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EFFECT OF FUEL INJECTION TIMING ON PERFORMANCE, COMBUSTION AND EMISSION CHARACTERISTICS OF C.I. ENGINE FUELLED WITH PALM OIL METHYL ESTER

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ABSTRACT

This paper presents the parametric study on effect of variation of fuel injection timing on performance, combustion and emission characteristics of compression ignition engine fuelled with palm oil methyl ester. During this work, a computer simulation model is used for analysis. The simulation model uses double wiebe's function to compute rate of heat release during premixed as well as diffusive phase of combustion. Effect of advancement and retardation of fuel injection timing by 2 degree crank angle from preset injection timing of 23°btdc on brake thermal efficiency, brake specific fuel consumption, peak cylinder pressure, NO_x emissions and soot density, etc. are predicted and discussed. Variation of fuel injection timing from 23°btdc to 21°btdc and 25°btdc resulted in inferior engine performance, combustion and emission characteristics.

KEY WORDS: Biodiesel, fuel injection timing, simulation, compression ignition engine.

1. INTRODUCTION

The demand for diesel in India during 2006-07 was 52.32 MTs, 66.91MTs during 2011-12 and the projected demand for diesel is 83.58 MTs during 2016-17[1]. India is highly dependent on import of crude oil and has been steadily rising over the years. The transportation sector accounts for almost 50% of the total crude oil consumed [1]. Extensive consumption of the diesel has resulted in continuous increase in its cost, heavy financial burden on economy and increase in air pollution. The Ministry of New & Renewable Energy, GOI made a National Policy on Biofuels for promoting the cultivation, production and use of biofuels in petrol and diesel engine as an alternative for fossil fuels [2]. Use of bio fuels (such as biodiesel) as an alternative to diesel could reduce the dependency on petroleum products and the pollution level, as it is renewable and can be derived from plant species.

The engine performance depends on several factors like fuel properties, the combustion chamber geometry and the injection parameters like injector opening pressure (IOP), fuel injection timing (FIT), etc. Variation of FIT results in variation in air temperature and pressure at the time of fuel injection, the delay period, rate of evaporation of fuel, rate of combustion etc., affecting engine performance, combustion and emission characteristics.

K Muralidharan and P Govindrajan, [3] investigated the effect of injection timing on performance and emissions characteristics of a single cylinder direct injection diesel engine fuelled with pongamia pinnata methyl ester and its blend with diesel from 0% to 30% with increment of 5% ester in diesel at varying loads. The tests were conducted at three different injection timings (19°, 23° and 27° btdc). The experimental work reveled that at advanced timing of 27° btdc the engine performance was better than standard timing of 23° btdc with significant reduction in emissions of HC and CO at all loading conditions. Retardation of injection timing indicated improvement over NO_x and CO_2 emissions for blend B10 over entire range of engine operation. Nwafor. O.M.I [4] investigated effect of variation in injection timing on performance of natural gas fuelled diesel engine. He observed that advanced timing resulted in slight increase in brake specific fuel consumption (BSFC) as compared to standard injection timing of 30° btdc. Advancement of injection timing by 3.5° crank angle resulted in significant reduction in carbon monoxide and carbon dioxide emissions as compared to standard timing. A.S. Ramadhas [5] developed a theoretical zero-dimensional model having single wiebe function with assumed adjustable parameters to predict the performance of engine fuelled with rubber seed oil.

As the experimental investigation for estimation of engine performance is costly and timing consuming, a simulation model may be used as a tool for speedy at low cost analysis. Hence a computer simulation model is used for analysis of effect of change in FIT on performance, combustion and emission characteristics of diesel engine fuelled with palm oil methyl ester (POME). During this work, FIT is changed from 21° btdc to 25° btdc in the step of 2° CA.

2. SIMULATION

In present analysis, a simulation model based on first law of thermodynamics developed by author of this paper in his previous work [6] is used. Suitable correlations are established between adjustable parameters of double wiebe's function, relative air-fuel ratio, IOP, FIT and engine operating conditions, so that the simulated cylinder pressure matches closely with the experimental results. Double wiebe function is used for predicting the rate of heat release during premixed and diffusion phase of combustion separately [7]. The molecular formulae for diesel and POME are approximated to $C_{10}H_{22}$ for and $C_{19}H_{34}O_2$ respectively. This model simulates the compression and expansion process with ideal gas equation and polytropic process. An ignition delay is computed using an empirical formula developed by Hardenberg and Hase[8]. The heat transfer is calculated based on Hohenberg's equation [9]. NO_x formation has been predicted using zeldovich mechanism explained by Turns [10]. The model predicts peak cylinder pressure, combustion temperature, brake thermal efficiency, brake specific fuel consumption, exhaust gas temperature and emissions like nitric oxide and soot density for neat POME (P100). Basic engine geometry and fuel properties used for present analysis are indicated in table 1 and 2 respectively.

