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Reduction of Emissions from a Direct Injection Diesel Engine Using Tio_2 Nano Particles Additives

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Abstract—*The aim of the work is to enhance the performance of a diesel injection engine and to simultaneously reduce the exhaust gas emissions. Nowadays, alternative fuel energy sources are becoming more important due to diminished fossil resource. The nano fluids have been introduced in this study in order to mix with diesel to make diesel-TiO_2 nano fluid blends. Nano fluids have been produced by using sol-gel method and the tests like SEM and TEM are conducted to characterize the particle. These nano fluids are mixed with diesel in the proportion of D90:N10 and the tests are conducted in the four stroke single cylinder diesel engine without any modifications. This blend is used in diesel engine in order to measure the emission rate and the results are compared with conventional diesel oil. Thus this project deals with an alternate approach to increase the combustion rate by effectively reducing the emissions.*

1. INTRODUCTION

Diesel engine plays a vital role in power generation, transportation and industrial activities. The reason for the surge in diesel popularity is simple: better fuel economy at minimal expense. Typically, a diesel is 20 to 30 per cent more efficient than an equivalent petrol engine. Diesel fuel is priced moderately higher than gasoline but diesel has a higher energy density, i.e. more energy can be extracted from diesel as compared with the same volume of gasoline. Therefore, diesel engines in automobiles provide higher mileage, making it an obvious choice for heavy-duty transportation and equipment. India stands 6th in the world of oil consuming countries with an oil utilization of 2,438,000 barrels per day and its pollution problem appeared many years ago.

1.1 Need of Alternative Fuels

In today's world, where fuel prices are increasing as a consequence of spiralling demand and diminishing supply, we need to choose a cost effective fuel to meet our needs. Diesel powered vehicles and equipments account for nearly half of all nitrogen oxides and more than two thirds of all particulate matter emissions. Emissions of diesel-fuelled vehicle have high concentration of NOx and particulate matter. The mixture contain carbon particle that are exceptionally small in size, less than one micron. These particle may be deeply inhaled into the lung and carry with them a collection of attached hazardous compound.

Moreover the rapid depletion of fossil fuels due to widespread use has forced to search for some low emission and renewable sources. Current transportation technologies that are based on fossil fuel combustion have created a fragile and environmentally harmful system. Fragile, because the system relies on a continuous supply of energy-rich fossil fuels. Fossil fuel combustion is harmful to the environment because of the emissions that they contain, among other toxic and carcinogenic pollutants, greenhouse gases such as Carbon Dioxide. Scientific evidence shows that increased atmospheric concentrations of greenhouse gases are contributing to global warming and globalclimate change. The purpose of this review work is to elaborate the techniques of nanofluids which are used as an alternative fuel (blend with diesel) in diesel engine.

1.2 Approaches Towards Nano Technology

Nanofluids - A simple product of the emerging world of nanotechnology are suspensions of Nano particles (nominally 1–100nm in size) in conventional base fluids such as water, oils, or glycols. Nanofluids have seen enormous growth in popularity since they were proposed by Choi in 1995. In the year 2011 alone, there were nearly 700 research articles where the term nanofluid was used in the title, showing rapid growth from 2006 (175) and 2001 (10). The first decade of nanofluid research was primarily focused on measuring and modelling fundamental thermo physical properties of nanofluids (thermal conductivity, density, viscosity, heat transfer coefficient). (**Taylor** et al, **2013**) Recent research, however, explores the performance of nanofluids in a wide variety of other applications.

There are mainly two approaches that are used in nanotechnology:

Top-down approach: It referred as the synthesis of nanostructures from bulk.

Bottom-up approach: It referred as the formation of nanoparticles from constituent atoms.

