

# Effect of Injection Timing on Compression Ignition Engine Fuelled with Thevetia Peruviana Biodiesel

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**ABSTRACT:**In the present study an experimental work had been carried out to analyse the performance and emission characteristics of various blends of ThevetiaPeruviana biodiesel by varying injection timings. The engine tests are conducted on kirloskar, 4-stroke, single cylinder, 1500 rpm, water cooled, direct injection, diesel engine with eddy current dynamometer with standard injection pressure 230 bar and injection timing 23°BTDC was maintained constant throughout the experiment. 3 different injection timings such as 20°BTDC, 23°BTDC and 26°BTDC varied to analyse the performance and emission characteristics. From the test results, it could be observed that among 3 different injection timings 26°BTDC gives higher efficiency and lower emissions as compared to other two injection timings.

**KEYWORDS:**Blends, Compression Ignition, Emission, Timing, Performance.

## I. INTRODUCTION

Increasing petroleum prices, increasing threat to the environment from exhaust emissions and global warming have generated interest in developing alternative non-petroleum fuels for engines. The use of vegetable oil in engines is not a recent innovation [1]. In the present scenario, oil has become a finite resource and its price tends to increase exponentially, as its reserves are fast depleting. Recent report says that lower smoke levels and higher thermal efficiencies are offered more by the methyl ester of vegetable oils than neat vegetable oils [2]. Further, it has been reported that the thermal efficiency of the engine increases with an increase in the methanol fraction in diesel. Intensive research is going on throughout the globe for a suitable diesel substitute [3]. In this race among different alternatives, vegetable oils have attained primary place as some of their physical, chemical and combustion related properties are nearly similar to that of diesel fuel [4]. Vegetable oils can be used directly or can be blended with diesel to operate compression ignition engines [5]. ThevetiaPeruviana grows mainly in jungle area and also in waste and uncultivated land its cultivation would not produce any impact on food production but would in long way improve the environmental condition by massive afforestation. ThevetiaPeruviana oil is non-edible vegetable oil, which is available in large quantities in India. In a country like India it is observed that biodiesel can be a viable alternative automotive fuel [6]. Biodiesel is a fastest growing alternative fuel and India has better resources for its production. The vegetable oils cannot be used directly in diesel engines as alternative fuel because of high viscosity of vegetable oils leads to problem in pumping and spray characteristics [7]. The best way to use vegetable oils as fuel in diesel engines is to convert it into biodiesel. It is a fact that biodiesel is a safer, more economical and infinitely more environmentally friendly than the conventional petroleum diesel that the majority of people currently use [8].

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Pradeep et al. [1] studied influence of injection timing on emission parameters of Adelfa biodiesel (Nerium oil methyl ester – NOME) fuelled DI CI engine. In that work, transesterified Adelfa oil (Nerium oil methyl ester – NOME) was used as the test fuel and the results were compared with diesel fuel. The injection timing was retarded to 24°BTDC and advanced to 30°BTDC and 33°BTDC. Results showed that, for all load conditions and for all injection timings the brake thermal efficiency was found to be maximum at three fourth of load condition. The maximum efficiency was obtained with diesel fuel to a value 25.608%. The decrease in the efficiency were found to be 11.71%, 3.71% and 3.87% when the injection timings were 24°BTDC, 27°BTDC and 33°BTDC. The brake thermal efficiency was found to be 25.502% when the injection timing was 30°BTDC.

Prabhakar et al. [2] studied optimization of esters of Nerium biodiesel in a diesel engine. In this work, methyl and ethyl esters of Nerium oil were prepared by transesterification using both methanol and ethanol. The Nerium oil blends were prepared in the proportion of 20%, 40%, 60%, 80% and 100% with diesel. Results showed that, the brake thermal efficiency was highest with diesel in all loads. The maximum efficiency was obtained for methyl esters of Nerium oil (MEON) blends compared with ethyl esters of Nerium oil (EEON) blends.

