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# Emission and Performance analysis of hydrotreated () CrossMark refined sunflower oil as alternate fuel



J. Hemanandh \*, K.V. Narayanan

Department of Mechanical Engineering, Sathyabama University, Chennai, India

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## **KEYWORDS**

Hydrotreatment; Refined sunflower oil; DI diesel engine: Emission and performance Abstract The experiments were conducted by using the hydrotreated refined sunflower oil as alternative fuel in a 4-stroke, stationary DI diesel engine at a constant speed of 1500 rpm. The effects of hydrotreated vegetable oil blends on diesel engine emission and performance were studied. The emission and performance were studied for different proportions such as HTSF B25 and HTSF B100 and at different loading conditions and comparison was made with petrodiesel. The emission and performance results of HTSF B25 and HTSF B100 showed that decrease in CO by 9% and 37%, HC by 42% and 55%, NO<sub>x</sub> by 10% and 18.18%, BSFC by 25% and 12.5%. The increase in brake thermal efficiency was by 10% and 38%. It was observed from the study that hydrotreatment of refined sunflower oil could be one of the best alternative fuels for the diesel engine. © 2015 Faculty of Engineering, Alexandria University. Production and hosting by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

# 1. Introduction

In India, energy crisis, though not yet assumed alarming proportions, has started causing concerns because of burgeoning population, fast depleting fossil fuels, and increase in environmental pollution which have forced us to look for an alternative fuel. Atadashi et al. [1] showed that by using membrane separate technique they could remove the potassium catalyst from palm oil biodiesel using transesterification. Further they optimized the temperature, flow rate and the transmembrane pressure in order to reduce the amount of potassium. Basha et al. [2] experimented with the jatropha methyl ester emulsion blended with carbon nanotubes at different proportions to effect an increase in brake thermal efficiency and decrease in

\* Corresponding author.

peak cylinder pressure. EL\_Kassaby et al. [3] investigated by varying the compression ratio from 14 to 18 in the diesel engine with the transesterified waste cooking oil being the fuel. The result showed an increase in brake thermal efficiency,  $NO_x$ ,  $CO_2$ , whereas a decrease in CO, HC. Hansdah et al. [4] produced bioethanol from Madhuca Indica flower and blended with diesel fuel at different proportions. The blend was tested in the 4.5 kW diesel engine. Longer ignition delay, decrease in NO<sub>x</sub>, smoke, and improved performance were the results. Gopal et al. [5] observed that using waste cooking oil had similar properties as diesel. The CO, unburnt hydrocarbon, smoke, and brake thermal efficiency decreased, whereas there was an increase in NO<sub>x</sub> and specific fuel consumption. Heikkilä et al. [6] studied the performance by adjusting the intake valve closure timing and start of injection using hydrotreated vegetable oil compared with fossil diesel fuel. The result showed reduction in  $NO_x$  and particle size at all loads. Liu et al. [7] produced the biohydrogenated diesel and liquid

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Nomenclature			
PD pure diesel		HC	hydrocarbon
HT SF B25 25% hydrotreated s	sunflower oil + 75% pure	$CO_2$	carbon-di-oxide
diesel blend		$NO_x$	nitrogen oxide
HT SF B100 100% hydrotreated	1 sunflower oil	BSFC	brake specific fuel consumption
CO carbon monoxide		BTE	brake thermal efficiency

petroleum gas from the palm, canola, and jatropha vegetable oil using Ni-Mo/SiO<sub>2</sub> as catalyst. The vegetable oil was converted into paraffins and used as a fuel in the diesel engine. Imperato et al. [8] studied the performance and emission characteristics of the hydrotreated vegetable oil in the medium speed large bore engine. The valve timing and injection parameters were tuned and tested with the hydrotreated oil. The engine was tuned and the  $NO_x$  emission was reduced. Murtonen et al. [9] used EN590 diesel fuel, FAME, HVO, and GLT fuels in the diesel engine and the results showed that NO<sub>x</sub> emission was high in FAME when compared with HVO and GTL. The other emissions were reduced compared with EN590 diesel fuel. Karonis et al. [10] used the hydroprocessed used cooking oil blended with EN590 diesel fuel displaying the cold flow properties and this improved the low quality cetane diesel resulting in better performance. Heuser et al. [11] converted the Crude Tall Oil into renewable diesel fuel using hydrotreatment process. The 30% of renewable diesel was blended with diesel and tested in the diesel engine. The results showed that the performance and emission were the same in comparison with diesel fuel. Lehto et al. [12] focused on miller cycle and exhaust gas recirculation. In miller cycle, the engine inlet valve close timing and the start of injection timing were varied. The hydrotreated fuel was tested in this condition and compared with EN590 diesel fuel and reported a reduction in NO<sub>x</sub>. Bhardwaj et al. [13] tested the hydrotreated rape seed oil in the diesel engine and compared with diesel fuel. The results showed reduction in CO, HC, and soot.

The aim of the work was to reduce the emissions and improve the performance of the diesel engine using hydrotreated refined sunflower oil as diesel fuel. The emission and performance of the diesel engine were studied.

### 2. Materials and methods

The Sunflower oil was procured from the local dealer. The experiments were conducted in two phases. Phase I: The Refined sunflower oil was hydrotreated. Phase II: The hydrotreated oil was tested in the diesel engine. The emission and performance were analyzed with diesel.

### 2.1. Preparation of hydrotreated refined sunflower oil

The refined sunflower oil was used as a feed. The feed was treated with high pressure-trickle bed reactor. The capacity of the tubular reactor was of a volume of 400 ml. The Ni–Mo/Al<sub>2</sub>O<sub>3</sub> catalyst was used. By using standard procedure the catalyst was dried and sulfided using diesel spiked with Dimethyl Disulfide (DMDS). The refined sunflower oil was preheated and treated with hydrogen gas. The sunflower oil was preheated and treated with hydrogen gas at temperature of 360 °C and a pressure of 60 bar.

The various reactions took place and n-alkanes were formed. The n-alkanes were converted into isoalkanes with the isomerization catalyst. The triglycerides were converted into propane. This could be observed in increase in cetane number. The hydrotreated vegetable oil has C-17 and C-18 for refined sunflower oil for 29% and the presence of C-18 shows the deoxygenation in the initial reaction. The deoxygenation absorbs more hydrogen than the decarboxylation reaction. The feed and the green diesel are shown in Figs. 1 and 2. There was increase in calculated cetane index, Flash point, and the calorific value, whereas lowering in density and kinematic viscosity were observed as given in Table 1 and compared with Euro Bharat stage-IV (see Table 2).

#### 2.2. Experimental set-up

The green diesel was tested in the stationary, vertical, 4S DI diesel engine to analyze the performance and emission of the diesel engine. The engine was tested for various loading conditions at a constant speed of 1500 rpm. The engine was coupled with an alternator and the eddy current was used to load the engine in steps of 25%. The different loading conditions were 0%, 25%, 50%, 75%, and 100%. The hydrotreated green



Figure 1 Refined sunflower oil.



Figure 2 Hydrotreated oil.

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