Thumba Biodiesel as an Alternative Fuel for CI Engine: Review

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ABSTRACT

The world is focusing on the impending energy crisis and each country needs to concentrate on energy security as well as growing pollution and environmental concerns. The rapid depletion of fossil fuel reserves with increasing demand and uncertainty in their supply as well as the rapid rise in petroleum prices has stimulated the search for other alternatives to fossil fuels. The thumba biodiesel is considered as alternative fuels to diesel. This review has been taken up to identify the performance and emission using thumba biodiesel.

Keywords: Thumba biodiesel, performance, blends, CI engine, emissions.

I. INTRODUCTION

Energy is the prime mover of economic growth and is vital to the sustenance of a modern economy. Future economic growth crucially depends on the long-term availability of energy from sources that are affordable, accessible and environmental friendly. Increasing industrialization, growing energy demands, limited reserves of fossil fuel and increasing environmental pollution have joined necessitated exploring some alternative of conventional petroleum fuels. Biofuels are strongly emerging as partial substitutes for fossil fuel from the economic as well as environmental angle. Among the biofuels, vegetable oils like jatropha oil, karanja oil, castor oil, jojoba oil, cotton seed oil, neem oil, mahua oil, thumba oil, palm oil, soybean oil, sunflower oil etc. are being explored as promising alternative to hydrocarbon based fuels to full fill the future energy needs. Vegetable oils can be used as alternative fuels because they are biodegradable, non-toxic and significantly reduce pollution. Vegetable oils and their derivatives as diesel engine fuels lead to substantial reductions in carbon monoxide, smoke and particulate emissions. Vegetable oils have approximately 90% heating value of mineral diesel due to higher oxygen content. One of the main problems of vegetable oil use in diesel engines is high viscosity than that of mineral diesel due to which problems occur in pumping and atomization, ring-sticking, carbon deposits on the piston, cylinder head, ring grooves, etc. Therefore, a reduction in viscosity is of prime importance to make vegetable oils a suitable alternative fuel for diesel engines. The problem of high viscosity of vegetable oils can be resolved in several ways, such as preheating the oils, blending or dilution with other fuels, transesterification and thermal cracking or pyrolysis. One of the possible methods to overcome the problem of high viscosity is blending of vegetable oil in proper proportions with diesel. It is a fact that biodiesel is a safer, more economical and infinitely more environmentally friendly than the conventional petroleum diesel. Thumba Biodiesel is a vegetable oil-based fuel that can be used to replace diesel oil.

A. THUMBA BIODIESEL (CITRULLUS COLOCYNTIS)

Citrullus colocyntis, commonly known as the colocynth, closely related to watermelon, is a member of the Cucurbitaceous family. Cucurbitaceous is a large family which consists of nearly 100 genera and 750 species. This plant family is known for its great genetic diversity and widespread adaptation which includes tropical and subtropical regions, arid deserts and temperate locations. Cucrbits are known for their high protein and oil content. The seeds of cucurbits are sources of oils and protein with about 50% oil and up to 35% protein. This plant is a drought-tolerant species with a deep root system, widely distributed in the Sahara-Arabian deserts in Africa and the Mediterranean region. It is native to the Mediterranean Basin and Asia and is distributed among the west coast of northern Africa, eastward through the Sahara, Egypt until India and reaches also the north coast of the Mediterranean and the Caspian seas. It grows also in southern European countries as in Spain and on the islands of the Grecian archipelago.

Fig-1: Thumba Fruits and Thumba Seeds

B. TRANSESTERIFICATION

It is most commonly used and important method to reduce the viscosity of vegetable oils. In this process triglyceride reacts with three molecules of alcohol in the presence of a catalyst producing a mixture of fatty acids, alkyl ester and glycerol. The process of removal of all the glycerol and the fatty acids from the vegetable oil in the presence of a catalyst is called esterification.

