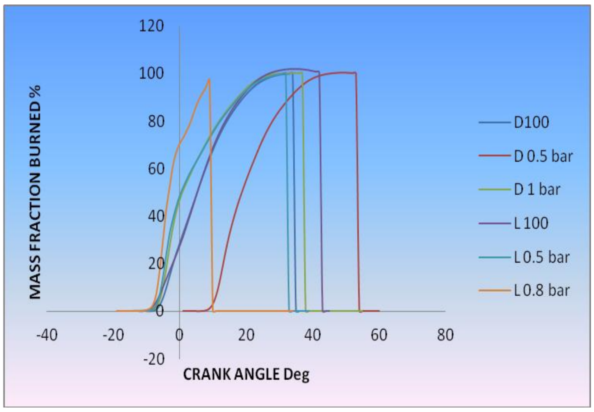

FIG.3.3.4: variation of crank angle vs mass fraction burned

The graph shown in the fig.3.3.4 is drawn between MFB and Crank Angle for compression ratio 18:1. The graph is drawn for base line diesel fuel and acetylene induction at various pressures. For pure diesel the mass fraction burned is about 100% at crank angle of 34deg. For linseed 101.88 at 34deg & for different acetylene flow rate at 0.5bar & 0.8bar, diesel (100.58 at 33deg, 100.38 at 34deg), linseed (100.59 at 34deg, 99.88 at 32deg) respectively. Higher mass fraction burned by acetylene due to higher flame speed and hence faster energy release. High self-ignition temperature of acetylene allows larger compression ratios than diesel engines. It is observed from the result the mass fraction burned is relatively higher than that of diesel.

CONCLUSION

In this project experiment is carried out on a single cylinder water cooled naturally aspirated kirloskar make 5.2 KW at1500rpm .the engine is operated on a dual fuel mode with DAG & biodiesel as fuel .The experiment were conducted for neat biodiesel at pressure of DAG 0.5 bar, 0.8bar & result are compared with that of pure diesel. Performance, emission and combustion characteristics of these fuels are evaluated & present .from this work the following conclusions are drawn. .

- Linseed biodiesel is collected & characterization is carried out. Density , viscosity , flash point , fire point are higher & calorific value is lower for this biodiesel compare to diesel because of inbuilt oxygen content linseed biodiesel catches fire earlier than of diesel ,i.e ignition lag of biodiesel is lower than that of diesel .
- Unbent hydrocarbon is higher at lower & decreases as the load increases in dual fuel mode.
- CO emission reduces with increase in quantity of DAG in dual fuel mode.
- CO_2 emission reduces with increases in percentage of DAG in dual fuel mode.
- NOx emission is higher for L0.8 bar i.e. 653ppm, increases in percentage of DAG increases the NOx considerably.
- At 0.8 bar of DAG pressures in dual fuel mode has lower emission with little sacrifice in brake thermal efficiency.
- Higher mass fraction burned by acetylene due to higher flame speed and hence faster energy release. Mass fraction burned is relatively higher than that of diesel.
- The peak cylinder pressure for acetylene induction at L0.8bar is 78.97bar and it is higher among that of all other pressures.
- The BSEC decrease as increasing the percentage of DAG.

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