Suresh et al. [3] studied performance and emission evaluation of a DI diesel engine using Nerium oil as alternative fuel. In this work, the performance and emissions characteristics were evaluated on single cylinder four stroke water cooled diesel engine which was capable of developing a power output of 7.5 kW at 1500 rpm fuelled with 20%, 30% and 40% of Nerium oil blended with diesel. Results showed that, the blends of Nerium oil showed lowest specific fuel consumption than diesel at part loads. Mechanical efficiency for NO 30 was higher compared to diesel fuel. Brake mean effective pressure was also increased as the percentage of the Nerium oil increases with the diesel. The volumetric efficiency was raised as the blend of Nerium oil increases in the diesel.

Lalvani et al. [4] studied DI diesel engine with renewable biodiesel – Adelfa. In this work, Adelfa oil methyl esters (AOME) were prepared using transesterification process and tests had been carried out in direct injection single cylinder diesel engine with their blends such as AOME 10, AOME 20, AOME 30, AOME 40 and AOME 100. Results showed that, diesel showed the superior brake thermal efficiency on all loads. Brake thermal efficiency of the engine was reduced by increased blend ratio of Adelfa biodiesel with diesel.

John et al. [5] studied performance, emission and combustion parameters of a direct injection diesel engine using Eucalyptus and Nerium biodiesels as fuel. In this work, an experimental investigation on the performance, emission and combustion characteristics of two different biodiesels – Nerium and Eucalyptus biodiesel, in a single cylinder direct injection diesel engine. Both Nerium and Eucalyptus biodiesels were blended separately with diesel fuel 30% by volume (N30 and E30) and the various characteristics were studied. Results showed that, maximum BTE of the engine using diesel was observed to be around 28.6%. There was a marginal decrease in the BTE of nearly 6.9% while using E30 blend as the fuel. The BTE of the engine for N30 fuel blend was found to be further lower than that of both diesel and E30 blends.

Harari et al. [6] studied effect of nozzle hole geometry on compression ignition engine fuelled with Thevetia Peruviana biodiesel and found that, among three different nozzles 5 hole nozzle gives higher thermal efficiency as compared to 3 and 4 hole nozzles.

Tyagi et al. [7] conducted experiments on neem methyl esters as biodiesel on CI engine. In this work, different blends proportion such as 10:90, 20:80, 30:70 are used to run a single cylinder CI engine. Results showed that, specific fuel consumption at different loads for all percentage of blends was found slightly decreased. As the brake power increased specific fuel consumption was decreased for all the blends. It was found that, B20 was having lower specific fuel consumption than all other blends. The BTE of B10 was very close to diesel and BTE of B20 fuel was better than B10 due to more oxygen content. The BTE of B30 was found slight dropped because improper combustion due to higher viscosity than B10 and B20 fuels.

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Jogdhankar et al. [8] conducted experiments on alternative fuels and performance of CI engine running on neem oil and biodiesel blends. In this work, different blends of neem oil-diesel and neem biodiesel-diesel in varying proportions (10%, 20%, 30% by volume) were prepared. Tests were conducted at different injection pressure such as 200 bar and 220 bar. Results showed that, at higher loads the BTE of N20 was slightly higher than diesel and low for N10. The blends B10 and B20 shows slightly higher BTE at high loads followed by B30 and diesel. It can be concluded that, the blend B20 at 220 bar injection pressure can be used as an alternative fuel to diesel.

Yadav et al. [9] conducted experiments on performance parameters of single cylinder four stroke DI diesel engine operating on neem oil biodiesel and its blends. In this work, experiments were carried out to analyze the performance of different blends 20%, 50%, 100% of neem oil biodiesel. Results showed that, the BSFC and BSEC were higher and BTE was less for biodiesel, when compared to diesel fuel. The BSEC was increased by 0.60% to 8.25% and BTE was decreased by 0.57% to 7.62% at 12 kg engine brake load as compared to diesel fuel. BSFC for biodiesel was increased by 2.5% to 19.5% than that of diesel fuel for B20, B50 and B100 blends at 12 kg engine brake load.

Nithyananda et al. [10] conducted experiments on performance study on diesel engine using different blends of neem biodiesel. In this work, different blends of neem biodiesel-diesel were prepared such as (10%, 20%, 30%, 40% and 50%). The tests were carried out on single cylinder water cooled diesel engine using different blends of neem biodiesel at variable loads. Results showed that, neem blends B10 and B20 have specific fuel consumption close to diesel. The blend B50 shows higher SFC than other blends at all loads. Blend B50 shows the minimum BTE at full load. It can be concluded that, B20 blend can be used as alternative fuel without any engine modification.

