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Experimental Investigation of CI Engine Performance and Emissions of Soap Nut Seed Oil as Biodiesel

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ABSTRACT

The developing enthusiasm for biodiesel owing to the closeness in its properties in contrast with those of diesel energizes. Diesel motors worked on biodiesel have lower emissions of carbon monoxide gas, hydrocarbons, particulate, and air toxics than once worked on petroleum-based fuel. Biodiesel, a promising substitute as an option fuel has increased huge consideration because of the anticipated shortness of traditional fuels and ecological concern. In the present study soap nut seed oil is used as biodiesel. The soap nut seed oil is changed over into soap nut oil methyl ester known as biodiesel. The physical properties of soap nut seed oil, for example, density, flash point, Calorific value etc., were nearer to the diesel. This oil is blended with the diesel as proportions of S5, S10, S15 is tested at constant speeds in the diesel engine. Performance and emissions are calculated for these blends of soap nut seed oil. There is a little improvement in results using the blends and the emissions are also low compared to the diesel. The qualities got from the soap nut oil methyl ester is firmly coordinated with the estimations of routine diesel and can be utilized as a part of the current diesel motor with no adjustment.

Keyword: Soap nut seed oil, Transesterification, Performance, Emission,

1. INTRODUCTION

In recent years The world is presently confronted with double crises of fossil fuel depletion and environmental degradation and also the costs are mounting day by day With increasing concern regarding fuel shortage and pollution management, analysis on rising and reducing exhaust emissions has become the key topic in combustion and engine studies demand increased attributable to the restricted supply of fossil fuels. The high cost of petroleum items is a major sympathy towards the country economy [1]. An intensive seek for new different fuels because of depleting fossil fuel reserves and increasing price of the fossil fuel merchandise, has nearly reached the wide unfold use of bio -fuel and this was restrained from its use in CI engine [2].The necessary benefits of utilising the biodiesel are its renewability, higher quality exhaust gas emissions, biodegradability; it doesn't contribute to an increase within the level of greenhouse gases within the atmosphere. Biodiesel is that the promising possibility as different fuels for internal combustion engines (edible or non-edible feedstock).Biodiesel are outlined because the mono-alkyl esters with long chain of fatty acids derived from the vegetable oils, animal fats or waste oil. Biodiesels are promptly offered with nontoxic, non-flammable, renewable and additionally eco-friendly. Biodiesel have some similarity as compared to the crude diesel. The foremost necessary advantages of biodiesel are biodegradability, higher flash point and improved cetane number and reduced emissions. They are free from sulphur and aromatic substance so it reduces air pollution like carbon dioxide, hydrocarbons etc..;. Thus therefore it is the perfect fuel for future and is so gaining attention of the world [3].

Biodiesels derived from vegetable oil and animal fats is being employed in country like USA and Europe to scale back the pollution and fuel utility. In USA and Europe, the surplus edible oils like soya bean oil, Linseed oil, sunflower oil, rapeseed oil are getting ready for the assembly of biodiesel [4][5]. Since India is net merchant of

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vegetable oils, eatable oils can't be utilized for creation of biodiesel. India can possibly be a main world maker of biodiesel, as biodiesel can be reaped and sourced from non-consumable oils like Jatropha Curcas, rapeseed, Pongamia Pinnata, Neem (Azadirachta Indica), Mahua, castor, linseed, Kusum (Schlechera trijuga), and so forth. Some of these oils delivered even now are not being appropriately used. Out of these plants, India is concentrating on Jatropha Curcas and Pongamia Pinnata, which can develop in parched and Bad Lands. Oil content is around 30-40% in the Jatropha and Pongamia seed. India has around 80-100 million hectares of no man's land, which can be utilized for Jatropha and Pongamia ranch. India is one of the biggest maker Neem oil and its seed contains 30% oil quantity. It is an unexplored source in India. Implementation of biodiesel in Republic of India can cause several advantages like the barren lands can be covered green, support to agriculture and rural economy and reduction in dependence of the foreign petroleum and there will be reduction in air pollution[6][7].

