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Acetylene an Potential Alternative Fuel for Stationary Diesel Engine

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Abstract: ***The present study focuses on incorporation of alternative fuels along with existing internal combustion engines (ICE) without making major modifications. Acetylene has good combustion qualities with auto ignition temperature of 3050C. To increase the use of acetylene as non-petroleum gas in ICE, we carried experimentation on a single cylinder constant speed diesel engine. In this study, direct injection (DI) and constant speed compression ignition (CI) engine tested with pure diesel and diesel-acetylene dual fuel mode. We conducted experiments to study the performance characteristics of DI diesel engine in dual fuel mode by aspirating acetylene gas in the inlet manifold with a flow rate of 2 liters/minute (lpm) of acetylene. Observation recorded that, during idling condition to get the same power output when aspirated with the 2 lpm acetylene, 3.5% less amount of diesel required. For maximum load 9% less amount of diesel required. And 12% less amount of diesel required during partial loading condition. Also, the performance shows increased trend in indicated power and brake power by 1-2%. It was also observed that use of acetylene gas has more influence on emission of CO2. Emission results showed that without a catalytic convertor, 8% decreased amount of CO2 released during idling condition. Similar emission results of engine found during full load condition when acetylene used along with diesel, supporting the health of environment for reduction of global warming.***

Index Terms: ***Alternative fuel, Acetylene, Diesel engine, performance of engine***

I. INTRODUCTION

Internal combustion engines holding a large number of share to develop the power. The demand of power increases day by day to fulfil the development of world and its economy [1]. The research for an alternative fuel provides a helping hand in the sustainable development, energy conservation, energy management, engine efficiency and environmental preservation [2]. Acetylene gas is easy to produce from simple and rapid hydrolysis reaction of calcium carbide and water at low cost [3]. As production of the calcium carbide from lime and coke, whose availability is abundant therefore acetylene gas becomes most prominent source as an alternative fuel for engines. The data from department of mines and geology about 210 million tons availability of calcium carbonate in Nepal [5]. Research is going on use of acetylene gas along with diesel in diesel engines for duel fuel operation mode to improve engine performance and to reduce the hazardous emission. Acetylene provides clean burning with good combustion properties and also available and produced at low cost fetch intention of most of the researcher [2, 14]. Acetylene is one of the substitute as an alternative fuel [9, 18]. Many researchers used acetylene in duel fuel mode to carry out engine performance and emission study [7, 10, 11]. The search also provides small modifications in the current engines to get same power output.

II. METHODLOGY AND EXPERIMENTAL SET UP

A. Acetylene production setup and properties of acetylene

Acetylene production chemical reaction [5] which used to produce acetylene gas for experimentation is stated as,

$$CaC_2 + 2H_2O = C_2H_2\,(\text{Acetylene}) + Ca(OH)_2$$

The acetylene produced in acetylene generator with the rapid hydrolysis process is used to carry out the experimentation. The flow of acetylene is regulated during experimentation with the help of rota meter. Also standard properties for diesel and acetylene considered for performance measurement were taken from Table 1 [5].

Table 1. Comparison of acetylene properties with other fuels [5]

Physical and Combustion properties of fuels	Hydrogen	Petrol	Diesel	Acetylene
Chemical Formula	H2	C8H18	C8-C20	C2H2
Density (kg/m^3 at atmospheric pressure & 20 ^{0}C)	0.08	719.7	840	1.092
Auto ignition temperature (^{0}C)	572	396	257	305
Stoichiometric air fuel ratio (kg/kg)	34.3	14.7	14.5	13.2
Flammability Limits (Volume %)	4-74.5	1.4-7.6	0.6-5.5	2.5-81
Lower Calorific Value (kJ/kg)	1,20,000	45,800	42,500	48,225

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Max deflagration speed (m/sec)	3.5	0.6	0.3	1.5
Lower heating value of Stoichiometric mixture (kJ/kg)	3399	3062	2930	3396

B. Engine setup and experimental setup

The experimentation is carried out for performance and emission measurement of the engine using the experimental setup as shown in Fig. 1.