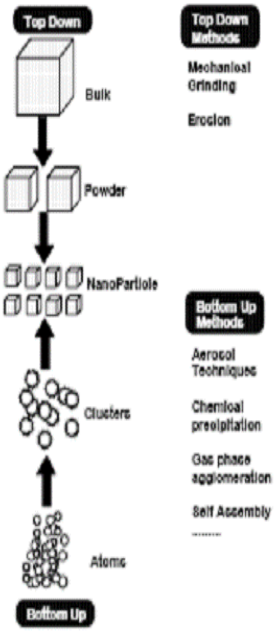

Fig. 1.1: Approaches of Nano Technology

2. MATERIALS AND METHODS

Nano TiO_2 was synthesised with pH condition of 4. Demineralized Water was obtained used for synthesis of nano materials. These are the some materials used to prepare the nano particles.

Titanium tetra iso propoxide - (Ti $(OiPr)_4$)

Acidic acid glacial - CH_3COOH

Demineralized Water - H_2O.

2.1 Synthesis of TiO_2 Nanoparticles

All the reagents used were of analytical grade and no further purification was done before use. TiO_2 Nano powders were prepared via sol–gel method using titanium tetra iso propoxide (Ti $(OiPr)_4$), Demineralized Water (H_2O), and glacial acidic acid (CH_3COOH) as the starting materials. The sol-gel synthesized TiO_2 was obtained from Titanium tetra iso propoxide was dissolved in absolute Acidic acid and distilled water was added to the solution in terms of a molar ratio of TTIP: H_2O: CH_3COOH =10:10:20 (ml). Nano particles were synthesized with pH condition of 4.

Initially take 20 ml of glacial acidic acid in the beaker and it is kept on the magnetic stirrer as shown in the Fig. 4.2.Now add 10ml of titanium iso propoxide in the acidic acid so it turned down into white slurry solution. Now the water is added drop by drop into the white slurry solution so that it can stirrer well. The Obtained slurry solutions were kept under slow-speed constant stirring on a magnetic stirrer for 40mins at room temperature. Now this white slurry solution turns down into white gel due to the continuous stirring and evaporation of water. Now add 10ml of titanium iso propoxide in the acidic acid so it turned down into white slurry solution.

Now the water is added drop by drop into the white slurry solution so that it can stirrer well. The Obtained slurry solutions were kept under slow-speed constant stirring on a magnetic stirrer for 40mins at room temperature.Now this white slurry solution turns down into white gel due to the continuous stirring and evaporation of water.

Now the gel is placed inside furnace where the temperature is maintained at 250^0c for 4 hours for calcination process.

2.3 Particle Size Determination

Fig. 6.2 indicated that TEM micrograph of TiO_2 nanoparticles. When the pH value is increased up to 4, the particle size was obtained in the range of 5-8nm and the size of the nano particles were quit uniform. The results of the TEM images are in good accordance with the results of the XRD patterns.

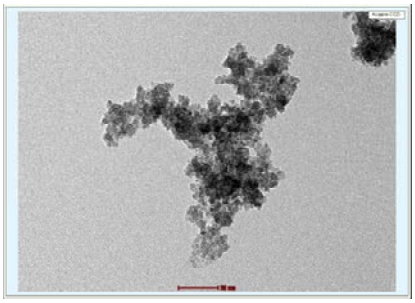

Fig. 2.1; TEM image of TiO_2

The average crystalline sizes of the synthesized nanoparticles were estimated from XRD line broadening using Scherer's equation by considering the full width and half maximum (FWHM) value.

$D=K\lambda/(\beta\cos\theta)$

Where D is the crystal size, λ is the wavelength of the X-ray radiation (λ=0.15406 nm) for Cu K α, K is usually taken as 0.9 and β is the full width at half-maximum height. It was found that an average crystalline size of prepared nano powder at pH4 is 6nm.

Table 2.1: Particle Size Determination

Angle (2Θ) (Degree)	Crystalline Size (nm)	Average Crystalline Size (nm)
27.5	6	6
36.1	4.3	
54.4	7.71	

From the table we can know that the obtained particle size for the pH level 4 for the TiO2 nano particle is 6nm. And it is calculated from the Scherer's equation. And the particle is in the form of anatase crystalline phase.