Using biodiesels as a bit of diesel motors is not another thought, Rudolph Diesel showed his initially created pressure ignition (CI) diesel motor utilizing nut oil as a fuel at the World Exhibition at Paris in 1900. However because of copious supply of diesel and vegetable oil energizes were more costly than diesel back then and the examination action and improvements on vegetable oil were not genuinely taken. There is a restored enthusiasm for vegetable oil in this decade when it was decisively acknowledged as petroleum fills are declining speedier and need of ecological neighbourly renewable substitutes must be found.

Therefore, the world of analysis on biodiesel is gaining a lot and a lot of interest as an alternative fuel for the reason of depleting fossil fuel and environmental degradation. Biodiesel that has combustion characteristics almost like diesel and biodiesel blends has higher ignition temperature and pressure , shorter ignition delay still as peak heat unharness when put next to diesel oil . Moreover, the brake power efficiency and engine power output was found to be nearer to diesel fuel. Diesel and biodiesel blends will scale back smoke opacity, un-burnt hydrocarbons and greenhouse emission however nitric monoxide emissions have slightly enlarged. The most disadvantages of biodiesel is their high viscosity and low volatility, that cause poor combustion in diesel engines together with formation of deposits and widget cocking due to poor atomization injection into the combustion chamber. By transesterification, of the oil reduces viscosity and will be range closer to that of diesel and therefore improves combustion. Feedstock costs represent an expansive part of the direct biodiesel creation costs, including capital cost and return [8].

Soapnut oil was found to have normal of 9.1% free FA, 84.43% triglycerides, 4.88% sterol and 1.59% others. Jatropha oil contains around 14% free FA, roughly 5% higher than soap nut oil. Soapnut oil biodiesel contains roughly 85% unsaturated FA while jatropha oil biodiesel was found to have around 80% unsaturated FA. Oleic corrosive was observed to be the overwhelming FA in both soap nut and jatropha biodiesel. More than 97% change to FAME was accomplished for both soap nut and jatropha oil [9]. In this present study soap nut seed oil is used as biodiesel and the performance and emissions are calculated and compared with diesel.

2. MATERIALS AND METHODS

2.1. Soap nut

The soap nut tree is used for multiple applications like rural building construction and oil and sugar presses, and agricultural implements would facilitate community biology to provide a lot of seeds as potential sources for the biodiesel feed-stock. Among others, the plant grows okay in deep loamy soil and leached soils so cultivation of soap nut in such soil avoids potential erosion. Soap nut may be a fruit of the soap nut tree usually found in tropical and sub-tropical climate areas in numerous components of the planet together with Asia, America and Europe. 2 totally different species (Sapindus mukorossi and genus Sapindus trifoliatus) area unit wide accessible in India, Nepal, Bangladesh, Asian nation and plenty of different countries. The oil from soap nut has been thought-about as a non-edible oil having a big potential for biodiesel production from the fabric that otherwise may be a waste product [9].

Soapnut has many applications from healthful treatments to soap and chemical agent. It has huge amount of surfactant, so soap nut fruit shells are in use as natural laundry detergents from history for laundry materials, bathing and ancient medicines [10].

2.2. Oil Extraction

Oil extraction is of two types by mechanical and by chemical process. Firstly from the nearby market get the soap nut and remove the kernel from the soap nut and clean it with hot water. After the seeds are dried to remove the moisture and the seed coat is removed from the seed and the pulp is powdered. Then the powder is dried in the presence of sunlight or use oven to remove any remaining moisture from it and taken to the oil extracting machine [11]. By utilizing the mechanical procedure for 100gm of powder the oil separated is 35ml. By chemical method i.e. soxhlet apparatus using n-hexane of 250ml with the 100gm powder for 6 hours yields the oil of 43ml [12].but the chemical used is costly though it is yielding more so, the mechanical process is better.

2.3. Transesterification

Transesterification is otherwise known as alcoholism. It is the reaction of fat or oil with alcohol to form esters and glycerol. A catalyst is utilized to boost the reaction rate yield. Among these methods transesterification process is the best process to produce the cleaner and environmentally safe form of vegetable oils. In this work a catalyst (NAOH) was used for converting soap nut oil which is a non-edible oil was used for the synthesis of biodiesel. The oil is mixed vigorously with methanol and catalyst (1%) at a ratio of 1:6 oil to methanol at a time interval of 45min to 1h and response temperature of 55-65° C are required for fulfilment of response and development of individual esters using the magnetic stirrer. After that proportion there is a reverse reaction so the above proportion is chosen [13].

