FUELLING DIESEL ENGINE WITH DIESEL, LINSEED DERIVED BIODIESEL AND ITS BLENDS AT DIFFERENT INJECTION PRESSURES: PERFORMANCE STUDIES

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Abstract:

Due to rapid depletion of fossil fuels and environmental concerns, the use of biodiesel is rapidly expanding around the world, making it imperative to fully understand the impacts of biodiesel on the diesel engine combustion process and pollutant formation. In the Indian context linseed can play an important role in the production of alternative diesel fuel. The climatic and soil conditions of India are convenient for the production of linseed (Linum Usitatissimum) crop.

In the paper Bio-diesel is prepared from core linseed oil by transesterification process. The performance study of a diesel engine with diesel and linseed based biodiesel were carried out at different injection (170 bar, 190 bar and 210 bar) pressures. Fuel characteristics (density, calorific value, viscosity and flash point), engine performance characteristics have been investigated and significant improvements were observed.

The results confirm that when compared to neat diesel fuel, biodiesel also gives similar thermal efficiency.

Keywords: Bio-diesel, Linseed oil, thermal efficiency, volumetric efficiency, blend

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Introduction:

Biodiesel, "The mono alkyl esters of long chain fatty acids derived from renewable lipid feedstock, such as vegetable oils or animal fats for use in compression ignition (diesel) engines", is made by Transesterification of linseed oil.

The trend of Biodiesel is being practiced all over the globe. In most European countries the production of Biodiesel is from sunflower and rapeseed whereas in USA it is produced from soybean. Thailand uses palm oil as a raw material for the production of Biodiesel, while Ireland uses frying and animal fats [1]. India is facing a shortage of edible oil in not meeting the demand.

Fuel injection pressures in diesel engine plays an important role for engine performance treatment of combustion. The present diesel engines such as fuel direct injection, the pressures can be increased to about 100 – 210 bars in fuel pump injection system. Experiments were conducted to assess effects of fuel injection pressure on engine performance. Naga Sarada et al concluded that the best performance of the pressure injection can be obtained at 220 bars, specific fuel consumption has been obtained at 200 bars for fixed load - variable speeds and at 180 bars for variable loads – fixed speed [2].

The major problem with the direct use of vegetable oils as fuel into CI engines is their higher viscosity. This property in vegetable oils can be overcome by techniques such as heating of fuel lines, transesterification, modification of injection system etc. Tests were conducted with cotton seed oil and diesel. To improve the combustion characteristics of cotton seed oil in an unmodified engine, effect of increase in injection pressure was studied. When the injection pressure was increased from 180 bars to 240 bars (in steps of 15 bar), the investigation revealed that the optimum pressure for cottonseed oil as 210 bars. Performance comparison of the engine was studied in terms of brake specific fuel consumption, brake thermal efficiency, indicated thermal efficiency, mechanical efficiency and exhaust emissions [3].

Suryawanshi et al. examine the effects of steam injection into the intake manifold of a single cylinder, low speed, and direct injection diesel engine fuelled with biodiesel palm methylester. [4].

Nurun Nabi et al. studied the blends of varying proportions of Honge Oil Methyl Ester and diesel to run a double cylinder CI engine and observed significant improvements in engine performance and emission characteristics. The thermal efficiency of the engine was improved, and emission of smoke was reduced [5].

Sippy Kalra Chauhan showed that biodiesel gives almost similar thermal efficiency, lower carbon monoxide (CO) and particulate matter (PM) while slightly higher nitrogen oxide (NOx) emission was experienced when compared with neat diesel fuel [6].

The advantage of biodiesel over gasoline and petroleum/diesel is its eco-friendly nature. This article reviews the production, characterization and current status of bio-fuels mainly biodiesel along with the environmental impacts of particulate matter, greenhouse gas emissions originated from biodiesel [7].

Roman et al. suggested that biodiesel with high levels of methyl oleate will have excellent, if not optimal, characteristics with regard to ignition quality, NOx emissions and fuel stability. Additionally, it has been estimated that biodiesel fuels with an average of 1.5 double bonds per molecule will produce an equivalent amount of NOx to conventional diesel, thus a fuel high in oleates (one double bond per molecule) should not result in higher Nox emissions [8].

2. Preparation of biodiesel from the linseed:

2.1. Properties of Linseed oil/ fat

The Iodine Value: 168-204, CN: 34.6, HG: 39307kJ/kg, Viscosity: 27.2 mm^2/s (38°), CP: 1.7°C, PP: -15.0°C and FP: 241°C.

