Influence of High Energy Ball Milled Titanium Dioxide Nanoparticles on Performance and Emission Pattern of Biodiesel in A 2-Stroke Diesel Engine

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Abstract – *The project work concentrates on the influence of nanoparticle additives in biodiesel fuel blends as an alternate fuel source in engines. The work comprises of preparation of nanoparticles of titanium dioxide by method of ball milling and its characterization. Characterization involves particle size determination and also the phase determination of the substance. It is followed by biodiesel preparation by transesterification to remove the glycerol content in pure oil. It is then followed by engine performance testing and emission analysis.*

Key Words: **Nanoparticles, Titanium Dioxide, Biodiesel, Ball milling, Hydrocarbons.**

1. INTRODUCTION

The world is sorely in need of clean energy and the conventional sources are at the brink of exhaustion. The severity of the situation can be understood by observing the attempts to change our ways and to tap other sources of energy which are renewable and clean. Automobile sector is responsible for the ever increasing consumption of fossil fuels and if we continue at this rate, soon the reserves will go empty, leaving us at a greater crisis situation. The problem can be overcome by employing efficient methods and practices to reduce or completely eliminate the use of conventional fuel sources. One of the ways to reduce fossil fuel consumption is to replace it with biodiesels, which were proven replacements for fossil fuels in automobile engines, after processing. The method can be further improved by the incorporation of nanoparticle additives. Hence, in this work, the effects of addition of nanoparticles of titanium dioxide to coconut testa biodiesel-diesel blend in a 2-stroke diesel engine was studied.

1.1 Objectives

Objectives of the study included:

1. Preparation of titanium dioxide nanoparticles by ball milling.
2. Determination of particle size and crystallinity of the samples.
3. Biodiesel from coconut testa oil has to be prepared.
4. Engine performance testing and emission characteristics results must be obtained and compared with that of neat diesel.

2. EXPERIMENTAL WORK

The experimental work consists of four stages according to the objectives, which were the ball milling operation of titanium dioxide, its characterization, biodiesel preparation from coconut testa oil and engine performance and emission analysis.

2.1 Nanoparticles Preparation

The first stage of the work was to prepare the nanoparticles of titanium dioxide by the method of high energy ball milling. The samples were prepared by using the RETSCH PM100.

Fig -1: RETSCH PM 100

The operation was carried out at a speed of approximately 260rpm and the interval time was 30minutes per 1hour of continuous milling. The samples were collected at 80hours and 90hours of milling time. The samples were to be tested for its particle size to identify whether they were in the range of nanometer and also to identify the crystallinity. The samples collected were tagged according to the time of collection in order to avoid accidental mixing or replacement while carrying out analysis.

2.2 Characterization of samples

The samples collected after 80hours and 90hours of milling were taken for determination of particle size using Scanning Electron Microscopy[SEM] and the crystallinity by X-ray Diffraction[XRD]. The sample collected after 80hours was found to have an average particle size of 40nm and the sample collected after 90hours was found to have an average particle size of 20nm.