3. NANOFLUIDS PREPARATION

The amount of TiO_2 nanoparticles and Nano composites required for preparation of nanofluids is calculated using the law of mixture formula. A sensitive balance with a 0.1mg resolution is used to weigh the TiO_2 nanoparticles very accurately. Since TiO_2 particles are insoluble in water we can't use the distilled water as a base fluid so we need to disperse these particles in the methanol or ethanol solution. According to the law of mixture formula the percentage of nano particles to be dispersed are tabulated below.

Table 3 1: Percentage of Volume Concentration

S. No	Volume concentration (%)	Weight of particles (grams)
1	0.1	0.491
2	0.2	0.982
3	0.3	1.473
4	0.4	1.964
5	0.5	2.455

3.1 Diesel – TiO_2 Blend Preparation

After preparation of nano fluid we need to blend these nanofluids in the diesel. The blend ratio will be taken as D90:N10 (i.e.,) 100 ml of nanofluid is mixed with 900ml of diesel. In order to mix these fluids properly the stirrer or sonicator is used.

4. RESULTS AND DISCUSSIONS

Exhaust gas emissions

4.1 NO_x emissions

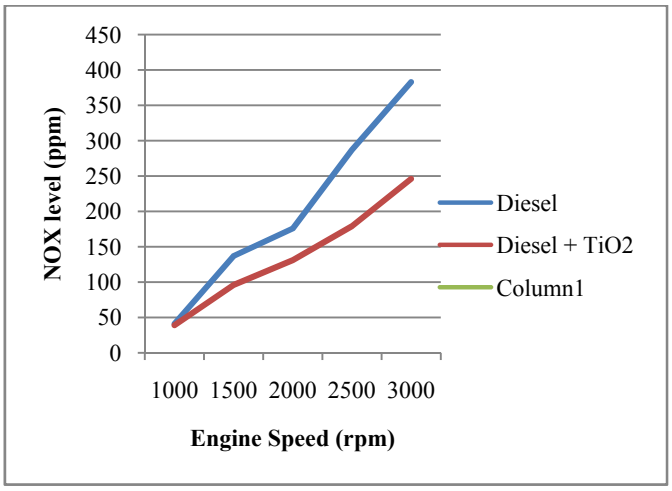

Fig. 4.1: NOx Emissions

From the Fig. we can say that NO_x level is increased with the increase of engine speed for diesel but for the D+TiO_2 blend NO_x level is considerably reduced when the speed of the engine is increased. This is due to the rise in thevolumetric efficiency and better mixing of fuel with the additive.

4.2 CO_2 Emissions

The results shows that lower CO_2 emissions were observed while using the additives as compared with diesel fuel. This is due to the catalyst effect during the combustion process.

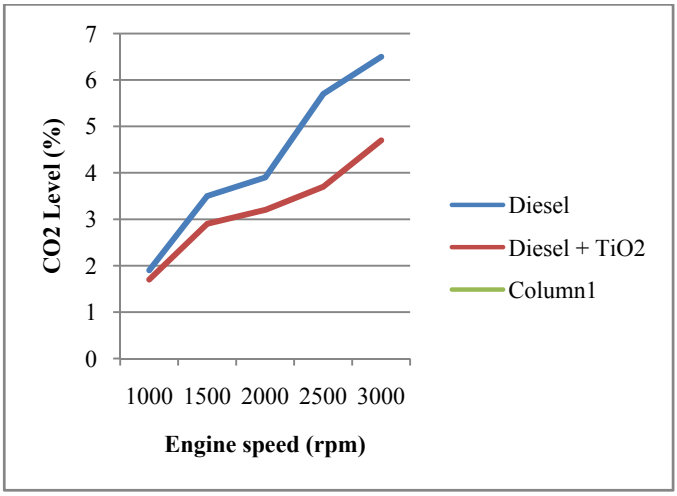

Fig. 4.2 CO_2 Emissions

5. CONCLUSIONS

This study provides the preparation of TiO_2 particles by sol gel process and the nanofluids are prepared by two step process. The characterizations of particles were conducted to determine the size and structure of the particles. Then these fluids were successfully blend with diesel and the engine tests were carried out. The result shows that fewer NOx and CO_2 emissions were observed when compared with diesel fuel.

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