Optimization of Transesterification of Safflower Seed Oil, Performance & Emission Characteristics of Safflower Oil Methyl Ester and its Diesel Blends in C.I. Engine: A Review

Dr. S. S. Ragit\textsuperscript{1} \hspace{1cm} Dr. S. K. Mohapatra\textsuperscript{2} \hspace{1cm} Nitin Kumar\textsuperscript{3}
\textsuperscript{1}Assistant Professor \hspace{1cm} \textsuperscript{2}Senior Professor& Head \hspace{1cm} \textsuperscript{3}Research Student
ME Department, ME Department, ME Department,
Thapar University, Patiala Thapar University, Patiala Thapar University, Patiala

ABSTRACT

This review paper presents a brief introduction of biodiesel production from safflower seed oil and performance and emission characteristics of safflower oil methyl ester and its diesel blends in a C.I. engine. Several bio-diesel production methods have been developed, among which transesterification using alkali catalyst gives high level of conversion of triglycerides to their corresponding methyl ester in short reaction time. In this work, an attempt has been made on review of biodiesel production with different catalyst, performance and emission characteristics of I.C. engine at different blending ratio. From the review, it is observed that blending of safflower oil or safflower oil methyl ester with diesel in distinct ratio give comparable performance with diesel. Biodiesel increase the oxide of nitrogen (NO\textsubscript{x}) emission whereas the carbon mono oxide (CO), hydrocarbon (HC) and particulate matter emission decrease when compared to diesel.

Keywords: Transesterification Process, Safflower oil biodiesel, Performance, Emissions

I. INTRODUCTION

Bio-diesel has become more attractive recently because of its environmental benefits and it is derived from renewable resources, bio-degradable and non-toxic in nature. The use of vegetable oils as sources of diesel would require more efforts to increase the production of oil seed and to develop new and more productive plant species with high yield of oil. Besides, some species of plants yielding non-edible oils. The planning commission of India has launched a bio-fuel project in 200 districts of the 18 states in India \cite{1}. Currently, the energy requirements of the world are mainly met through fossil fuels, such as gasoline, petroleum-based diesel, and natural gas. Such fossil-derived resources are scarce toward fulfilling the future energy demands and meeting the challenges of rapid human population growth and technological developments \cite{2}. The anticipated decreasing supply of fossil fuels coupled with environmental safety concerns has provoked the efforts to encourage the use of bio-based fuels as renewable energy sources. Several types of biofuels, such as vegetable oil/animal fat (raw, processed, or used), methyl esters from oil/fat, and ethanol or liquid fuels from biomass have been searched as a replacement for gasoline and petroleum diesel \cite{3}. Since the beginning of this century researches have accelerated their works on alternative and renewable fuels. Vegetable oils and their derivatives have already been recognized to be main alternative fuels for diesel engines. But direct use of vegetable oils leads to some problems in engines. These problems are attributed to high density, viscosity, and poor volatility of vegetable oils. It is suggested that trans-esterification is the best way to use vegetable oil as a fuel in existing diesel engines \cite{4,5}. The purpose of the trans-esterification of vegetable oils to their methyl esters (biodiesels) process is to lower the viscosity of the oil. The main factors affecting trans-esterification are molar ratio of glycerides to alcohol, catalyst, reaction temperature and pressure, reaction time and the contents of free fatty acids and water in oils. The commonly accepted molar ratios of alcohol to glycerides are 6:1-30:1\cite{6}. The various characteristics of bio-oils acquired under different pyrolysis conditions from safflower oil were identified \cite{7}. Some chemical and physical fuel characteristics of safflower obtained biofuel were determined. It was found that the bio-oils obtained from safflower were an environmentally
friend feedstock candidate for biofuels and chemicals [10]. The largest safflower producing country is India but only small amounts are exported. In terms of world trade, the USA and Mexico are the largest producers, followed by Australia and Argentina [8].

Carthamus tinctorius is a botanical name of safflower oil and it is colorless and flavorless. Safflower oil has used in cooking, cosmetics as well as for production of methyl ester. Safflower oil methyl ester is an alternate fuel of CI engine. The aim of this review paper on safflower oil methyl ester is to study the production of biodiesel from safflower oil, performance and emission characteristics of diesel engine with safflower oil methyl ester and at distinct blending with diesel.