## 1.1. Objectives

- ❖ To study ThevetiaPeruviana blends in single cylinder diesel engine as an alternative fuel.
- ❖ To increase the Brake Thermal Efficiency (BTE) and reducing emissions of diesel engine.
- ❖ To study the best suitable injection timing for existing engine in terms of performance and emissions.

## II. METHODOLOGY

- ❖ Collection of raw oil of ThevetiaPeruviana.
- ❖ Transesterification reaction to convert raw oil into biodiesel.
- ❖ Prepare blends with diesel such as B0, B10, B20, B30, B40, B50.
- ❖ Determine fuel properties such as Density, Kinematic viscosity, Flash point, Fire point, Calorific value.
- ❖ Single Cylinder, Water Cooled, 4-Stroke, 1500 RPM, 5.2 kW, 230 bar Injection Pressure, 23° BTDC Injection Timing, Hemispherical Combustion Chamber, 3 Hole Nozzle, 17.5:1 Compression Ratio engine is used for the study.
- ❖ Change the injection timings such as 20° BTDC, 23° BTDC, 26° BTDC.
- ❖ Determine performance and emission characteristics Brake Thermal Efficiency, Brake Specific Fuel Consumption, Total Fuel Consumption, HC, CO, NO<sub>x</sub>, Smoke emissions.
- ❖ Compare the results and find the optimum injection timing for engine.

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## 2.1. Properties of fuels

Table 1 Properties of fuels

Property	B0	B10	B20	B30	B40	B50
Density (kg/m <sup>3</sup> )	829	835	839	841	843	846
Viscosity at 40°C (CSt)	3.52	3.76	3.96	4.09	4.22	4.71
Flash Point (°C)	53	68	77	81	83	87
Fire Point (°C)	59	75	86	89	92	95
Calorific Value (MJ/kg)	42.19	41.82	41.45	41.18	40.92	40.31

## III. EXPERIMENTAL SETUP

A single cylinder, direct injection, four-stroke, water cooled, Compression Ignition (CI) engine is used in the experimental study. The fuel flow rate was measured by noting down the time taken for the consumption of a known quantity of fuel (10cc) from a burette. The viscosity of raw as well as esterified oil was measured by red wood viscometer, density by hydrometer, calorific value by bomb calorimeter, flash and fire point by open cup method. Initially, before starting experimental tests, the engine was made to run under ideal condition as warm up phase and then the tests were conducted. The engine was started and allowed to warm-up for about 10 minutes. The engine was tested under five discrete part load conditions i.e. 20%, 40%, 60%, 80% and 100%.

