OPTIMISING THE DIESEL ADDITIVES IN A SINGLE CYLINDER DIESEL ENGINE

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Abstract: Engine exhaust pollution is a prime concern in the automobiles which affects the living species health in many ways. Hence controlling the exhaust emissions by doing enumerable research work by many scholars throughout the universe. This research work emphasizes the usage of different additives like Cyclohexylamine, DEE, Methyl acetate and amyl alcohol with Diesel in proportions of 2.5 ml,5 ml and 7.5 ml and experimented at different loads in a single cylinder air-cooled Kirloskar diesel engine and arrived at a conclusion as Cyclohexylamine is a very promising additives with Diesel which gives optimal performance and lesser pollutions with a very economical fuel consumption within engine operating range.

Keywords: Brake Thermal Efficiency, NO_x, HC, CO Smoke and SFC

Introduction

The alternative to diesel fuel must be technically feasible, economically competitive, environmentally acceptable, and readily available [1]. the properties and application of di-methyl ether (DME) as a candidate fuel for compression-ignition engines. DME is produced by the conversion of various feedstock such as natural gas, coal, oil residues and bio-mass. To determine the technical feasibility of DME, [3] The emission characteristics of a turbocharged diesel engine using rapeseed oil methyl ester was investigated as a fuel.[4]. The effects of post injection on engine combustion characteristics and emission reduction were investigated at low speed and low load conditions. Combustion performance and exhaust emissions were tested by varying the post injection timings and quantities. The main injection was fixed at 2 crank angle degree after top dead center. Post injection timing varied from 12 to 50 crank angle degree after top dead center. The fuel quantity of post injection varied from 1 to 3 mg, and the fuel quantity from main injection was adjusted to maintain a constant load.[5]. and low fuel consumption. Current common-rail direct-injection (DI) CI engines with turbochargers show about 20% higher efficiency than gasoline engines. This increased efficiency can also be achieved with alternative fuels [2]. However, CI engines have some problems, such as noise and the oxides of nitrogen (NO_x) and soot emissions.[6]. Self-ignition and ignition delay directly influenced combustion performance and pollutant levels in the engine. This property is called the cetane number of fuel and is mainly used as a measure of the compression ignition quality. In general, diesel fuel has a cetane number of 46 - 55, while the cetane number of DME is greater than 55 [8,9] The percentage energy that leaves due to heat transfer is about 20.7% for the isooctane case, and about 20.3% and 22.6% for the methanol and hydrogen cases, respectively. The exergy retained in the exhaust gases is about 25.6% for the isooctane case, and about 30.6% and 31.6% for the methanol and hydrogen cases, respectively.[10]. The indicated thermal efficiencies for the alcohols are the highest, and for carbon monoxide and hydrogen are the lowest for these conditions. Fernando et al. [12] suggested that the thermal mechanism is dominating in NO_x formation in the combustion of biodiesel. Thus when biodiesel is combusted together with methanol, the cooling effect of methanol can lead to reduction of NOx emission. On the other hand, the higher oxygen content of methanol and the increase in fuel burned in the premixed mode might lead to increase in NOx emission.[11]. The high octane rating of ethanol could be used in a mid-level ethanol blend to increase the minimum octane number (Research Octane Number, RON) of regular-grade gasoline. Higher RON would enable greater thermal efficiency in future engines through higher compression ratio (CR) and/or more aggressive turbocharging and downsizing, and in current engines on the road today through more aggressive spark timing under some driving conditions.[12] [13] [14] [15]. The test results demonstrated that, the fuel energy flow rate of the SI

DME engine was only 30% of that of the original SI gasoline engine whereas the IMEP (indicated mean effective pressures) of the SI DME engine was effectively enhanced in the first 5 cycles. The SI DME engine had a shortened flame development period compared with the original SI gasoline engine. Meanwhile, the HC emissions were averagely decreased by 80% under the pure DME mode. The instantaneous CO and NO_x emissions from the SI DME engine were slightly increased in the initial seconds after the onset of cold start and then markedly reduced compared with those from the original SI gasoline engine. In view of the above, starting an SI engine with pure DME could improve the combustion and emissions performance[16].