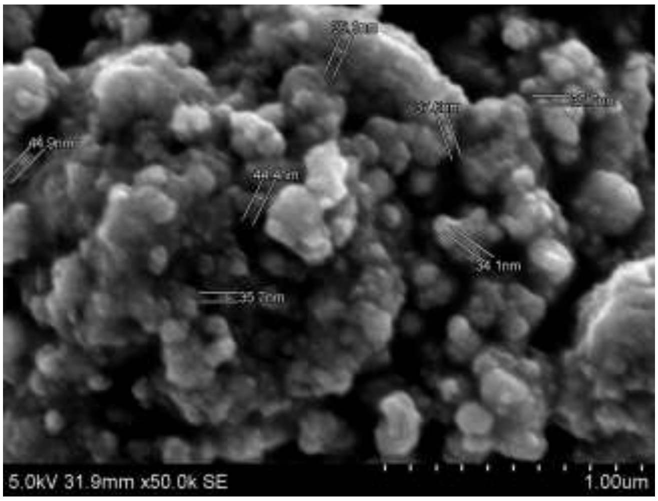

Fig -2: SEM image of sample collected at 80hours

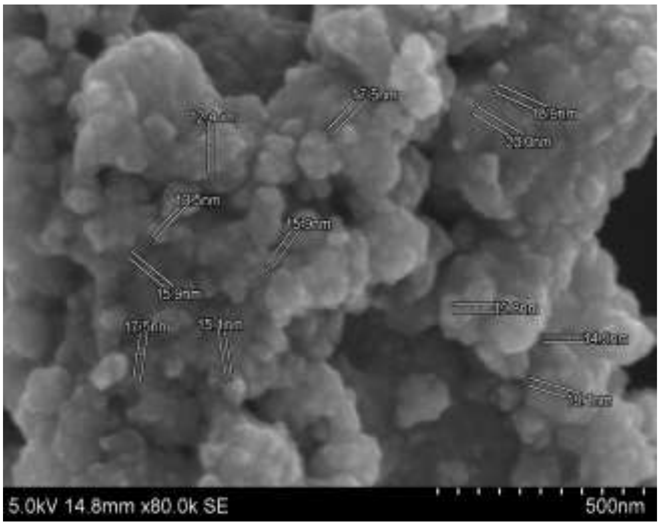

Fig -3: SEM image of sample collected at 90hours

The particle size determination of samples were simultaneously accompanied by crystallinity determination of the samples and the peaks obtained were as follows:

Table -1: Peaks and corresponding phase

SL.NO	2theta(degrees)	PHASE	PLANE
1	25.3^0	ANATASE	(1 0 1)
2	27.6^0	RUTILE	(1 1 0)
3	36.2^0	RUTILE	(1 0 1)
4	41.4^0	RUTILE	(1 1 1)

2.3 Preparation of Biodiesel

The biodiesel was prepared from coconut testa oil by the method of transesterification. Potassium hydroxide was the catalyst used in the reaction to form biodiesel. The biodiesel obtained was tested using ASTM standards and 6 fuel samples were prepared:

Sample 1	100%Diesel
Sample 2	70%Diesel+30%Testa Biodiesel
Sample 3	70%Diesel+30%Testa Biodiesel+20nmTiO_2[250ppm]
Sample 4	70%Diesel+30%Testa Biodiesel+20nmTiO_2[500ppm]
Sample 5	70%Diesel+30%Testa Biodiesel+40nmTiO_2[250ppm]
Sample 6	70%Diesel+30%Testa Biodiesel+40nmTiO_2[500ppm]

2.3 Engine performance and Emission analysis

The engine performance test was carried out in RING two stroke diesel engine test rig.

Table -2: Engine specifications

SPECIFICATION	DESCRIPTION
Manufacturer	RING
Number of cylinders	1
Number of strokes	2
Rated power	10 HP
Rated speed	1000rpm
Cooling type	Water cooled
Loading type	Rope brake drum loading
Brake drum diameter	457mm

The emission analysis carried out using AVL DIGAS analyzer.

3. RESULTS AND DISCUSSIONS

The results included engine performance and emission characteristics. The engine performance included variation of brake thermal efficiency[BTE] and brake specific fuel consumption[BSFC] against loading.