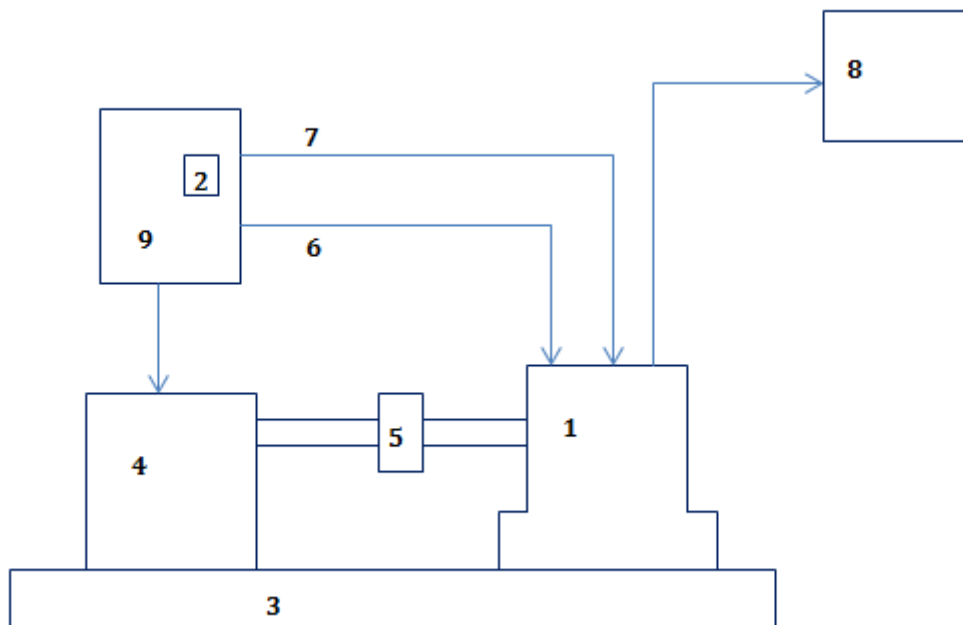


Fig 1 Experimental Setup

1-Diesel engine, 2-Burette for fuel measurement, 3-Base, 4-Dynamometer, 5-Coupling, 6-Air supply line, 7-Fuel supply line, 8-Exhaust gas analyzer, 9-Control panel.

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### 3.1. Engine specifications

Table 2 Engine parameters

Engine Parameter	Specifications
Engine Type	Kirloskar
No. of Strokes	4
No. of Cylinders	1
Type of Cooling	Water Cooling
Type of Injection	Direct Injection
Bore	87.5 mm
Stroke	110 mm
Compression Ratio	17.5:1
Rated Power	5.2 kW
Rated Speed	1500 rpm
Injection Pressure	230 bar
Injection Timing	26° BTDC

### 3.2. Changing injection timing

The fuel injection timing can be varied by adjusting shims provided between fuel pump and engine body which is as shown in Fig 3.



Fig 2 Shims arrangement in engine

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Fig 3 Photographic view of shims

## IV. RESULTS AND DISCUSSIONS

### 4.1. Brake thermal efficiency

Among all the blends tested B0 blend gives higher brake thermal efficiency because of higher calorific value of the B0 blend. Among different injection timings tested 26°BTDC gives the higher brake thermal efficiency because with the advancing in injection timing from 20°BTDC to 26°BTDC there is much time availability for the mixing of fuel and air and hence brake thermal efficiency increases.

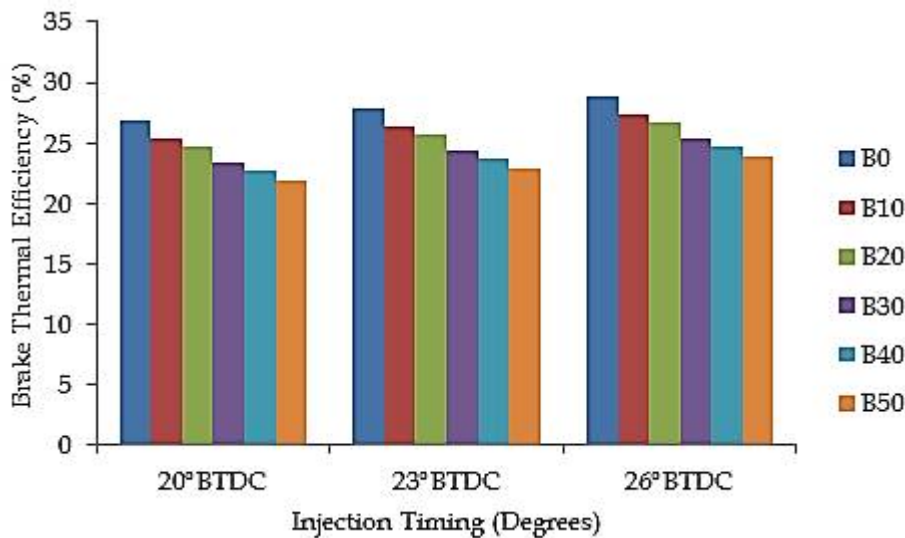


Fig 4 Variation of brake thermal efficiency with injection timing

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## 4.2. Brake specific fuel consumption

Among all the blends tested B0 blend gives lower brake specific fuel consumption because of lower viscosity of the B0 blend. Among different injection timings tested 26°BTDC gives the lower brake specific fuel consumption because with the advancing in injection timing from 20°BTDC to 26°BTDC there is much time availability for the mixing of fuel and air and hence brake specific fuel consumption decreases.