Table1: Engine Specification

Type	Specification
Engine make	Kirloskar
Number of cylinder	One
Type of cooling	Air cooled
Bore	87.5 mm
Stroke	110 mm
Connecting rod length	220 mm
Displacement volume	661 cc
Piston	Hemi spherical shallow bowl
Compression ration	17.5:1
Rated power	4.4 kW at 1500 rpm
Nozzle	200 bar
Injection timing	23° BTDC
Fuel oil	High speed Diesel

Experimental set up

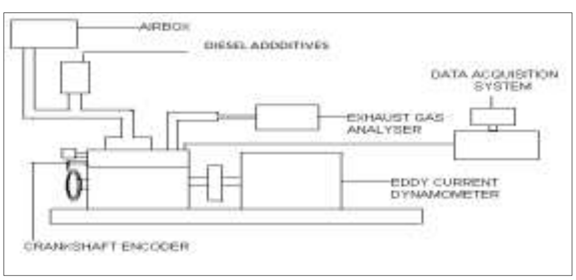

Fig.1: Experimental set up

Test Matrix

Fuel	Additives		Performance
Diesel	base		
	Cyclohexyl amine	2.5 ml	
		5.0 ml	
		7.5 ml	Optimal
	DEE	2.5 ml	
		5.0 ml	
		7.5 ml	Optimal
	Methyl acetate	2.5 ml	
		5.0 ml	
		7.5 ml	Optimal
	Amyl alcohol	2.5 ml	
		5.0 ml	
		7.5 ml	Optimal

Table 2: Properties of additives

	Diesel	Cyclohexyl amine	DEE	Methyl acetate	Amyl alcohol
Chemical formula		$C_6H_{13}N$	$C_4H_{10}O$	$C_3H_6O_2$	$C_5H_{12}O$
Molecular weight		99.17	74.8	74	88
Density @15°C	0.8325	0.8328	0.8334	0.8317	0.8327
Gross CV(kJ/kg)	41845	44840	42335	41695	46064
Flash Point(°C)	52	54	38	50	60
Cetane Number	51	52	50	53	56
Auto Ignition Temp(°C)	257	293	180	454	350

Results and analysis

Operating range of 60% to 80% of load conditions decide the selection of fuel additives and the same is discussed in the forth coming test results and the illustrations.

Brake Thermal Efficiency:

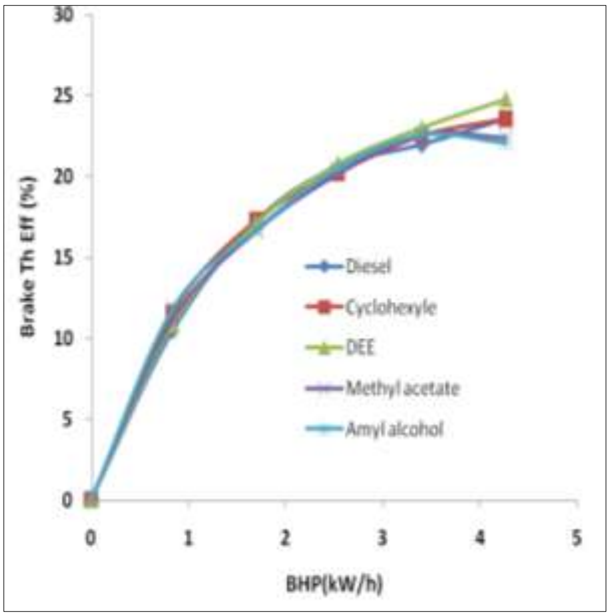

Fig.2: Brake Thermal Efficiency

Figure 2 shows the variation of Brake Thermal efficiency with Brake Power. Brake Thermal efficiency is more with DEE and Cyclohexylamine at 80% load conditions (Figure 2). Amyl Alcohol has the efficiency of 22.6% at 80% load which is greater than Cyclohexylamine. SFC is also lesser at this load and is (0.375 kg/kWh) when compared with Diesel(0.386kg/kWh) (Figure 3). Heating value of these additives is more than that of Diesel which assists for this improvement.