The mixture was mixed constantly and afterward permitted to settle under gravity in a separating funnel. There will be two particular layers structure after gravity settling for 24 h. The upper layer was of ester and lower layer was of glycerol. The lower layer was isolated out. The isolated ester was blended with some warm water (around 10 % volume of ester) to evacuate the catalyst present in ester and permitted to settle under gravity for another 24 h. The catalyst got broke up in water, which was isolated and expelled the dampness. The methyl ester was then mixed with mineral diesel in different focuses for planning biodiesel mixes to be utilized as a part of CI motor for directing different motor tests [6, 13].

2.4. Blending

After transesterification the oil which we get has still higher viscosity to reduce it the next step is blending. By blending the oil can be handled easily it is the main purpose to reduce the volatility. In order to evaluate the biodiesel

(a) (b)

Figure 1: (a) Mixing the oil using magnetic stirrer (b) Phase separation

Table 1
Properties of Biodiesel [15]

PROPERTIES	DIESEL	SOAPNUT OIL
Density (Kg/m^3)	813	903
Calorific Value (kJ/Kg)	42000	38171
Kinematic Viscosity (cSt)	2.88	5.16
Flash Point (^oC)	78	236
Fire point (^oC)	83	238

in the CI engine, various blends of Soap nut seed oil and the conventional diesel has been prepared by mixing with the different amounts of diesel and biodiesel [14, 15]. In this study the blends of S5, S10, and S15 were prepared for testing.

2.5. Experimental Setup

The test motor utilized was the Kirloskar, single cylinder four-stroke water cooled diesel motor creating 3.68 kW at 1500 rpm. The point by point specialized details of the standard motor are given in the table II. This motor was coupled to a swirl current dynamometer with a control framework. The heap and speed can be changed on the dynamometer and in this manner on the motor by exchanging on or off the heap resistances [17]. The adjustment in voltage and current at individual burdens has been watched utilizing sensors put at proper areas. The stream rate of fuel is figured by method for a burette and a stop watch. An advanced tacho meter is utilized to record the motor velocity. The fuel infusion framework utilized is with fuel injector worked at spout opening. UBHC and CO were measured utilizing an INDUS 5 gas analyser model PEA 205. All the tests were led at three distinctive motor loads alongside no heap as far as mean viable weight. The motor kept running with no obvious issue all through the tests and it did not demonstrate any beginning challenges when fuelled with biodiesel-diesel mixes. Every one of the information were gathered after the motor was balanced out. This information were then examined from the charts including BSEC, BTE, indicated thermal efficiency (ITE), mechanical effectiveness and exhaust emissions for all the fills at various loads.

Figure 2: Blends of Soap nut oil

Table 2
Specification of tested Engine

ENGINE SPECIFICATION	
Manufacturer and model	Kirloskar India, AV1
Engine Type	4stroke,single cylinder
Maximum power output	3.68 KW
Rated Speed	1500 rpm
Bore	80mm
Stroke	110m
Compression ratio	16:1
Orifice diameter	20mm
Dynamometer	Electrical type
Method of start	crank start
Type of cooling	Water cooling
Type of ignition	compression Ignition