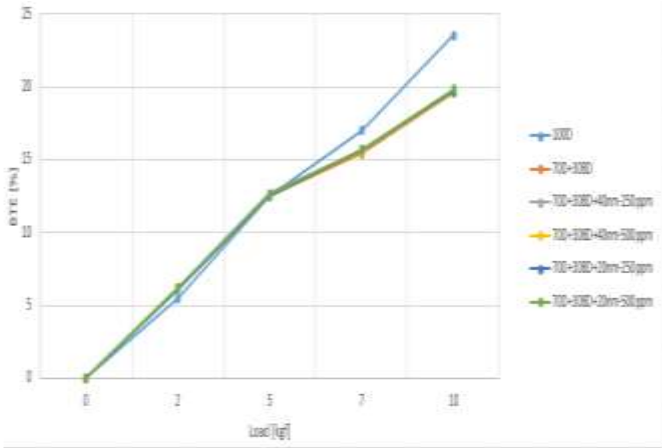

Chart -1: BTE v/s Load

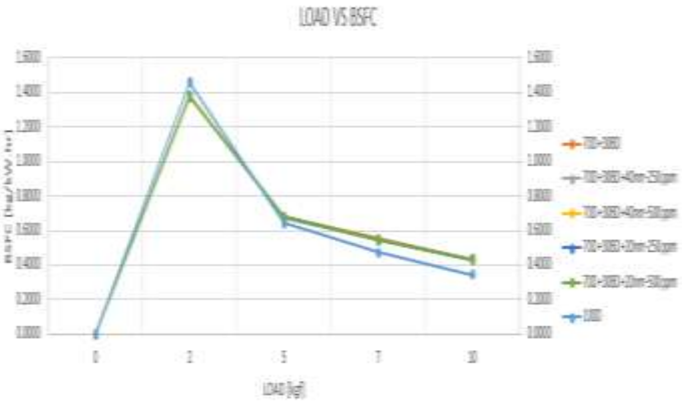

Chart -2: BSFC v/s Load

In both cases of BTE and BSFC, the performance if diesel fuel lags behind biodiesel blended fuel at lower loads, whereas, at higher loads, biodiesel based fuels are inferior in performance compared to diesel fuel. Among the biodiesel blended fuel samples, the variations are negligible to be compared on a plot. The prominent reason for inferior performance of diesel at lower loads may be due to the fact that temperature is lesser and causes incomplete combustion. While in case of testa biodiesel, the increased oxygen content aids in combustion and hence the better performance at lower loads.

While coming to the case of emission analysis, the parameters considered are, carbon monoxide[CO], carbon dioxide [CO_2], hydrocarbons[HC] and oxides of nitrogen[NO_x]. The variation of parameters was compared against brake power[BP]. The plots of variation are as follows:

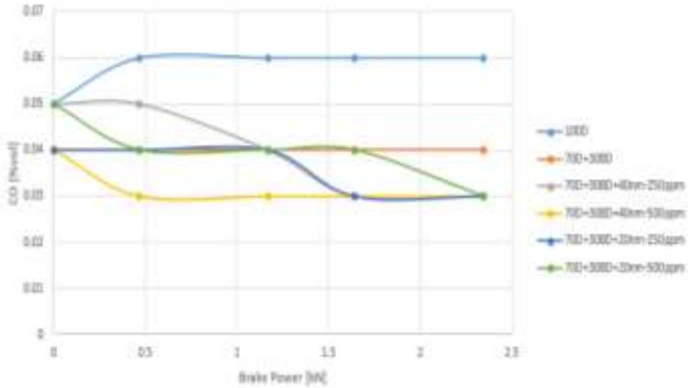

Chart -3: CO v/s BP

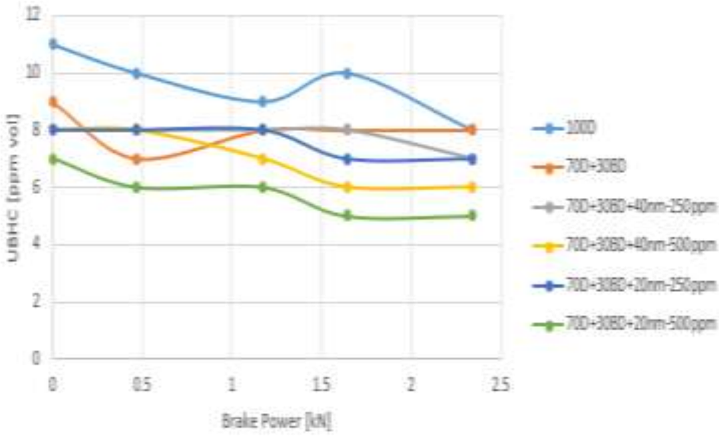

Chart -4: HC v/s BP

Except for the case of emission of NO_X, for all other cases its seen that the emission is lesser for testa biodiesel blend than neat diesel fuel. The prime reason for lesser emission is the increased oxygen content that facilitates better combustion and hence lesser emission. Among the biodiesel blends, sample6 performed better in emitting lesser gases. The factor of higher energy release due to increased specific surface area of nanoparticles causes vigorous combustion thereby constricting emission levels. The emission of NO_X was higher while compared to that of neat diesel fuel due to the fact that testa biodiesel has higher density and Cetane number which causes abrupt rise in the emission of oxides of nitrogen.

4. CONCLUSIONS

The following were the conclusions after studying the results of the performance and emission analysis:

1. The BTE of sample6 was 12.29% higher than sample1 on initial loading conditions.

2. The BSFC of sample6 was 5.66% lesser than that of sample1 on initial loading conditions.

3. The emission of CO by sample6 was 33.3% lesser than that by sample1 at initial load and 50% lesser at final load.

4. The emission of CO_2 by sample6 was 41.67% lesser than sample1 at initial load and 39.28% lesser at final load.

5. HC emission by sample6 was 40% lesser than sample1 at initial load and 37.5% lesser at final load.

6. The emission of NO_X by sample6 was 16.67% higher than sample1 at initial load and it was 65.71% higher at final load.

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