Specific fuel consumption:

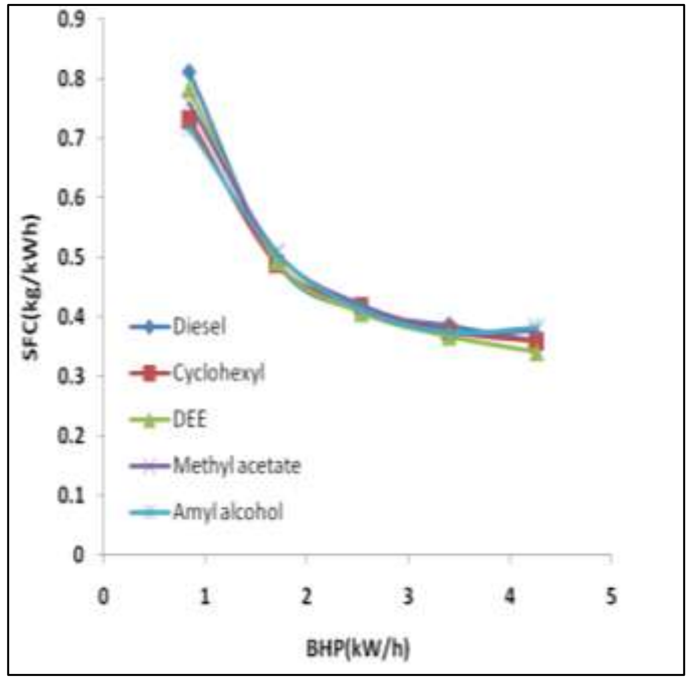

Fig.3: Specific Fuel Consumption

The variation of brake specific fuel consumption with brake power is shown in Figure3 for diesel and different additives. The specific fuel consumption of Amyl Alcohol is 0.375kg/kWh at 3.4kW(80% load). Comparing with Diesel, the specific fuel consumption at 80% is low. Hence with low fuel consumption Amyl alcohol can give same amount of power as produced by Diesel. With the increase in brake power, the specific fuel consumption decreases.

Heat Release Rate:

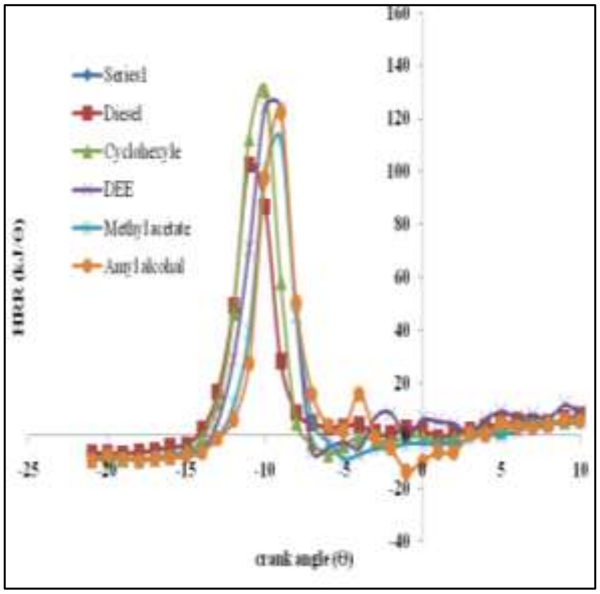

Fig.4: Heat release

Heat release rate with respect to crank angle is shown in Figure 4. Amyl alcohol produces heat release very nearer to TDC and the lesser combustion duration is also effectively assists the heat release. Cyclohexylamine produces more heat release but at retarded time. For the same injection timing Amyl alcohol combustion is more due to its own oxygen contents. Diffused combustion at which maximum power is developed in Diesel is happening with these additives is the advantageous for reducing the pollutions. Cyclohexylamine is having a heat release rate of 136.8 kJ/deg.CA and Amyl alcohol has 136.2 kJ/deg.CA at 80% load which is higher than Diesel 112.6 kJ/deg.CA.