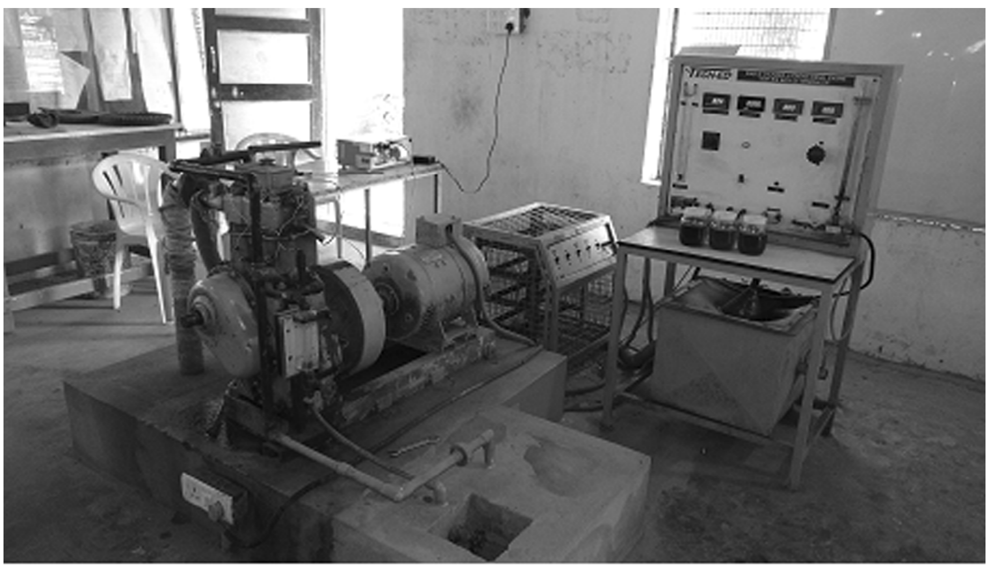

Figure 3: Engine with Gas analyser

3. RESULTS AND DISCUSSIONS

The progression of engine test were completed utilizing diesel and biodiesel to discover the impact of different mixes on the execution and discharge attributes of the engine. Examinations are done on the engine principally to contemplate the impact of specific fuel consumption, brake thermal efficiency, and exhaust gas temperature and emissions such as CO, HC, and CO_2. The specific fuel consumption was observed that the decrease from 0.5 to 0.3 kg/kW-hr at varying loads in the range of 1.2 – 3.7 BkW.

3.1. Performance

In Figure 4, shows the variation of brake specific fuel consumption of various blends of Soapnut seed oil and diesel at different loads. From the readings it is found that the fuel consumption for S15 is close to diesel. However the other blends of soap nut seed oil is found to be high at all loads compared to the diesel. It is because of the increase in the calorific value in the blends. The difference of brake thermal efficiency of the engine at different loads with respect to brake power of various blends is shown in the figure 5, is compared with the brake thermal efficiency of the diesel. It is observed that the values of blends are lower compared with the diesel. Within the blends S15 at load 2kW having much similar to the diesel while the other blends have less. Similar to the mechanical efficiency the thermal efficiency of diesel is higher than the blends somehow the S5, S15 at different loads are comparable to the diesel. The Fig 6, shows the variation of mechanical efficiency and brake power. Mechanical potency is the live of effectiveness of a machine that converts energy and power as input into the force and movement of a tool as output .The mechanical efficiency of blends S5, S10, S15 are lower compared to the diesel whereas the S15 blend is nearer to the diesel. The Fig 7 shows the variation of brake power to the Indicated thermal efficiency. The amount of power developed within the cylinder or the facility exerted on the piston defines indicated power and also the magnitude relation of indicated power to fuel power provides ITE.

3.2. Exhaust Emissions

The output from the CI motors i.e., emissions for example, CO, CO2 and o2 were measured and investigated. As the blends and diesel is tested in the diesel engine the emissions are collected from the gas analyser. The

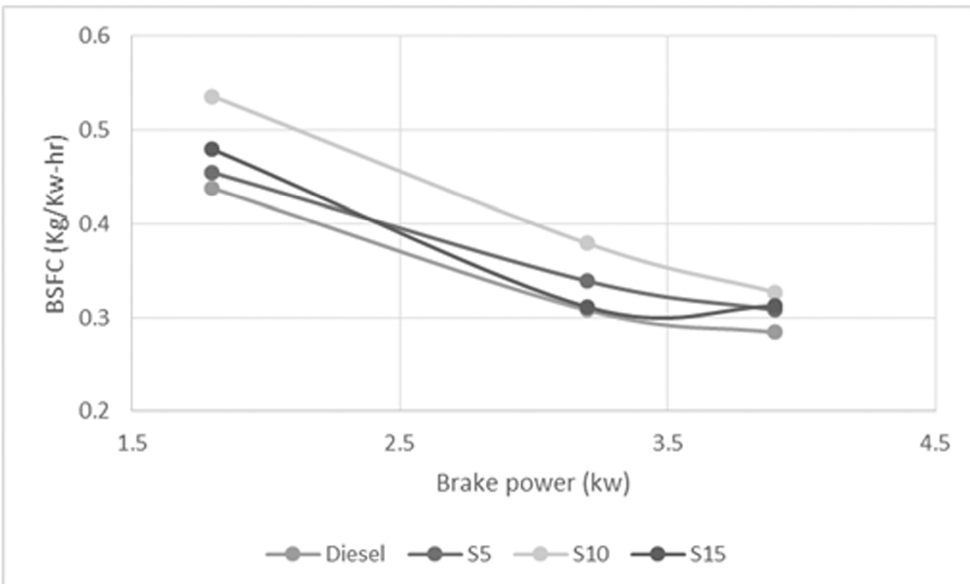

Figure 4: Variation of Brake Specific Fuel Consumption with Brake Power.

