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AN EXPERIMENTAL STUDY OF HCCI ENGINE USING VARIABLE INJECTION TIMING AND PRESSURE WITH COMMON RAIL SYSTEM

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ABSTRACT

Homogeneous charge compression ignition is the way of achieving low NOx and soot emission with objectionable increase in Hydro carbon and Carbon mono-oxide emissions. In this study homogeneity of fuel charge is achieved prior to combustion through 4 pulse injection where injected quantity in each pulse remains equal (even mode) with early pilot injection of fuel during compression at 100° BTDC. The scope of this study is to observe effect of injection schedule adjustment (Closer to TDC) and injection pressure on HCCI combustion and emission formation. The experiments were conducted under ECU controlled EGR, intake boost, and exhaust backpressure and injection pressure were varied from 800 to 1400bar. In this whole study, experiments were conducted at constant engine speed 1800rpm to develop 4bar IMEP with constant back pressure in naturally aspirated condition with no EGR.

INTRODUCTION

Gasoline and diesel engines power the majority of ground transportation today. Although similar in the fact that both are reciprocating piston engines, differences between the two exist in the form of power efficiency, fuel economy and emissions. HCCI combustion combines the best features of gasoline and diesel engines to produce diesel-like power efficiency while maintaining gasoline-like soot free emissions within certain operating limits. Advancing pilot injection timing & increase in pilot mass reduces soot, NOx, peak cycle pressure with increase in HC, CO, SFC. The HCCI diesel combustion organized by multiple injection strategy is extremely sensitive to the injection mode. As the pulse number increases, the last pulse mass should be reduced to meet reduced mixing time. With increase in injection pressure increases brake thermal efficiency and decreases engine emission. The peak of cylinder pressure and the pressure rise rate increase slightly as pilot quantity increase. The cycle to cycle variation decreases with the rise of pilot quantity. When the pilot quantity increased further, the cycle to cycle variation starts to increase.

EXPERIMENTAL SETUP

Experiments were carried out in 4cylinder, turbocharged, 2.2L Dicor engine whose details are mention in table 1.An eddy current dynamometer is been coupled to the engine to apply the load on the engine. AVL fuel balancer is used to measure fuel consumption. Emission measurements were done with Horiba (Motor Exhaust Gas Analyzer) Mexa-7100. Chemiluminescence Analyzer-CLA-756 for measurement of NOx in ppm. Flame Ionization Analyzer-FIA-726 for measurement of Hydro Carbon emission in ppm. Non-Dispersive Infrared Analyzer for measurement of CO in ppm, CO_2 in vol%. Smoke Meter (Variable SampleType) gives values in FSN (Filter Smoke Number).

Table.1.Engine Specification

Engine manufacturer	TATA MOTORS	Connecting Rod Length	149 mm
Bore and Stroke	85 (mm)x 96 (mm)	Number of Hole / Diameter	6 (0.142mm)
Number Of Cylinders	4	Cone Angle	153
Compression Ratio	17.2:1	Rated power	105 Kw @ 4000rpm
Cubic Capacity	2.2 litre	Rated torque	320 N-m @1750-2750 rpm
Method of cooling	Water cooled		

RESULTS AND DISCUSSION

Unburnt Hydrocarbon: Fig 1 variation of total unburnt hydrocarbon emission with respect to injection timing and injection pressure. From the graph it is clear that unburnt hydrocarbon emission purely depends on main injection timing i.e hydrocarbon emission decreases with timing the main injection closer to TDC than exactly at TDC. And also for very early and post injection, hydrocarbon emission strictly increasing with injection pressure as shown in graph. For injection closer to TDC there is small variation in HC emission with injection pressure.

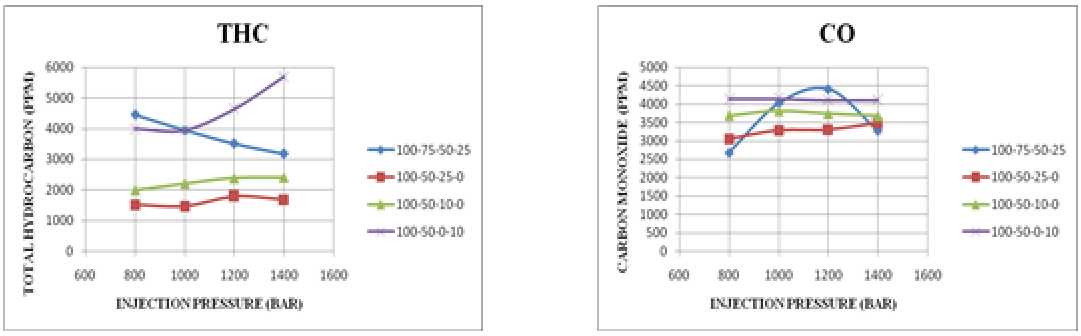

Fig 1,2 variation of HydroCarbon and Carbon Monoxide with injection timing and pressure.