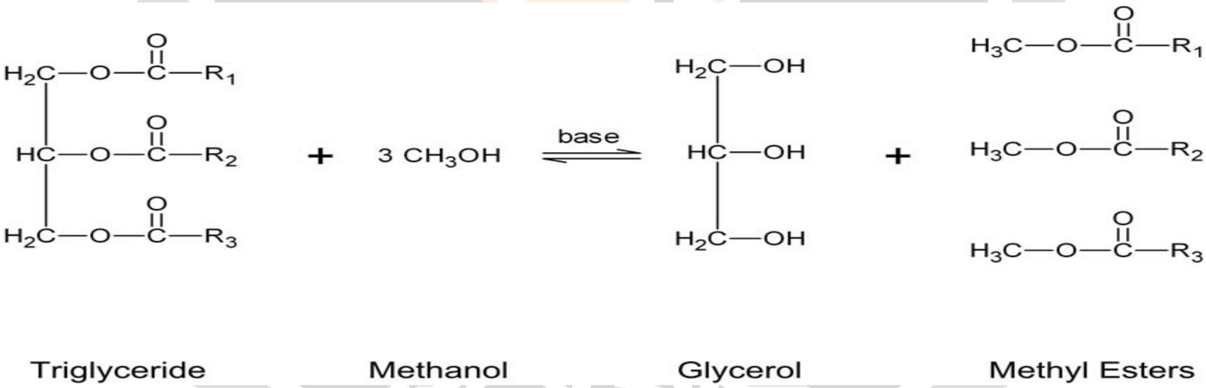

Fig-2: Transesterification reaction

C. PROPERTIES OF FUELS

Properties	Diesel	Thumba oil	Thumba biodiesel (TOME)
Density (kg/m³)	850	930	880
Kinematic viscosity at 40˚C (cSt)	2.75	31.52	5.86
Flash point (˚C)	57	112	91
Fire point (˚C)	64	122	110
Calorific value (MJ/kg)	42.25	39.78	39.37
Cetane number	47	45	53

Table-1: Properties of diesel, thumba oil and thumba biodiesel

II. Literature review

1. E. Sivakumar, R. Senthil, R. Silambarasan, G. Pranesh, S. Mebin Samuel [1]

Conducted experiments on performance, emission and combustion characteristics of thumba oil methyl ester blends in a DI diesel engine. In this work, the blends were prepared on volume basis, in the proportion of 20%, 40%, 60%, 80% thumba oil methyl ester with diesel.

Results showed that, brake thermal efficiency increases with the increase in load. Brake thermal efficiency decreases with the increase in the concentration of the thumba oil in thumba oil methyl ester – diesel blends. Diesel has lower brake thermal efficiency compared with the thumba oil methyl ester – diesel blends. NO_x emissions increase with increase in diesel proportion in blend. Pure thumba oil methyl ester emits less NO_x emissions at higher load than lower load compared with diesel. Diesel emits lesser hydrocarbon emission when compared with various blends. Hydrocarbon emissions were low at lower loads and increases when load increases. Hydrocarbon emissions of B40 were almost equal to diesel. Carbon monoxide emissions of various blends were low at lower load and increases gradually as the load increases. Diesel emits less carbon monoxide emissions compared with other blends.

2. Sunilkumar R. Kumbhar, H. M. Dange [2]

Conducted experiments on performance analysis of single cylinder diesel engine, using diesel blended with thumba oil. In this work, the performance and emission characteristics of various dual biodiesel blends (mixture of biodiesel and diesel fuel) of thumba biodiesel in various proportions such as B10, B20, B30, B40, B50 and B100 were used as fuel in engine.

Concluded that, at CR 18, BTE of thumba B10 (36.31%) showed better performance than all other blends of thumba biodiesel and pure diesel fuel (33.27%). At CR 18, BSFC of thumba B10, B20 (0.23 kg/kW-hr) showed better performance than all other blends of thumba biodiesel and pure diesel fuel (0.25 kg/kW-hr). At CR 18, BP of thumba B40 (5.15 kW) showed better performance than all other blends of thumba biodiesel and the pure diesel (5.07 kW). Thumba B50 showed better emission performance of HC at all compression ratios than B10, B20, B30, B40 blends of thumba biodiesel. Thumba B40 showed better emission performance of CO at CR 14 and for other compression ratios thumba B100 showed better emission performance. Thumba B100 showed better emission performance of CO_2 than other blends of thumba biodiesel at all compression ratios. For all the compression ratios ppm of NO_x coming from pure diesel was less than all other blends of thumba biodiesel. At CR 18 thumba B20 Showed better emission than other blends of thumba biodiesel.