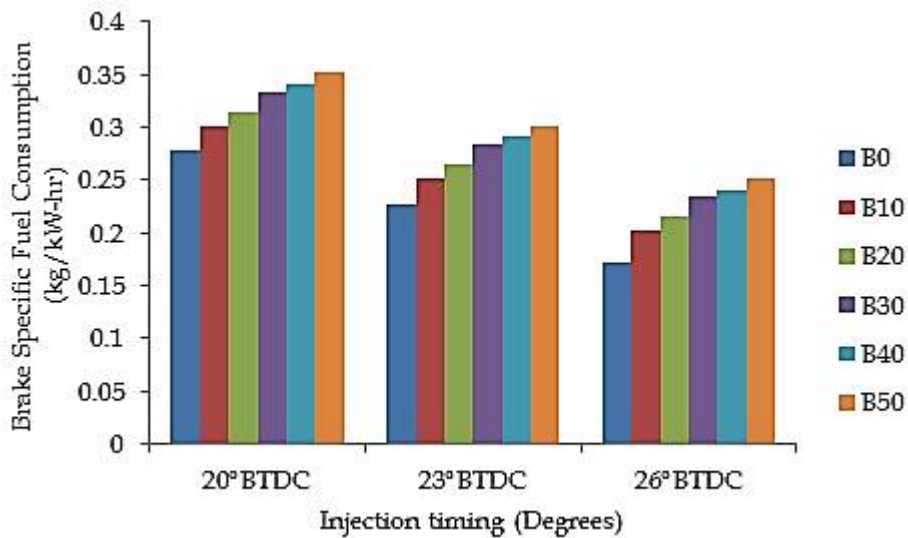


Fig 5 Variation of brake specific fuel consumption with injection timing

## 4.3. Total fuel consumption

Among all the blends tested B0 blend gives lower total fuel consumption because of lower viscosity of the B0 blend. Among different injection timings tested 26°BTDC gives the lower total fuel consumption because with the advancing in injection timing from 20°BTDC to 26°BTDC there is much time availability for the mixing of fuel and air and hence total fuel consumption decreases.

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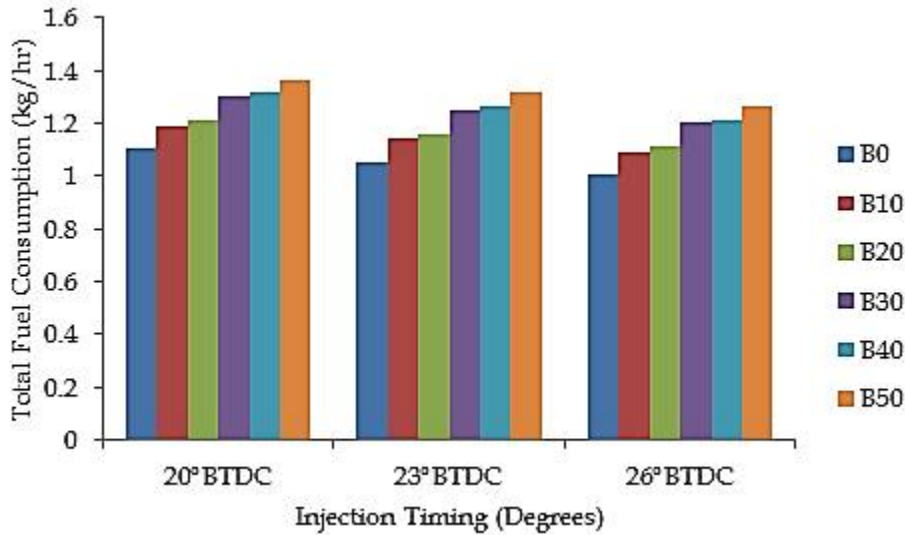


Fig 6 Variation of total fuel consumption with injection timing

## 4.4. Hydrocarbon emissions

Among all the blends tested B0 blend gives lower HC emissions because of better mixing of the B0 blend with the air. Among different injection timings tested 26° BTDC gives the lower HC emissions because with the advancing in injection timing from 20° BTDC to 26° BTDC there is much time availability for the mixing of fuel and air and hence HC emissions decreases.

