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An experimental analysis on the influence of fuel borne additives on the single cylinder diesel engine powered by Cymbopogon flexuosus biofuel

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ABSTRACT

Researchers all around the world are making strenuous efforts to find alternative fuel to ameliorate the problem of depletion of fossil fuel. we have identified a novel plant based biofuel, namely Cymbopogon flexuous biofuel. It has excellent fuel properties and is widely available in India and it seems to have the potential to make India self-sufficient in energy production. Cerium oxide nanoparticles were synthesized using sol–gel combustion methods. Their structural, morphological and elemental properties were studied with the help of XRD, SEM, TEM and EDS respectively. On volume basis, 20% raw Cymbopogon flexuous biofuel was blended with diesel fuel, and various proportions of Cerium oxide nanoparticles, namely C20-D80 + 10 ppm, C20-D80 + 20 ppm andC20-D80 + 30 ppm were prepared. The properties like density, kinematic viscosity, calorific value of the test fuel were measured as per ASTM standards and compared with those of diesel fuel. An experimental study of its performance, emission, and combustion behavior was conducted at varied load conditions at a constant speed of 1500 rpm. NO_x and smoke emission was simultaneously reduced by 3% and 6.6% respectively as compared with biofuel blend. Due to higher thermal stability and oxygen buffer of Cerium oxide nanoparticle the brake thermal efficiency was higher by 4.76% and cylinder pressure and heat release rate was also higher.

1. Introduction

In the context of a country's cultural and economic evolution, energy plays a crucial role all over the world. Energy from wind and geothermal are promising solutions but they lack in the storages of energy. Fossil fuels cover a major proportion in the energy consumption all over the world as they are used in all modes of transport sectors [1]. Consequently, there arises interest in finding out a less toxic, renewable, environmental friendly and biodegradable fuel to balance the energy requirement. Increased focus on higher efficiency engine for transport sector has resulted in the usage of a large number of diesel fueled engines. Moreover, countries like European Union, United States, China, India and Japan import fossil fuels in large quantities for the development of their nations. But the fast depletion of fossil fuel has been causing great worry to all nations. This disturbing thought of depletion and the bleak chances of finding new resources of fossil fuel have impelled the researchers all over the world to seek a suitable alternative fuel from their own nations and to attain self-sufficiency in the usage of fuel [2]. K. Purushothaman and G. Nagarajan et al. [3], conducted the performance, emission and combustion study on a C.I engine operating with neat orange oil. From their findings they concluded that the brake thermal efficiency, peak pressure, heat release rate and oxides of nitrogen (NO_x) were higher, whereas Carbon monoxide (CO) and hydrocarbon (HC) emissions were lowered as compared with diesel fuel. R. Vallinayagam et al. [4], investigated the characteristics study of pine oil in a single cylinder diesel engine. From the results, they observed that 100% pure pine oil reduced 30% of HC, 65% of CO, and 70% of smoke emissions. S. Vedharaj et al. [5], conducted the

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Nomenclature

C20-D80	Fuel blend of Cymbopogon flexuosus biofuel 20% + Diesel 80%
C100	Cymbopogon flexuosus biofuel 100%
C20-D80 + 10 ppm	Fuel blend of Cymbopogon flexuosus biofuel 20% + Diesel 80% + 10 ppm cerium oxide nanoparticle
C20-D80 + 20 ppm	Fuel blend of Cymbopogon flexuosus biofuel 20% + Diesel 80% + 20 ppm cerium oxide nanoparticle
C20-D80 + 30 ppm	Fuel blend of Cymbopogon flexuosus biofuel 20% + Diesel 80% + 30 ppm cerium oxide nanoparticle
D100	Diesel fuel
CFB	Cymbopogon flexuosus biofuel
BP	Brake Power
BTE	Brake Thermal Efficiency
BSEC	Brake Specific Energy Consumption
CA	Crank Angle
CI	Compression Ignition
CO	Carbon Monoxide
HC	Hydrocarbon
NO_x	Oxides of Nitrogen
Ppm	Parts per million
TDC	Top dead Centre
ASTM	American Society for Testing and Materials
RPM	Rotation per minute

experimental investigation of kapok (Ceibapentandra) oil biodiesel as a suitable alternative fuel for diesel engine. Kapok Methyl Ester was synthesized by trans-esterification process. The thermal efficiency was superior by 4% for the 25% blend of Kapok Methyl Ester. Biofuels seem to be suitable alternative solution to the research world but they cause reduction in thermal efficiency and increase in the emission levels majorly oxides of nitrogen in general [6,7].