Table No.1

Parameter	Specification
Type	Four stroke direct injection single cylinder VCR diesel engine
Software used	Engine soft
Injector opening pressure	200 bar
Rated power	3.5 kW @1500 rpm
Cylinder diameter	87.5 mm
Stroke	110 mm
Compression ratio	17.5:1
Injection timing	23 degree before TDC

Table.No.2

Properties	Diesel (D0)	POME (P100)
Viscosity in cst(at 30°C)	4.25	4.7
Flash point(°C)	79	170
Fire point(°C)	85	200
Carbon residue (%)	0.1	0.62
Calorific value(kj/kg)	42000	36000
Specific gravity (at 25°C)	0.830	0.870

3. RESULTS AND DISCUSSION

3.1 Effect of Injection Timing on

(i) Performance parameters.

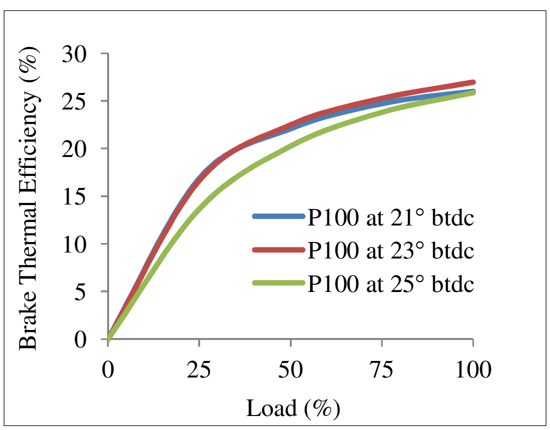

Figure: 1 Variation of brake thermal efficiency at Different fuel injection timing

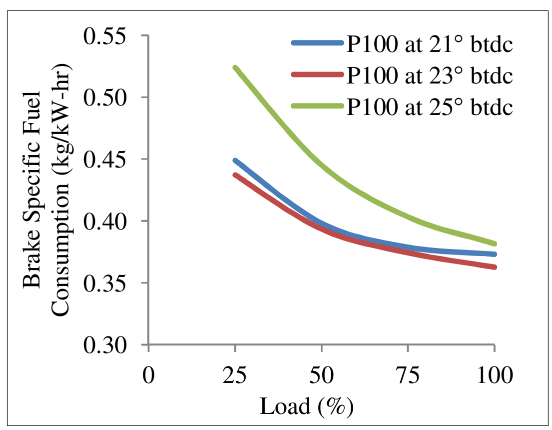

Figure: 2. Variation of brake specific fuel consumption at different fuel injection timing

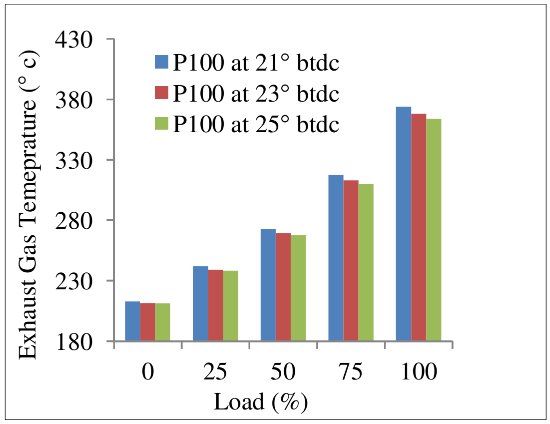

Figure: 3 Variation of exhaust gas temperature at Different fuel injection timing

Figure 1, 2 and 3 shows variation of brake thermal efficiency, brake specific fuel consumption and exhaust gas temperature at various fuel injection timings. Reduction in brake thermal efficiency (BTE) is observed at 21°btdc and 25° btdc injection timings as compared to standard injection timing of 23° btdc. However, reduction in BTE is lower with retarded timing. Similar trend has been observed with BSFC. The Exhaust gas temperature (EGT) is increased with retarded timing due to late start of combustion and more heat release during diffusion phase of combustion. Advancement of FIT resulted in lower EGT due to earlier start of combustion and earlier occurrence of point of peak pressure and peak rate of heat release, etc.