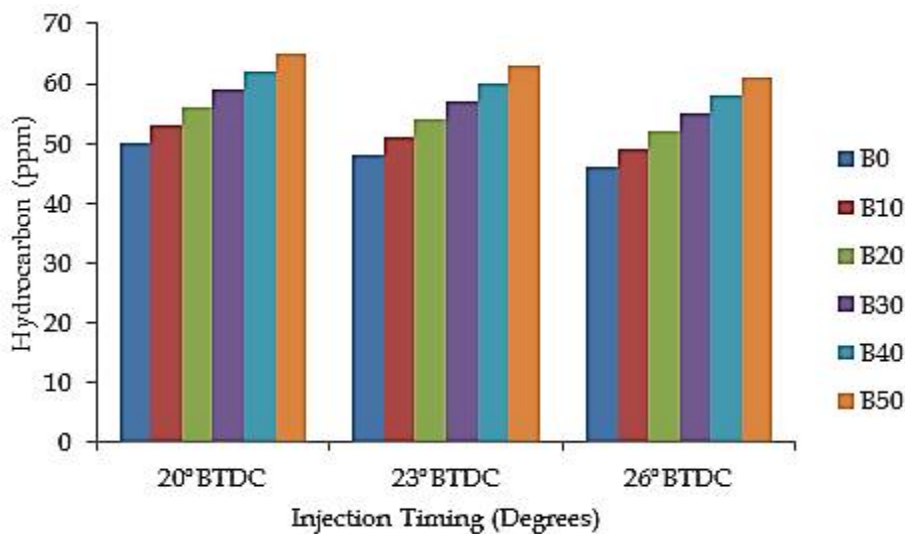


Fig 7 Variation of hydrocarbon emissions with injection timing



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## 4.5. Carbon monoxide emissions

Among all the blends tested B0 blend gives lower CO emissions because of better mixing of the B0 blend with the air. Among different injection timings tested 26°BTDC gives the lower CO emissions because with the advancing in injection timing from 20°BTDC to 26°BTDC there is much time availability for the mixing of fuel and air and hence CO emissions decreases.

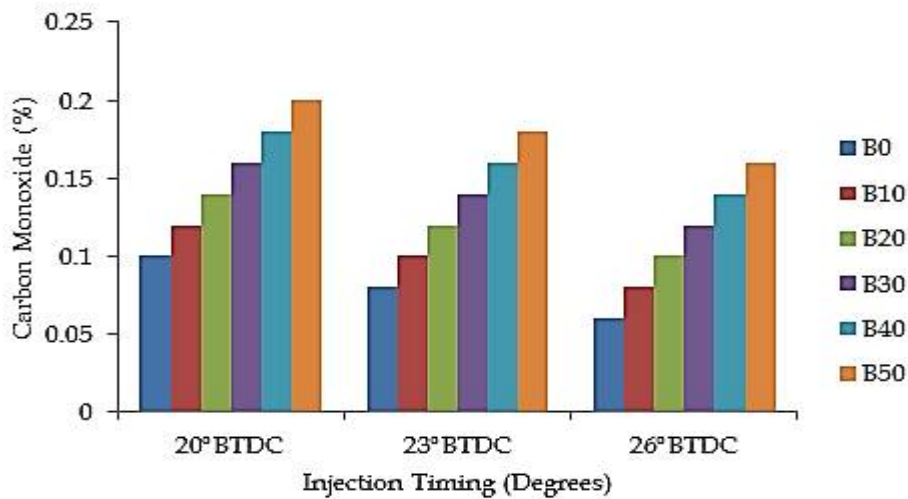


Fig 8 Variation of carbon monoxide emissions with injection timing

## 4.6. Nitric oxides emissions

Among all the blends tested B0 blend gives higher NOx emissions because of higher calorific value of the B0 blend. Among different injection timings tested 26°BTDC gives the higher NOx emissions because with the advancing in injection timing from 20°BTDC to 26°BTDC there is much time availability for the mixing of fuel and air and hence NOx emissions increases.