Figure-1: Linseeds

2.2. Laboratory Procedures for the Production of Linseed Biodiesel

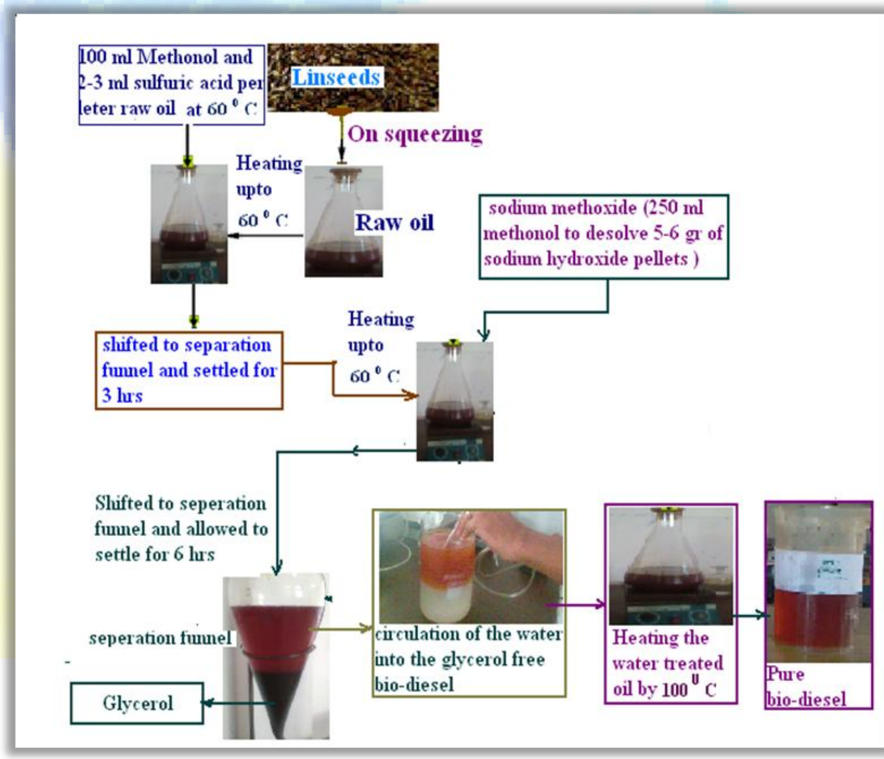

Figure-2: Transesterification process of bio-diesel.

Linseeds are shown in Figure-1 and the production of biodiesel (methyl ester) by transesterification is shown in the Figure-2. First oil is produced by using the press machine squeezing the Linseed. Normally there are different kinds of production of oil from their seeds. The oil produced by this mechanism has some residues remained with it, and then it requires some filtration using filter. Therefore the oil has been filtered.

The following steps are required to prepare biodiesel from raw oil:

A. Acid treatment followed by settling process
B. Base treatment followed by settling process
C. Water washing
D. Dehydration

A. Acid treatment

Raw oil is heated up to 60 ^{0} C and 100ml methanol and 2-3 ml of sulphuric acid is added. Settling is carried out in decanter for 3 Hrs. Pulp is separated from the oil. Figure-3 shows the raw oil heating.

Figure-3: Linseed raw oil on heater with magnetic stirrer

B. Base treatment

Base treatment is carried out at 60 ^{0} C. In this process a mixture of methanol and sodium hydroxide (Sodium methoxide) is added to the acid treated oil. . For the preparation of the sodium methoxide, 250 ml methanol is used to dissolve 6-7.5 grams of sodium hydroxide pellets. It is an exothermic reaction.

Figure-4: Separations of biodiesel and glycerol

Separation of biodiesel and glycerol takes place by gravity. The black part is glycerol in the separation funnel as shown in the Figure-4. Settling is carried out in the decanter for 6 Hrs and the settled glycerol will be drained out.

C. Water washing

The base treated oil is washed with the distilled water bye circulating of air by air motor. Wash the oil till the oil and water are clear.

D. Dehydration process

Dehydration is carried out at 100 ^{0} C and the biodiesel is obtained.