Researchers have been further focusing on fuel modification by adding additives to the fuel to enhance its performance and emission characteristics. Vallinayagam et al. [8], examined the performance of pine oil biofuel ignition assistance in a single cylinder diesel engine. From his finding, the researchers stated that emissions namely CO and smoke was minimal for the inlet temperature of 40 °C. Brake thermal efficiency was encountered to be closer to that of the diesel fuel, while emissions such as smoke and CO got reduced for the air temperature of 60 °C. Varatharajan et al. [9], carried on an experimentations using jatropha fuels with antioxidant additives, such as N, N-diphenyl-1,4-phenylenediamine and for the addition of 150 ppm, NO_x was reduced by 16% while the emission of HC and CO was higher. Prabhu and Arockiasamy et al. [10], conducted an experimental analysis using alumina nanoparticle with jatropha biodiesel which ensued in step down of harmful emission such as carbon monoxide, oxides of Nitrogen, smoke and unburned hydrocarbon. Sajith et al. [11], performed an experimental study with cerium oxide nanoparticle and jatropha biodiesel in a single cylinder, diesel engine for respective doses of 20, 40, and 60 ppm. From the observation, the author reasoned out that reduction in NO_x and HC emissions was mainly due to the catalytic activity of nanoparticle. V. Arul MozhiSelvan et al. [12], studied the effect of cerium oxide nanoparticle at 25 ppm with diesel-biodiesel ethanol blends on a variable compression ratio diesel engine. They observed a drastic reduction of exhaust emissions such as hydrocarbon, nitric oxide, and carbon monoxide. M.J. kao et al. [13], studied the effect of the addition of Aluminum nanoparticle to diesel along with 3–6% volume of water on a diesel engine and encountered a reduced concentration of smoke and nitrous oxide with significant improvement in brake thermal efficiency. Basha and Anand et al. [14], attempted the blending of two different nanoparticles, namely alumina and carbon nanotube proportion of 25 and 50 ppm with Jatropha biodiesel and ascertained utmost diminution of NO_x by 23%. Among various fuel modification techniques, recently fuel additives, namely nanoparticles were preferred for minimizing the NO_x, HC, CO, and smoke emissions efficiently [15,16].

From the above literature, it has been established that the performance characteristics and emission magnitude has a higher influence with the addition of nanoparticle in biofuel. Not much attention has been paid by researchers all around the world to the use of Cymbopogon Flexuosus as a biofuel in diesel engines. Nevertheless, researchers such as (Avinash Alagumalai, 2015) [17] has conducted an experimental study in a partial premixed charge C.I engine with Cymbopogon flexuosus and observed a drop in heat release rate and cylinder pressure. Researcher Sathiyamoorthi R and Sankaranarayanan. G studied the effect of anti-oxidants on the neat lemongrass oil and concluded that antioxidant resulted in reducing NO_x emission with lemon grass oil [19]. In this present investigation, constitute the utilization of Cymbopogon Flexuosus biofuel, a renewable and biodegradable novel biofuel and its effects on cerium oxide nanoparticle as additive in C20-D80 biofuel for different doses of 10, 20 and 30 ppm respectively were studied. As on concern with authors earlier finding the study is restricted to C20-D80 biofuel blend which resulted in superior performance compared with other blend proportions of Cymbopogon Flexuosus biofuels [30].

2. Materials and methods

2.1. Test fuels and cerium oxide (CeO_2) nano particles

2.1.1. Cymbopogon flexuosus

The alternative fuel considered for this work is Cymbopogon Flexuosus oil, which is lemony and dark yellow in color, which grows mainly in India such as Kerala, and Tamil Nadu. it belongs to the family of Poaceae, which is tall repeated sedge and whose base is tightly buckled. The oil is essential in nature and extracted by steam distillation procedure. The chemical formula for the oil is $C_{51}H_{84}O_5$ which consists of 63%