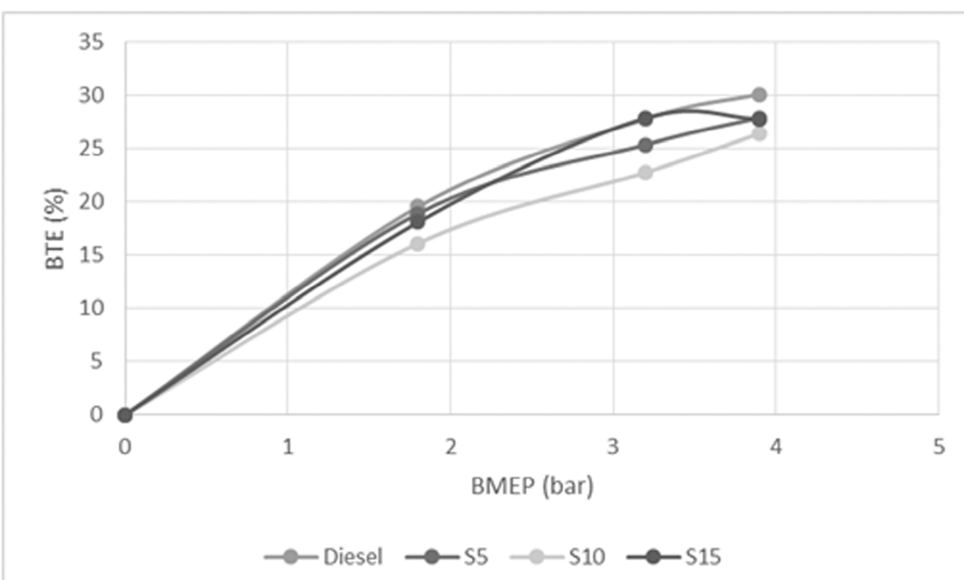

Figure 5: Variation of Brake thermal efficiency with Brake Power.

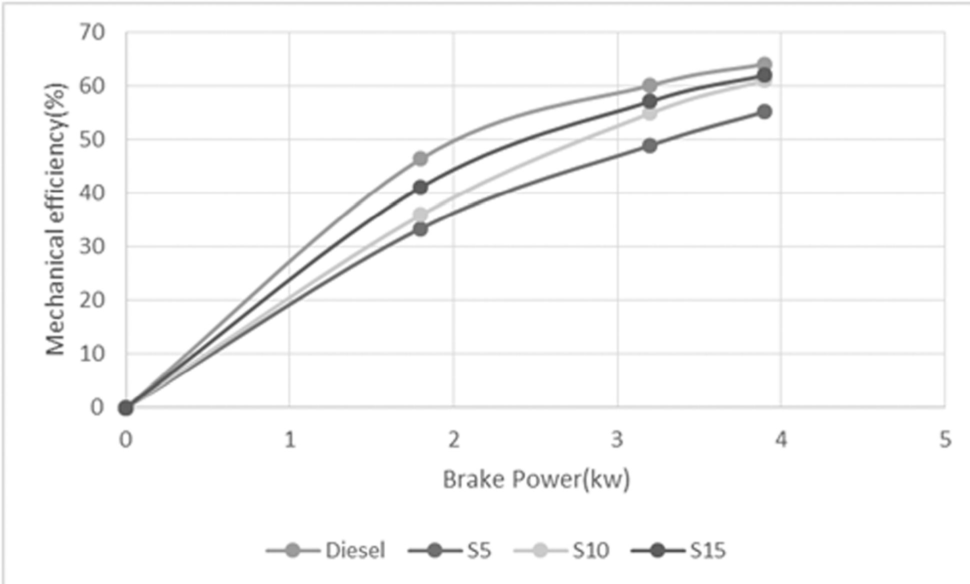

Figure 6: Variation of Mechanical efficiency with Brake Power.