2.3. Blending

Figure-6: Blends of Biodiesel and diesel

The blends of varying proportion of cotton seed, coconut oils and diesel were prepared, analyzed and compared with diesel fuel. From properties and engine test result it can be established that two oils can be substituted for diesel without any engine modification and without preheating of the blends. The various blends are 25% alternative oil and 75% diesel, 75% alternative oil and 25% diesel, 50% alternative oil and diesel 50% pure alternative oil.

2.4. Experimental setup

A single cylinder 4-stroke water-cooled diesel engine having 5 HP as rated power at 1500 rpm was used for the research work and the setup is shown in Figure-7. The engine was coupled to an electrical dynamometer for loading it. A photo sensor along with a digital rpm indicator was used to measure the speed of the engine. The fuel flow rate was measured on volumetric basis using burette and a stopwatch. Thermocouples in conjunction with a digital temperature indicator were used for measuring the engine and exhaust gas temperatures.

Figure-7: Experimental setup

3. Results and discussions

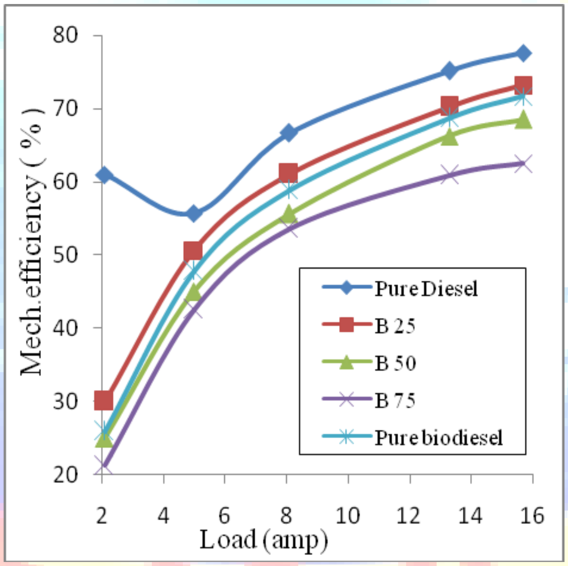

Fig 8: Mechanical efficiency at 170 bar pressure

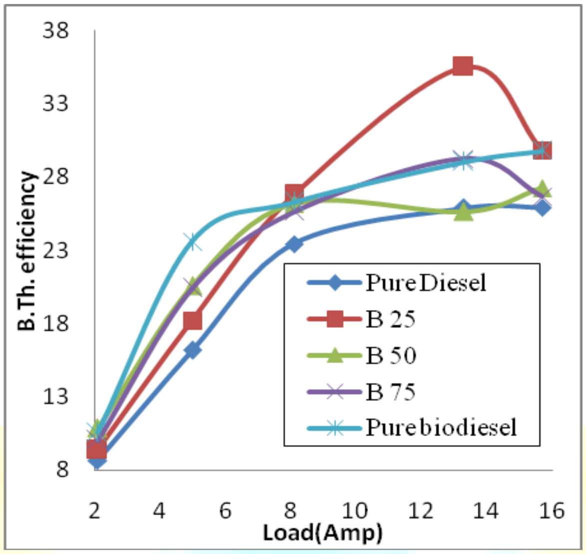

Fig 9: Brake thermal efficiency at 170 bar pressure

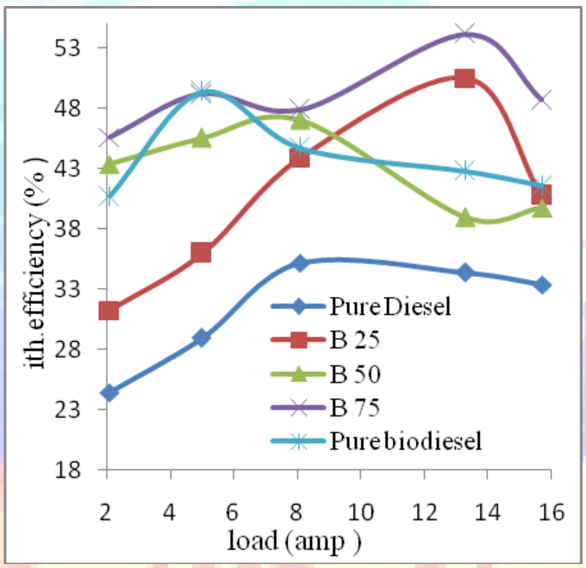

Fig 10: Indicated thermal efficiency at 170 bar pressure

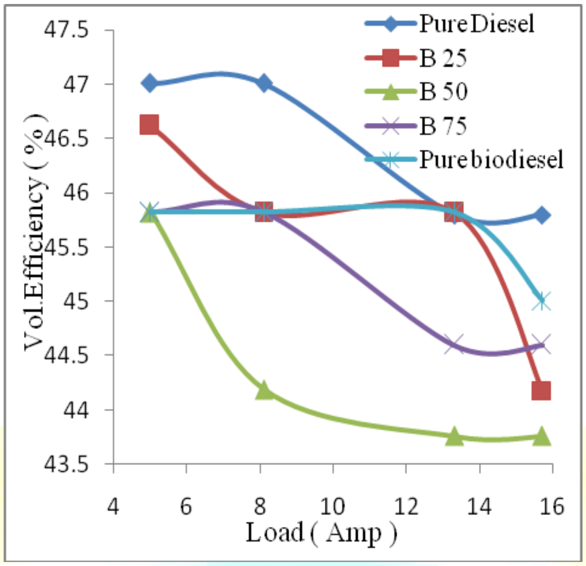

Fig 11: Volumetric efficiency at 170 bar pressure

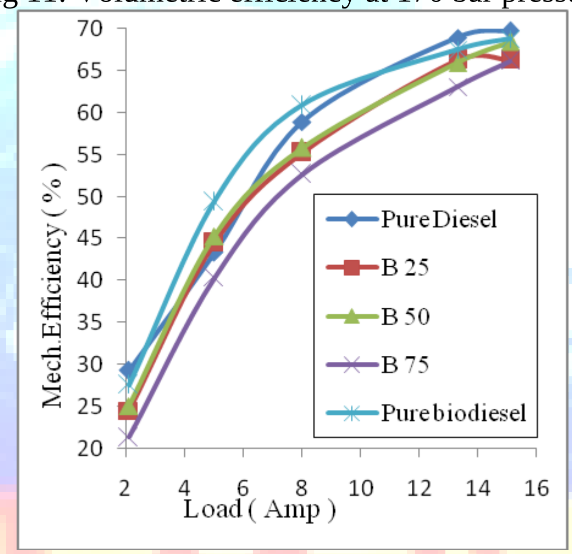