II. LITERATURE SURVEY

Rashid [9] et al. reported the production of biodiesel by using safflower oil through base-catalyzed trans-esterification process. It studied that yield of safflower oil methyl ester at different temperature, concentration of catalyst, molar ratio and rate of stirring with respect to time. In this experimental work, it studied various parameters such as oil to methanol ratio (molar ratio) (1:3, 1:6, 1:9, 1:12, 1:15 and 1:18) and reaction temperature (30, 45, 60°C) and rate of stirring (180, 360, 600 rpm) and types of catalyst (NaOH, KOH, NaOCH₃, KOCH₃) with concentration (0.25, 0.50, 0.75, 1.00, 1.25, 1.50 %) were used for obtaining the maximum conversion of safflower oil into safflower oil methyl ester (SOME). The catalyst sodium methoxide (NaOCH₃) have greater potential for better quality and high yield of biodiesel is produced in this case. Catalyst NaOCH₃ with 1% concentration, oil/methanol molar ratio 1:6 and rate of stirring 600 rpm at fixed reaction temperature 60°C and constant reaction time of 120 min give the maximum methyl ester yield. It is concluded that by and beyond these parametric limit, the yield of safflower oil methyl ester (SOME) decreased with respect to time. Sodium methoxide (NaOCH₃) offered 98% yield of methyl ester at catalyst concentration 1%, molar ratio 1:6, 600 rpm stirring rate, 60°C reaction temperature and 120 min reaction time.

Likic [10] et al. investigated the safflower oil methyl ester application in diesel engine and its production. The trans-esterification process was employed for preparation of biodiesel by safflower oil with pretreatment temperature of oil 50-55°C, 0.4% catalyst (NaOH), 20% methyl alcohol of prepare oil. It is reported that the performance of single cylinder, four stroke, air cool CI engine and its emission characteristics at various engine speeds. In this study, safflower oil methyl ester and diesel were blended in the ratio of 5% (B5), 10% (B10) and 50% (B50) and evaluating effect of these blends on the engine performance and emission. The results showed that power and torque of biodiesel decrease and brake specific fuel consumption (bsfc) increases for B50 fuel in comparison to B5, B20 fuel and showed reduction in smoke, particulate matter (PM) and CO emission in comparison to mineral diesel.

Aydin [11] et al. studied the biodiesel–kerosene fuel blend used in diesel engine for evaluating the performance and emission characteristics. In this study, safflower oil was taken for biodiesel production by trans-esterification method. In this investigation, safflower oil was blended with kerosene in distinct proportion of S90&K10 (90% safflower oil biodiesel-10% kerosene), S75&K25 (75% safflower oil biodiesel-25% kerosene) and S50&K50 (50% safflower oil biodiesel-50% kerosene). The experimentation work was conducted on 4 cylinders, direct injection, water cooled diesel engine and tests were taken out at 3.6 KW, 7.2 KW and 10.2 KW loads operation with constant engine speed 1500 rpm and constant compression ratio 17:1. It is observed that average mass fuel consumption and brake specific fuel consumption (bsfc) lowest for blending S50&K50 and diesel fuel, due to its higher heating value, in comparison of S90&K10, S75&K25 blending fuel. Brake thermal efficiency (BTE) increased by 3% for S50&K50 fuel when compared to diesel fuel. The amount of NOx emissions were decreased with percentages of 68%, 56.9% and 55.1% with increase in kerosene percentages of 50%, 25% and 10% in blending respectively.

Kumari [12] et al. investigated the performance evaluation of diesel engine with safflower oil. This experiment was performed on single cylinder kirloskar diesel engine at constant speed 1500 rpm and compression ratio 16.5:1. It is reported that performance of diesel engine was taken out in the consideration of no load, 20%, 40%, 60%, 80% and 100% of rated load with blending of safflower oil to diesel in the proportion of B20 (20%
safflower and 80% diesel), B40 (40% safflower and 60% diesel), B60 (60% safflower and 40% diesel), B80 (80% safflower and 20% diesel) and B100 (100% safflower and 0% diesel). It was found that minimum average fuel consumption and brake specific fuel consumption (bsfc) for blend B20 in comparison of B40, B60, B80, B100 and mineral diesel and brake thermal efficiency (BTE) increased from 21.9% to 27.1% (5.2%) for B20 at 80% full load when compare with mineral diesel.