3. Vandana Kaushik, Dr. O. P. Jakhar, Dr. Y. B. Mathur [3]

Conducted experiments on performance analysis of lower concentration blends of thumba methyl ester with diesel. In this work, performance were obtained with thumba methyl ester blends with diesel in different proportions such as TME10, TME20, TME30 and optimization of engine operation using different thumba methyl ester blends (TME10, TME20, TME30) was carried out in terms of compression ratio.

Results showed that, the brake thermal efficiency increases with increasing of engine load for diesel fuel as well as for all the blends tested. Higher brake thermal efficiency was observed for diesel fuel engine operation for entire load range compared to all thumba methyl ester diesel blends. The maximum brake thermal efficiency among all thumba methyl ester diesel blends was observed for 20% thumba methyl ester diesel blend. When blending has been increased to 30% thumba methyl ester in diesel, brake thermal efficiency was found marginally lower as compared to blend of 20% thumba methyl ester in diesel. The specific fuel consumption for various blends of thumba methyl ester in diesel found marginally higher than diesel at all load conditions. At maximum load the specific fuel consumption of engine fuelled with 20% thumba methyl ester diesel blend was found minimum among all the tested blends of thumba methyl ester in diesel. The exhaust gas temperature increases with increase in load for diesel as well as for all thumba methyl ester blends. The exhaust gas temperature was observed higher for all thumba methyl ester blends compared to diesel fuel at high loads. The lowest exhaust temperature among all the thumba methyl ester diesel blends was observed for the blend of 20% thumba methyl ester in diesel at low as well as at high load conditions. The volumetric efficiency for thumba methyl ester will be higher than that pure diesel. When engine was fueled with blends of thumba methyl ester the higher volumetric efficiency obtained was highest for TME20 CR19 than TME10 CR18 and TME30 CR19. The mechanical efficiency was increases with increase in load. The diesel fuel has the highest mechanical efficiency than TME fuel. The highest efficiency at full load was achieved for TME20 CR19 than TME10 CR18 and TME30 CR20.

4. Y. B. Mathur, M. P. Poonia, U. Pandel and R. Singh [4]

Conducted experiments on performance and emission characteristics of diesel engine using low concentration thumba oil diesel blends. In this work, the various low concentration blends of thumba oil and diesel were prepared on volumetric basis ranging from 10% to 50% thumba oil in petro-diesel. Experiments were initially carried out on the multi fuel engine using diesel as a fuel in order to provide base line data, subsequently experiments were conducted with prepared specified blends of thumba oil in diesel. All tests were conducted at 19 compression ratio, 203 bar injector opening pressure and at 23° CA BTDC injection timing for entire load range at rated engine speed of 1500 rev/min.