Fig 12: Mechanical efficiency at 190 bar pressure

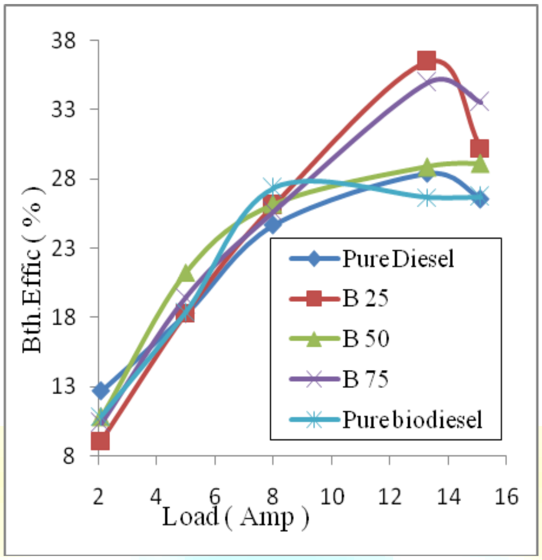

Fig 13: Brake thermal efficiency at 190 bar pressure

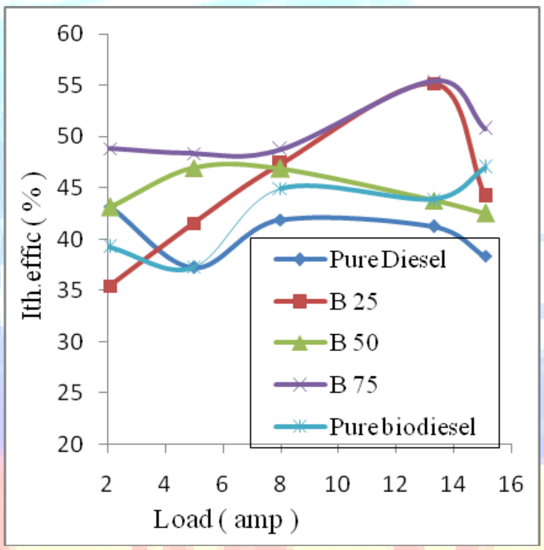

Fig 14: Indicated thermal efficiency at 190 bar pressure

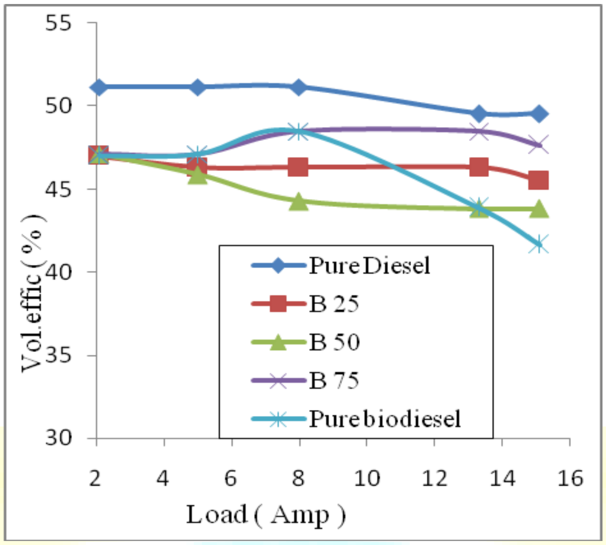

Fig 15: Volumetric efficiency at 190 bar pressure

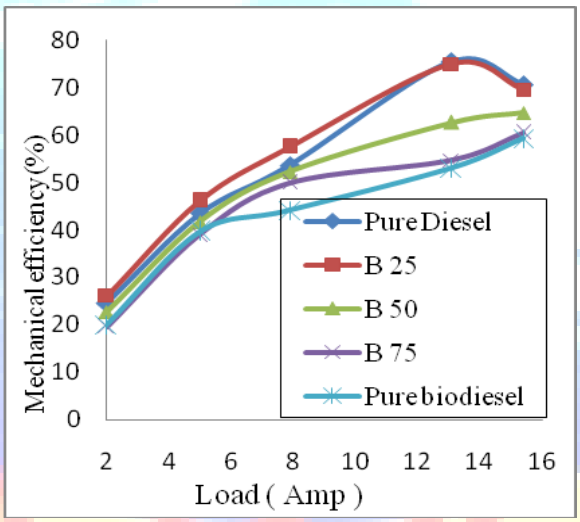

Fig 16: Mechanical efficiency at 210 bar pressure

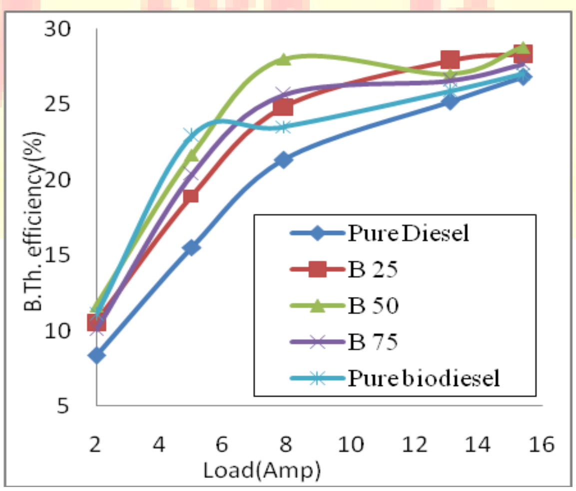

Fig 17: Brake thermal efficiency at 210 bar pressure

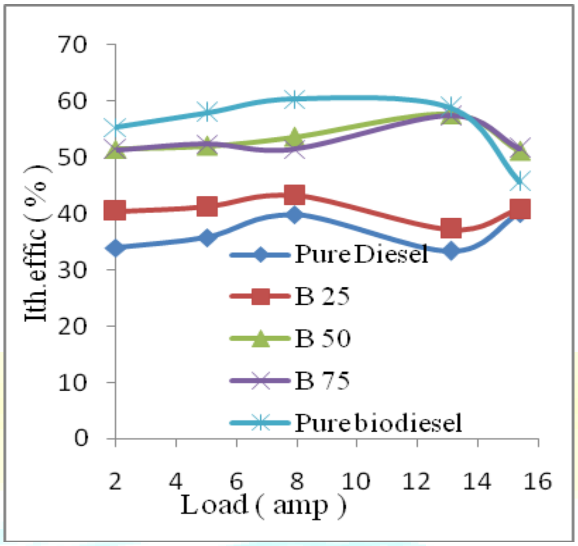

Fig 18: Indicated thermal efficiency at 210 bar pressure

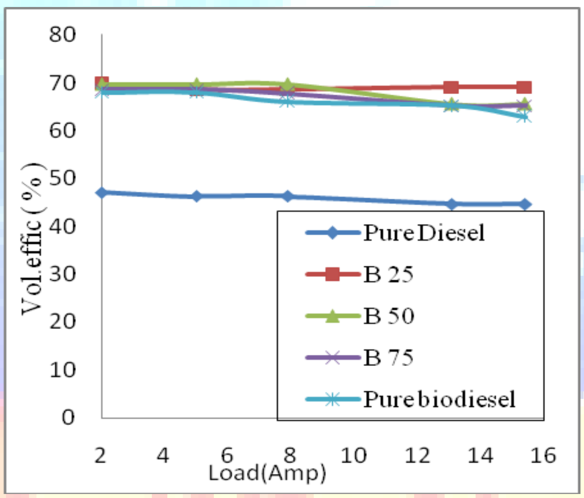

Fig 19: Volumetric efficiency at 210 bar pressure

The mechanical efficiency at the injection pressure of 170 bar and when fueled with pure diesel is very near to that of B25 biodiesel and the variation in mechanical efficiency between pure biodiesel and pure diesel is limited to 21 percent as in the Fig 8. From Fig 9 it is evident that the brake thermal efficiency of the engine, fueled with pure B25 biodiesel blend is more than that of diesel fuel at 170 bar pressure. Also the brake thermal efficiency of the pure diesel is less than all biodiesel blends at 170 bar pressure.

The pure diesel results in poor indicated thermal efficiency of the engine compared to the all the tested blends of biodiesel as in the Fig 10 , at the pressure of 170 bar Also when the engine is fueled with B 75, it is Higher than that diesel fuel and also pure biodiesel