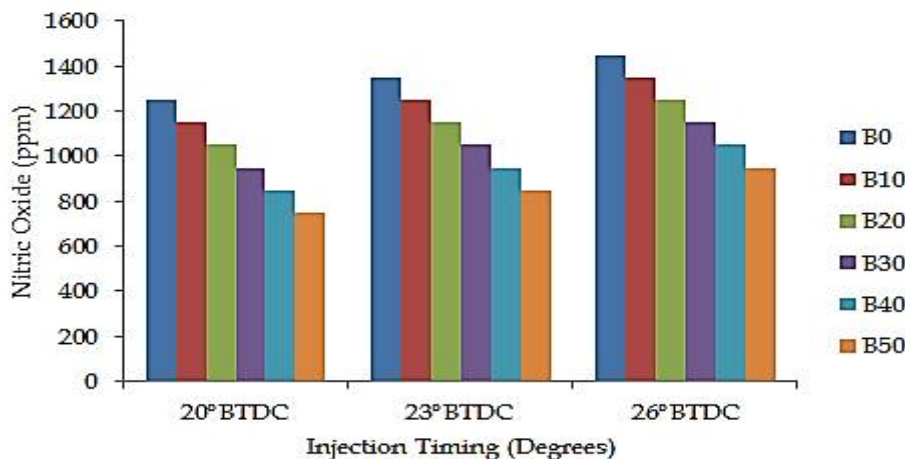


Fig 9 Variation of nitric oxide emissions with injection timing

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## 4.7. Smoke emissions

Among all the blends tested B0 blend gives lower smoke emissions because of better mixing of the B0 blend with the air. Among different injection timings tested 26°BTDC gives the lower smoke emissions because with the advancing in injection timing from 20°BTDC to 26°BTDC there is much time availability for the mixing of fuel and air and hence smoke emissions decreases.

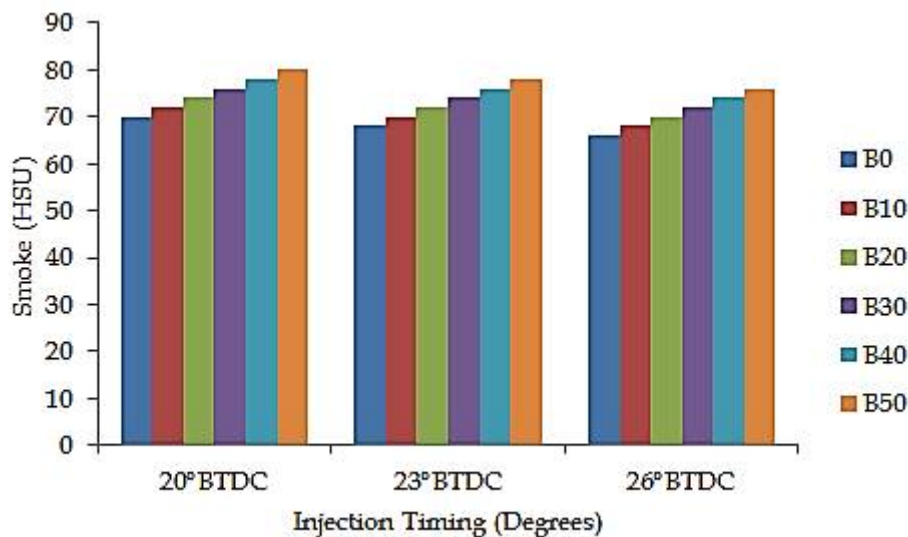


Fig 10 Variation of smoke emissions with injection timing

## V. PROJECT OUTPUT

- ❖ ThevetiaPeruviana biodiesel can be successfully used in diesel engines.
- ❖ ThevetiaPeruviana biodiesel can partially replace for diesel fuel successfully.
- ❖ By changing injection timing we can increase the Brake Thermal Efficiency (BTE) and reduce emissions.

## VI. CONCLUSIONS

- ❖ The brake thermal efficiency for 26°BTDC injection timing was found to be higher as compared to other injection timings.
- ❖ Brake specific fuel consumption for 26°BTDC injection timing was found to be lower as compared to other injection timings.
- ❖ Total fuel consumption for 26°BTDC injection timing was found to be lower as compared to other injection timings.
- ❖ Hydrocarbon and carbon monoxide emissions for 26°BTDC injection timing were found to be lower as compared to other injection timings.
- ❖ Nitrogen oxide emissions are lower for 26°BTDC injection timing was found to be higher as compared to other injection timings.
- ❖ Smoke emissions for 26°BTDC injection timing were found to be lower as compared to other injection timings.
- ❖ Hence 26°BTDC injection timing is recommended for existing diesel engine.
- ❖ Among the biodiesel blends tested, B10 and B20 gave the best performance with reduced emissions.
- ❖ Hence B10 and B20 blends are recommended for existing diesel engine.

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