Results showed that, the brake thermal efficiency increases with increasing of engine load for diesel fuel as well as for all the blends tested. Higher brake thermal efficiency was observed for diesel fuel engine operation for entire load range compared to all thumba oil diesel blends. The maximum brake thermal efficiency among all thumba oil diesel blends was observed for 20% thumba oil diesel blend. When blending has been increased to 30% thumba oil in diesel, brake thermal efficiency was found marginally lower as compared to blend of 20% thumba oil in diesel. The lowest brake thermal efficiency was observed while using 50% blend of thumba oil in diesel fuel. The specific fuel consumption for various blends of thumba oil in diesel found marginally higher than diesel at all load conditions. At maximum load the specific fuel consumption of engine fuelled with 20% thumba oil diesel blend was found minimum among all the tested blends of thumba oil in diesel. The exhaust gas temperature was observed higher for all thumba oil blends compared to diesel fuel. The lowest exhaust temperature among all the thumba oil diesel blends was observed for the blend of 20% thumba oil in diesel at low as well as at high load conditions. Close values of exhaust gas temperatures were also observed for 10% and 30% thumba oil blend in diesel. The smoke opacity of the exhaust gas increases with increase in load for diesel fuel and for all blends tested. The smoke opacity increases with the increase of concentration of thumba oil in the blends. The minimum smoke level was found for 20% thumba blend in diesel, followed by 30% and 10% concentration of thumba oil in blend. The minimum values of carbon monoxide were found for 20% thumba blend in diesel. The 20% blend of thumba oil in diesel showed about 7.2% reductions in carbon monoxide emission compared to diesel at full load. Significant reduction in hydrocarbon emission was observed for all the thumba oil blends compared to neat diesel engine operation. Lowest level of hydrocarbon emission was found for 20% thumba oil blend. The 20% blend of thumba oil in diesel showed reduction of about 51.72% in hydrocarbon emission compared to diesel at peak loads. With blends of thumba oil, engine usually yield higher NOx emissions compared to diesel fuel operations for entire load range. The higher NOx emission was noticed at higher concentration blends and lowest level of NOx was observed at 20% thumba oil blend.

5. Shiv Lal, V. K. Gorana, N. L. Panwar [5]

Conducted experiments on comparative study of thumba seed biodiesel. In this work, five blends B05, B10, B15, B20 and B25 of thumba seed oil biodiesel were papered and performance was evaluated with 7HP four-stroke diesel engine. The performance of thumba seed oil biodiesel were compared with biodiesel prepared by mustard, castor and Jatropha seed oil with same blends.

Results showed that, for all blends tested, brake specific fuel consumption was found to decrease with increase in BHP. Blend, B10 of all biodiesel yield better results as compared to other blends. Thumba seed biodiesel blends (B20) shows comparable mechanical efficiency with other biodiesel. ISFC of thumba seed biodiesel was lowest at B25 for all loads.

6. Ashish Karnwal, Naveen Kumar, Mohd. Muzaffarul Hasan, Arshad Noor Siddiquee and Zahid A. Khan [6]

Conducted experiments on performance evaluation of a medium capacity diesel engine on thumba biodiesel and diesel blends. In this work, investigations carried out on assessing potential of biodiesel derived from Thumba oil and its blends with mineral diesel (B10, B20, B40, B60, B80, B100) in a medium capacity, single cylinder, direct injection, water-cooled diesel engine.

Results showed that, brake thermal efficiency was found to increase with increase in loads for all the fuels. Amongst all loading conditions, B10 had the maximum thermal efficiency (30.89%) in comparison to diesel (29.30%). For all test fuels, BSEC decreases with increase in load. B10 has lowest value of BSEC for all loading conditions followed by diesel and other biodiesel-diesel blends. B100 had the highest BSEC. The exhaust gas temperature for all fuels increases with increase in the load. Using B100, higher exhaust temperature was attained. Biodiesel and its blends with diesel produced lesser smoke than neat diesel. Smoke level increased sharply with increase in load for all fuels. The engine emits more CO for diesel as compared to TME blends under all loading conditions. CO emission level decreases with increasing biodiesel percentage in the fuel. CO_2 emissions increase linearly with increase in load for all the test fuels. It was found maximum for B100 at all loading conditions. The lower percentage of biodiesel blends emits very small amount of CO_2 in comparison to diesel. As the concentration of biodiesel increases in blends, CO_2 emission was found to increase. There was a significant reduction in HC emission level on blends of methyl ester of thumba oil as compared to diesel operation. There was a reduction from 44 ppm to 14 ppm at full load condition and 36 ppm to 12 ppm at low load conditions. Increasing proportion of biodiesel in the blends has resulted in increased NOx emissions in comparison to neat diesel operation except for B10. At all loads, NOx emissions were least for B10 and maximum for B100.

III. CONCLUSION

Thumba biodiesel satisfies the important fuel properties as per ASTM specification of biodiesel. Engine works smoothly on thumba methyl ester with performance compared to diesel operation. The thumba biodiesel can be successfully substituted as alternative fuel for CI engine.

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