Mihaela [13] et al. investigated perspective of safflower oil as biodiesel source for south eastern Europe and comparative study of safflower, rapeseed, soybean. Biodiesel industries promoted safflower oil as an alternative fuel. As per Romania, weather condition (not for all region) rapeseed, soybean, sunflower and etc. were mainly used corps of biodiesel industries. It reported that safflower corps are capable to utilize the land in southern part of Romania, characterized by difficult climate condition. In this paper, the author discussed distinct method of oil extraction, two stage trans-esterification method, properties of oil and fatty acid pattern (% wt.) of safflower, soybean and rapeseed oil. It is examined that safflower oil is suitable for very extreme weather conditions and detrimental land of Europe and South Romania and sulphur content of safflower, rapeseed, soybean were examined to be below 2 ppm.

Duz [14] et al. conducted the experimental investigation of alkali catalyzed trans-esterification of safflower seed oil assisted by microwave irradiation. Safflower seed oil extracted by soxhlet extraction method and biodiesel was prepared by trans-esterification method, using 10:1 molar ratio (alcohol/oil) and 1% w/w NaOH as catalyst. In this investigation, they discussed the advantage of microwave irradiation heating over convectional heating of product during trans-esterification method. They reported that microwave irradiation increased the rate of chemical reaction and produced high quality product. Under microwave irradiation condition, chemical reaction time reduced from 120 min to 6 min and percentage conversion of oil to ester was obtained 98.4% which is higher than in comparison of conversion under convectional condition i.e. 93%.

Eryilmaz [15] et al. evaluated the influence of blending ratio on the physicochemical properties of safflower oil methyl ester-safflower oil (SOME-SO), safflower oil methyl ester-euro diesel (SOME-ED), safflower oil-euro diesel (SO-ED). The blending of SOME-SO, SOME-ED and SO-ED were prepared in the ratio of 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 % by volume. They studied the preparation of safflower oil methyl ester (SOME) by trans-esterification method at temperature 60°C with 6:1 methanol to oil ratio and NaOH as catalyst. In this, they conducted the experimental investigation of physical and chemical properties of SO, SOME, ED and blending such as density, kinematic viscosity, flash point, pour point etc. They developed the mathematical relation between properties and additive content like SO, SOME which showed linear regression.

Haldar [16] et al. investigated the performance and emission characteristics of a diesel engine using three non-edible vegetable oils such as Putranjiva, Jatropha and Karanja as non-edible vegetable oil. Degumming process was employed to remove impurities (gummy material) from the vegetable oils. It is a chemical process and the chemical used in this process is phosphoric acid. It is economical process because the cost for production of biodiesel by degumming process less than the trans-esterification. By degumming process, the properties of vegetable oils like viscosity, cetane number, combustion have been improved. In this study, degummed non-edible vegetable oils and diesel have been blended in the ratio of 10%, 20%, 30% and 40% and tested on Richard variable compression engine under the varying load condition 0-2.7 KW and the performance is compared. They have concluded that the overall performance of jatropha is good at high loads in all respect and diesel engine has given satisfactory performance using 20% blend with diesel at 45° bTDC timing, 1200 rpm, 20 compression ratio.

III. CONCLUSION

From the detailed literature survey on safflower oil methyl ester, the following conclusion can be made:

1. Catalyst sodium methoxide (NaOCH₃) offer maximum conversion of safflower oil into safflower oil methyl ester.
2. Under microwave heating in trans-esterification process, the conversion safflower oil into safflower oil biodiesel increase from 93% to 98.4% and reaction time also reduce from 120 min to 6 min.
3. Blending of straight safflower oil with diesel in the ratio of 20%, increase the brake thermal efficiency 5.2% at 80% full load.
4. Blending of safflower oil methyl ester with kerosene, reduce NOx emission and improve the performance of I.C engine.

5. REFERENCES