Oxides of Nitrogen:

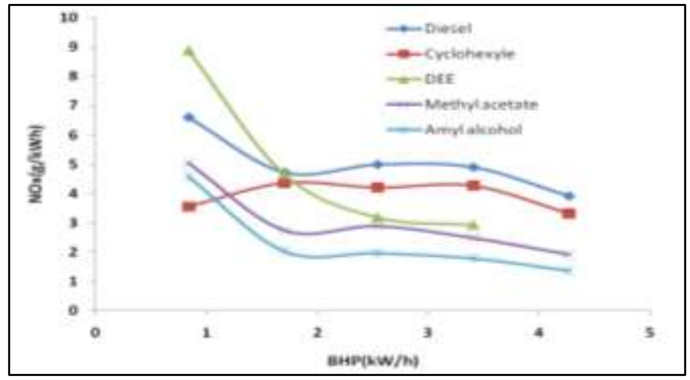

Fig.5: Oxides of Nitrogen

Figure 5 shows the NO_x emission at various brake loads of different additives. At 0.8kW (20% load) the NO_x emission level of amyl alcohol is 4.58g/kWh which is lesser than Diesel. The NO_x level reduces to 1.77g/kWh at 3.4 kW(80% load) at which the Amyl alcohol has the highest thermal efficiency. There is even further reduction in NO_x level at full load. Hence it can be concluded that amyl alcohol has the lowest NO_x level of all other diesel additives.

Hydro Carbon Emission:

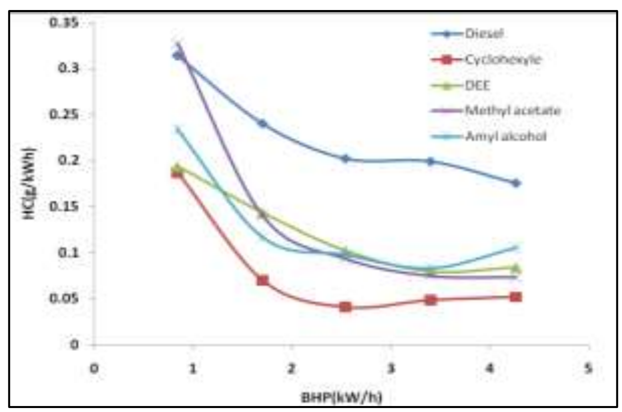

Fig.6: Hydro Carbon emission

Variations of Hydro Carbon emission level with brake power is shown in Figure6. At lower load conditions the hydro carbon emission is 0.24 g/kWh which is less than conventional diesel fuel. The increase in brake power decreases the hydrocarbon level. At 80% load, Amyl alcohol has the lowest hydrocarbon emission of 0.08 g/kWh.

Carbon Monoxide emission:

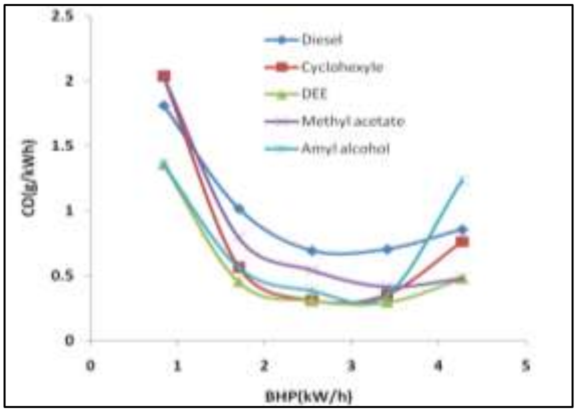

Fig.7: Carbon monoxide emissions

Figure 7 shows the change in carbon monoxide level with different brake power. The CO amount of amyl alcohol is in par with DEE at starting condition. The amount is far more less than diesel having a value of 1.35g/kWh with diesel having 1.8g/kWh. The CO amount at the maximum brake thermal efficiency of 22.56% has 0.35g/kWh which is in line with Cyclohexylamine. The formation of carbon monoxide is due to the incomplete combustion of fuel, insufficient supply of oxygen and burning of rich mixture.