(ii) Combustion Parameters

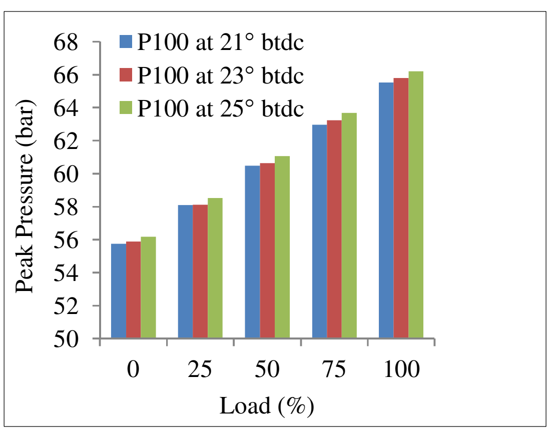

Figure: 4 Variation of peak pressure at different Fuel injection timing

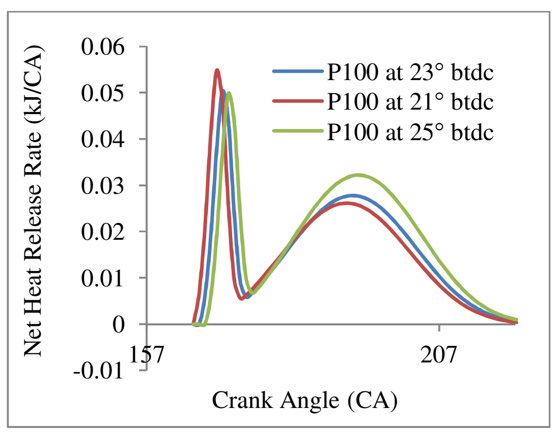

Figure: 5 Variation of heat release rate at different Fuel injection timing

Figure 4 and 5 shows variation of peak pressure and net rate of heat release with change in fuel injection timing. Advancement in FIT shows increase in peak pressure due to longer ignition delay period; earlier start of injection of fuel and injection of more quantity fuel during delay period, etc. increase in maximum rate of net heat release and shifting of point of peak heat release rate earlier during compression is also observed with advanced injection timing. Retardation of FIT from rated value resulted in lower peak pressure and net rate of heat release. Also, with retarded injection timing, occurrence of peak heat release rate observed to be late in the cycle. This may be due to combined effect of late injection and shorter delay period, etc.

(iii) Emission Parameters

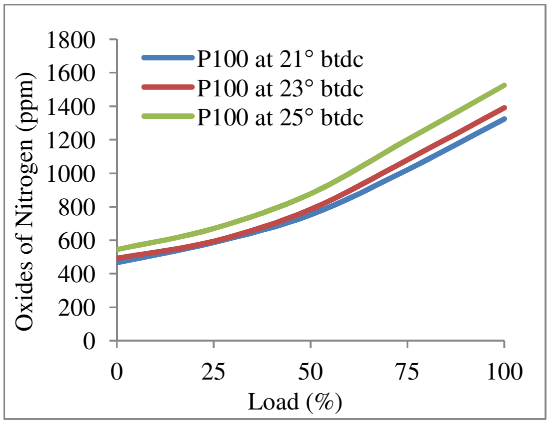

Figure: 6 Variation of oxides of nitrogen at different Fuel injection timing

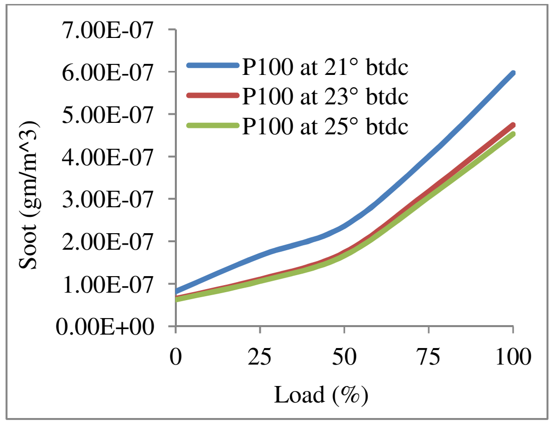

Figure: 7 Variation of soot density at different fuel injection timing

Figure 7 and 8 shows variation of nitric oxide and soot density at various fuel injection timings. The advancement in injection timing shows reduction in soot density due to availability of sufficient time for combustion. Whereas, retardation of injection timing shows increase in soot density due to incomplete combustion of fuel, slow and late combustion and reduction in highest local peak temperature, etc. The nitric oxide emissions are higher with advanced timing and lower with retarded timing as compared to rated FIT.

4. CONCLUSION

From the results of computer simulation model and experimental results following conclusion are drawn.

- Advancement and retardation of FIT resulted in lower BTE and higher BSFC.
- Reduction in EGT at advanced FIT of 25° btdc and increase in EGT at 21° btdc is observed.
- Advanced injection timing resulted in higher peak pressure and net rate of heat release.
- The simulation results are found to be in closer approximation with experimental results.

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