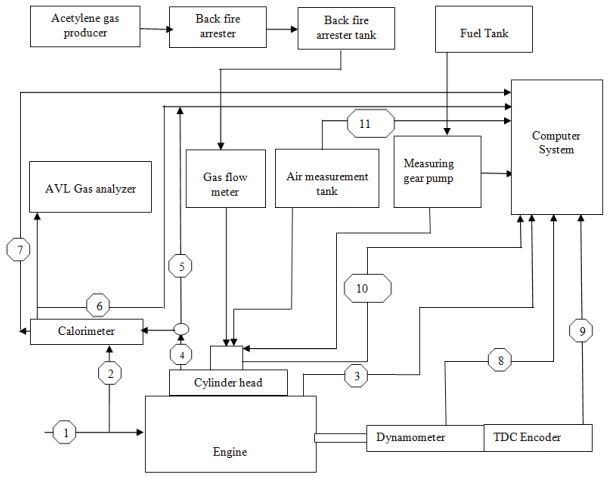

Fig. 1 Experimental setup

Process No	Process	Parameter
1	Cooling water in to engine	T1
2	Cooling water in to calorimeter	T1
3	Engine water out	T2
4	Exhaust gas in to calorimeter	T3
5	Exhaust gas out from engine	T3
6	Exhaust gas out to calorimeter	T4
7	Calorimeter water out	T5
8	Load cell	F
9	TDC Encoder	Position
10	Pressure Sensor	P
11	Air measurement	mmwc

The experimentation was carried out on a diesel engine setup with the details mentioned in Table 2.
Standard measurement techniques used for air measurement. For fuel measurement gear pump is used and for acetylene gas measurement rota meter is used. Emission measurement for 4 gases made with the AVL 444 gas analyser. All the measured and observed values recorded and analysed thereafter.

Table 2 Engine and performance measurement parameters

Engine details	Kirloskar make single cylinder, four stroke, water cooled, constant speed diesel engine
Power output	3.5 kW at 1500 rpm
Bore diameter and stroke length	87.50 mm and 110 mm respectively
Compression ratio	18
Orifice diameter and coefficent of discharge	20 mm and 0.6 respectively
Dynamometer arm length	185 mm

III. RESULTS AND DISCUSSION

Comparison of diesel and acetylene + diesel duel fuel operation made in Fig. 2 for power against applied load on engine for constant speed operation. The increased indicated pressure recorded for acetylene + diesel operation rather only diesel provides increased brake power by 1-2% with decreased friction power by 2%. The increase in indicated power represents an increase in indicated pressure for the constant speed operation at TDC because of early oxidation process of acetylene which increases the temperature inside the combustion chamber and helps to reduce the delay period for diesel injected thereafter. Fig. 3 represents performance of the engine in terms of efficiencies plotted against load for diesel and diesel + acetylene duel fuel mode. The increased indicated thermal efficiency represents, for same power output heat required will be less. Mechanical efficiency found increased by 1% to 3% shows availability of peak pressure at top dead center. This also represents decreased delay period of combustion for acetylene aspiration at suction stroke. Volumetric efficiency decreased during operation of engine in duel fuel mode. The early entry of acetylene in suction stroke and oxidation of acetylene at this event reduces the suction pressure.

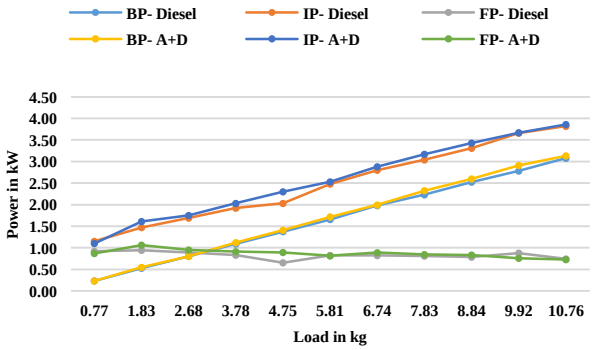

Fig. 2. Comparison of power verses load for diesel and diesel + acetylene

The engine performance again calculated for its specific fuel consumption and brake specific fuel consumption against load for diesel and diesel + acetylene duel fuel mode. For same output power during engine idling and full load tested, and the observation recorded as stated in Fig. 4, gives a decrease of the specific fuel consumption by 4% to 7.3% and brake specific fuel consumption by 3.5% to 9%. The decrease in specific and brake specific fuel consumption, increases possibility of acetylene suitable for diesel engine as an alternative fuel.