at 170 bar pressure. The Fig 11, is the replica of the variations in the volumetric efficiency of the engine .The volumetric efficiency is maximum when the engine is fueled with pure diesel and is minimum when it is fueled with B50 biodiesel blend at 170 bar pressure.

The blends B25 and B50 are results in approximately same mechanical efficiency of the engine at the injection pressure of 190 bar and the trends are shown in Fig 12, At the same injection pressure (190 bar), When the engine is fueled with pure biodiesel, the brake thermal efficiency is slightly more than that of diesel fuel. Interestingly the brake thermal efficiency of the engine, when fueled with B 25 is maximum as given in the Fig 13

At the injection pressure of 190 bar and at all the tested load conditions the indicated thermal efficiency of the engine, when fueled with pure biodiesel is more compared to the case with diesel fuel. The Fig 14 shows the deviation of the indicated thermal efficiency, But the B75 is resulting in the maximum indicated thermal efficiency at 190 bar pressure. The Fig 15 shows that the volumetric efficiency of the engine, fueled with pure biodiesel is so less than that of diesel fuel at 190 bar pressure

The selected engine is also tested at an injection pressure of 210 bar. In the aspect of mechanical efficiency the B 25 is resulting in good value at this pressure. Also as shown in the fig 16, the mechanical efficiency of the engine when fueled with pure biodiesel is less than that of diesel fuel at 210 bar pressure. Compared to all the blends and the pure biodiesel the brake thermal efficiency of the pure diesel is comparatively low at this pressure condition the trend is shown in the Fig 17. also it is evident that the brake thermal efficiency of the engine when fueled the B 75 is maximum at this injection pressure.

On comparison at the injection pressure of 210 bar the indicated thermal efficiency of the engine, when fueled with the pure biodiesel is more than the case when it is fueled with pure diesel fuel, as in the Fig 18. At this injection pressure the volumetric efficiency of the engine, when fueled with the pure biodiesel has given a positive sign as it more than that of pure diesel fuel as the trend shown in the Fig 19. But at the same pressure the B25 is giving the maximum volumetric efficiency and it is almost constant at all loads.

CONCLUSIONS

The experiments are conducted for diesel and pure biodiesel and for different blends at various loads and the following conclusions arrived at:

- The engine performance parameter brake thermal efficiency is found increasing in the order 170-210-190 bar injection pressure running with pure biodiesel.
- No appreciable change in mechanical efficiency at 170 bar,190 bar and 210 bar when the engine is fuelled with B25 blend
- At 210 bar the volumetric efficiency is more for the biodiesel and for all its blends compared to diesel.
- With local availability of the fuel it is favorable to adopt in the economic point of view

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