Carbon Monoxide: Fig 2 shows variation of carbon monoxide emission with respect to injection timing and injection pressure. From the graph it is clear that carbon monoxide emission purely depends on time available for miture formation and oxygen concentration. Carbon monoxide emission is observed lower with increased dwell time between each injection there by fuel rich mixtures due to deficiency of oxygen is avoided. Carbon monoxide emission is higher at post injection and injection timed very close to each other i.e dwell time between each injection less than 15°CA.

Smoke: Fig 3 shows variation of smoke with repect to injection timing and pressure. Smoke is observed higher than conventional mode in advanced injection timing (100-75-50-25). This is due to the rise of pilot quantity would have consumed more in-cylinder oxygen, and thus less oxygen is available for main combustion and results in increased smoke. And also mixing time between each pilot quantity is less in (100-75-50-25) when compared to other injection timing. So that graph concludes that smoke emission can be avoided by increasing dwell time between each pilot quanity based on speed and load. Smoke emission decreases with increase in injection pressure due to fine atomization thereby overmixing of fuel is avoided.

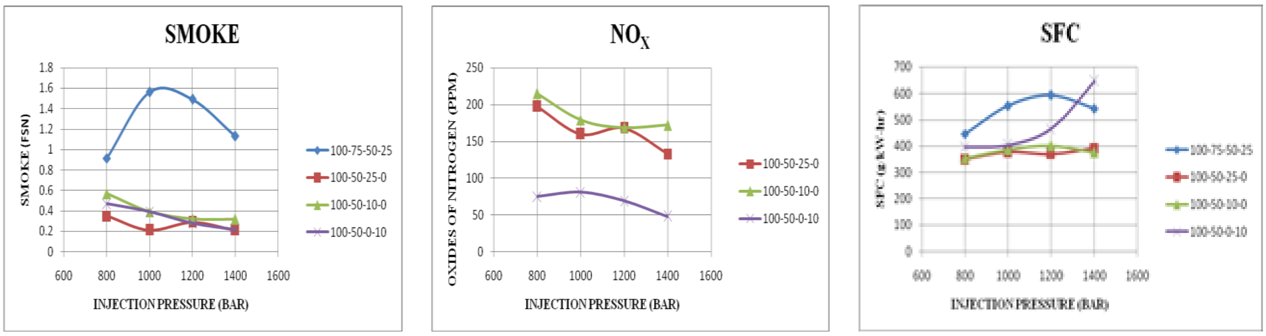

Fig 3,4,5 Variation of Smoke, NO_X and SFC with injection timing and pressure.

Oxides of Nitrogen: Fig 4 shows variation of oxides of nitrogen emission with respect to injection timing and injection pressure. NO_x emission is very high in injection timing (100-75-50-25) than conventional mode hence results are not shown in graph. NO_x emission is purely depends on combustion temperature which in turn depends on premixed combustion intensity and combustion phasing. For earlier injection timing intensity of premixed combustion is higher with absence of diffusion combustion because of accumulated heat release of pilot quantity in premixed combustion contributes for higher NO_x emission. NO_x emission is very low at injection timing (100-50-0-10) due to off-phasing of combustion in early expansion stroke. From the graph it is clear that NO_x emission decreases with increase in injection pressure by reducing physical delay of pilot quantity there by premixed combustion peak is reduced with widened premixed combustion.

Specific Fuel Consumption: Fig 5 shows variation of specific fuel consumption with inection timing and injection pressure. Specific fuel consumption is higher in very early injection timing due to the off-phasing of combustion process before TDC and negative work due to combustion before end of compression stroke. In case of post injection, specific fuel consumption increases with increase in injection pressure due to the fact that fuel injected in post injection are utilized for oxidation of unburnt fuel molecules rather than workoutput contribution. For injection closer to TDC there is no significant varition in SFC with injection pressure.

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CONCLUSION & FUTURE WORK

From the above experimental study optimum results were obtained at injection timing (100-50-10-0) & (100-50-25-0) and injection pressure at 1200 bar. In above stated condition oxides of nitrogen emission and smoke emission observed lower than conventional mode and also specific fuel consumption is closer to conventional diesel mode but little higher. But higher HydroCarbon and CarbonMonoxide emission were observed. So by reducing HydroCarbon and CarbonMonoxide emission of HCCI combustion, it can be effectively used for power generation application. Because of higher load limits of HCCI combustion makes it difficult to implement this combustion concept in automobile application.

Future work is to select suitable EGR (Low Pressure, High Pressure, Hot, and Cold) and Boost (Naturally aspirated, Super Charger, Single Turbo Charger, Twin Turbo Charger) strategies to expand load limit. Selection of suitable fuel blends and fuel reforming techniques which assist and enhances HCCI combustion in DI diesel engine.

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