Heat balance sheet for the engine calculated per minute basis for diesel and diesel + acetylene duel fuel mode and recorded as shown in Fig. 5. The increase of heat dissipated in jacket water and exhaust gases during duel fuel mode represents clean burning of fuel during this operation. Reduction of unaccounted heat during duel fuel mode operation increases the heat accounted in brake power. The silent decreased nature of unaccounted heat during duel fuel mode again represents less abnormal combustion in the engine which will reduce the noise.

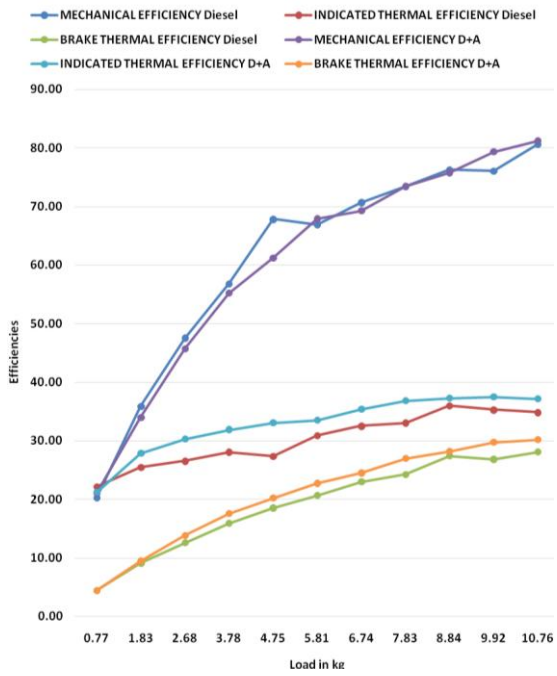

Fig. 3. Comparison of efficiency verses load for diesel and diesel + acetylene

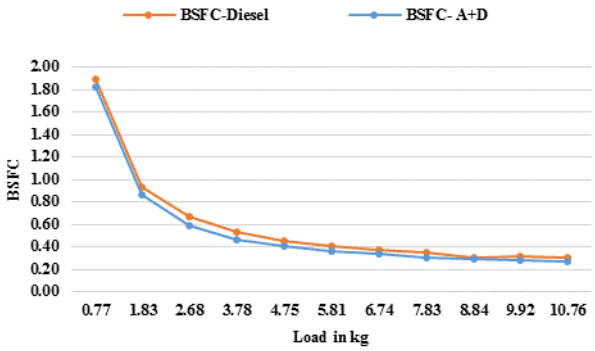

Fig. 4. Comparison of BSFC verses load for diesel and diesel + acetylene

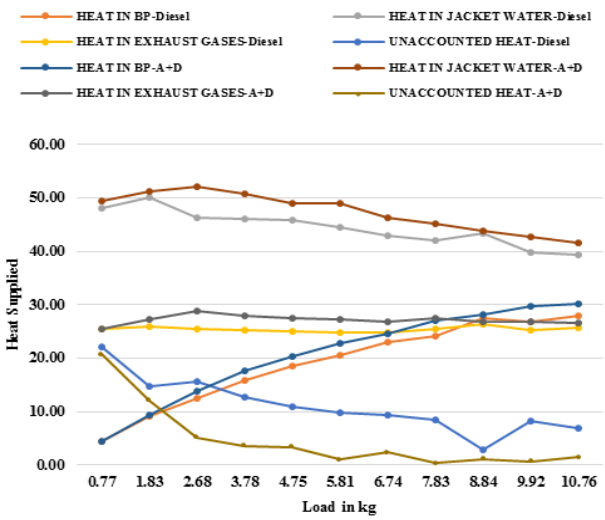

Fig. 5. Comparison of heat balance sheet verses load for diesel and diesel + acetylene

IV. CONCLUSION

Based on the experimental findings to run the constant speed diesel engine with the 2 lpm acetylene aspiration following conclusions are made.

- For a reduced supply of heat by 5.5%, the unidealized heat reduced by 79% at full load condition represents the clean and normal combustion operation of the diesel engine which increase the output power by 3%.
- Operation of the engine during duel fuel mode increases the thermal efficiency of the engine by 7% to 14%.

The possibility of clean burning again reduces noise and pollution from engine.

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