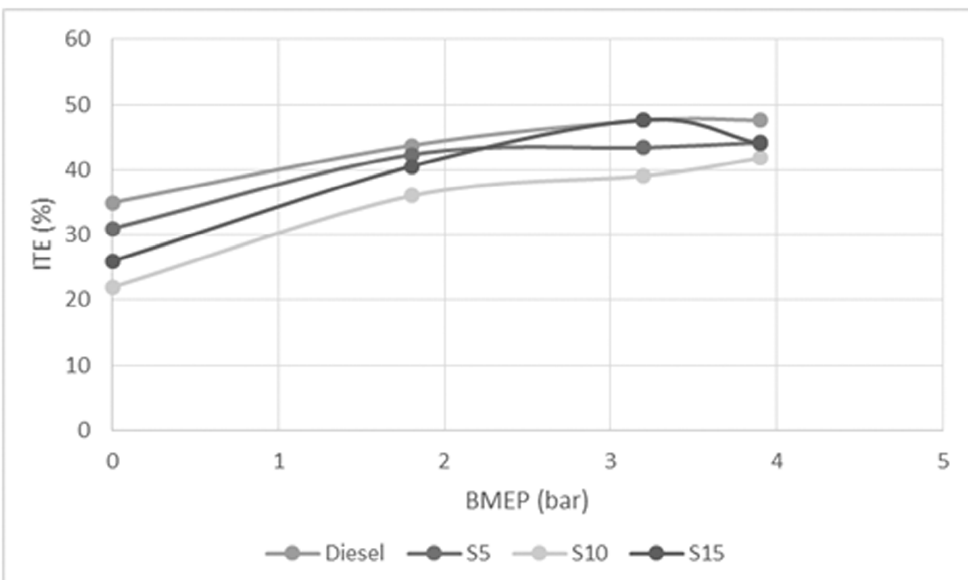

Figure 7: Variation of Indicated thermal efficiency with Brake Power.

smoke released from the engine as the blends are used at different loads the intensity was observed to be increased. In the figure 8, it shows the variation of carbon dioxide for various blends and diesel. While looking at the results the CO_2 emissions are less when compared to the results of diesel at different loads. Biodiesels have lesser carbon in them so the CO_2 is less compared to the diesel. In the figure 9 shows the variation of oxygen for different blends and diesel at different loads .As the biodiesel has high oxygen content the combustion will be properly done .the results clearly show that the oxygen gas released from the diesel is less when compared to the blends at different loads. The figure 10 shows the variation of CO emissions with the brake power of various blends and diesel which is tested in the engine at different loads. The values clearly shows that there is decrease in the emissions at different loads with increase in the brake power at different loads with respect to the diesel.

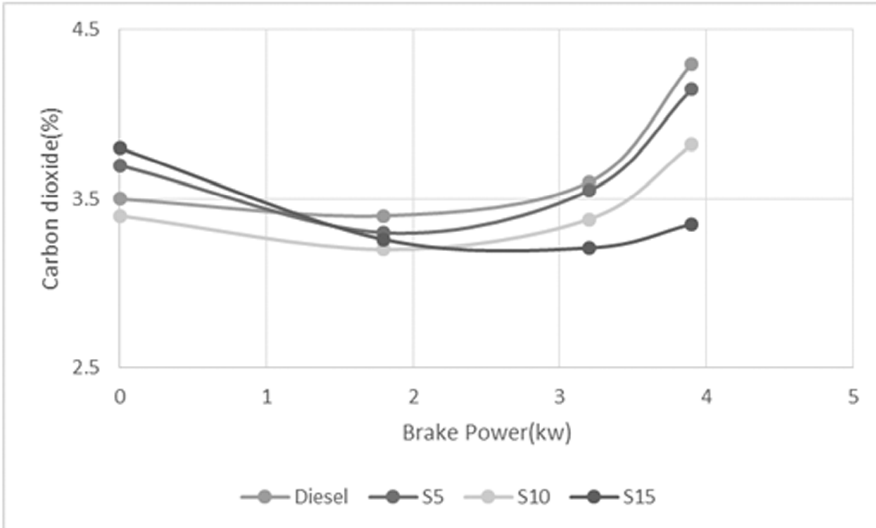

Figure 8: Carbon dioxide emissions from blends are compared with diesel.