Carbon-di-oxide emission:

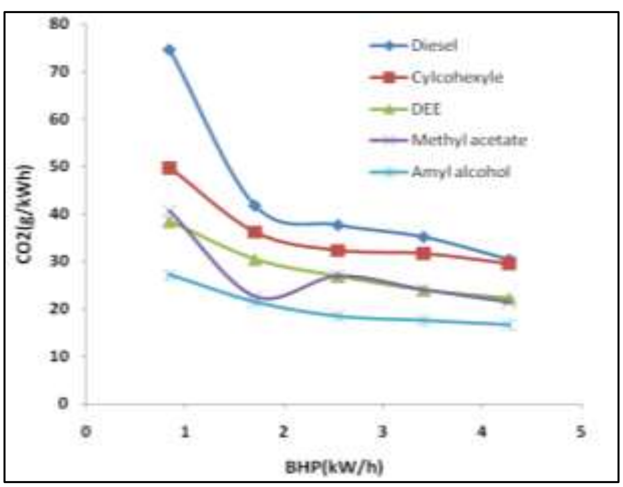

Fig.8: Carbon-di-oxide emissions

The change of amount in carbon-di-oxide with brake power of diesel and different additives is displayed in Figure 8. CO_2 forms when the fuel is burned in the presence of excess air or when the lean mixture is burned. Amyl alcohol finds to be a good additive as it have lower CO_2 emission compared with diesel, DEE, methyl acetate and Cyclohexylamine. The amount of CO_2 formed at different brake power is low when compared with conventional diesel fuel. At 3.4kW, Amyl alcohol produces 17.57g/kWh which is lower than Diesel. At full load conditions, the CO_2 is 16.63g/kWh which is lower than that of Diesel with other additives.

Accumulated Heat Release:

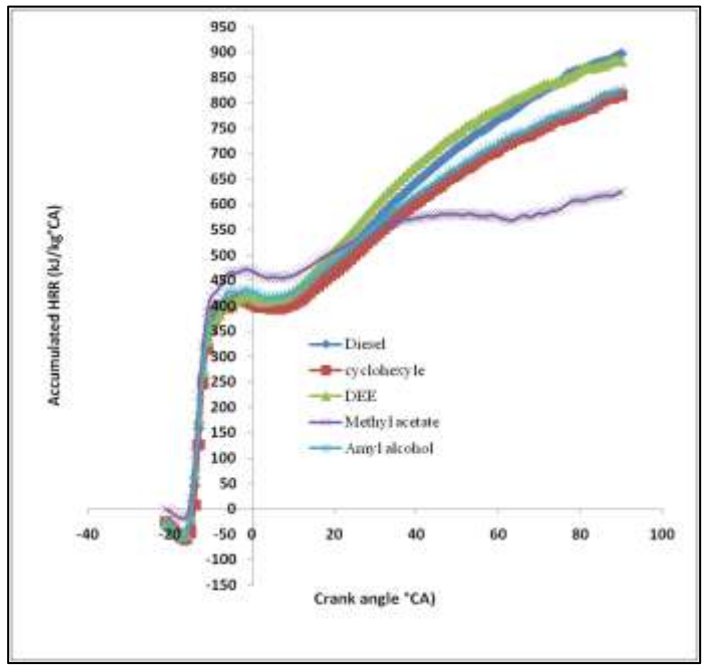

Fig.9. Accumulated heat Release (kJ/° CA)

The contrast curve of accumulated heat release between mixed fuel engine and diesel is illustrated in the figure 9. Accordingly, the cumulative heat release of hybrid fuel engine is higher than that of the diesel. And with diesel fuel content decreases, the accumulated heat release of mixed fuel engine will be reduced, but not very different. This shows that the mixed fuel can be burned more fully than diesel, and its thermal efficiency is higher.

Conclusion:

The performance and emission characteristics of different fuel additives like Methyl acetate (C3H6O2) DEE(C4H10O) and Amyl alcohol (C5H12O) which are having oxygen content which are supporting combustion and NO_x emissions may be higher than that of Diesel. Increasing their concentration with Diesel due to their higher heating capacity HC and CO emissions can be well controlled. However of all these additives Amyl alcohol is a promising additive which may be experimented as sole fuel may yield favorable support along with Diesel in future.

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