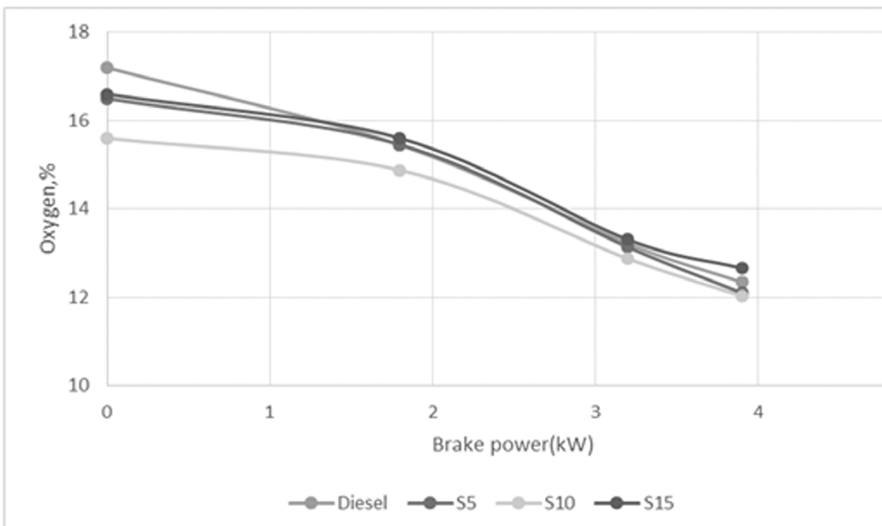

Figure 9: Oxygen emissions from blends are compared with diesel.

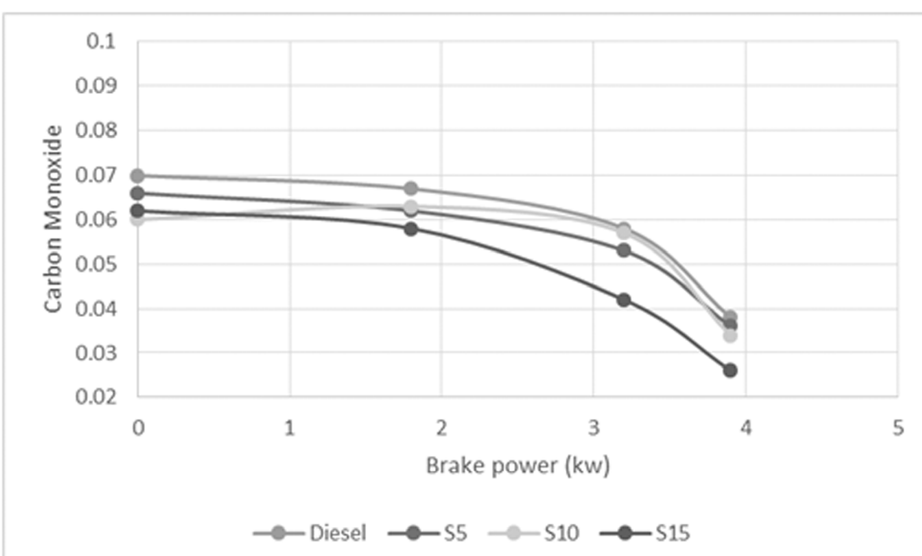

Figure 10: Carbon monoxide emissions from blends are compared with diesel.

4. CONCLUSION

In this study, biodiesel was prepared from soap nut seed oil through transesterification process and it wasblended with mineral diesel in three concentration ratios of 5%, 10% and 15% (v/v). Later the performance and exhaust emissions of a CI engine were experimentally investigated when the engine was fuelled with biodiesel-diesel blends. The experimental data was compared with baseline mineral diesel. The important findings are as follows: BSFC for biodiesel blends is comparable to diesel fuel at different loads. BTE is optimum for biodiesel blends at S15. All blends showed good ITE next to diesel. Diesel has shown highest mechanical efficiency compared to blends. S15 has shown better mechanical efficiency at second load. Diesel is the least contributor of CO and CO_2 emissions when compared to biodiesel-diesel blends. Overall, the optimum is found to be regarding blend wise S15 is considered to be better in getting mechanical efficiency.

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