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Experimental studies on fuel filter coated with nanoparticles on the exhaust emissions of 4-stroke engine

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Abstract – *The fuels used in the vehicles emit huge amount of exhaust gases due to the incomplete combustion in the engine. The exhaust gases often consists of Oxides of Carbon(CO,CO_2), Nitrogen(NO_X) and Hydrocarbons(HC).Fuel filters play an important role in supplying clean fuel for combustion there by reducing emissions. In this work, coating of fuel filters using Nanoparticles has been proposed to improve the performance of fuel filters and reduce air pollution from the vehicular exhaust. Nanofilters are intended to provide good filter performance, maintain high efficiency, and reduce maintenance cost and also service intervals. Tests have been conducted to improve overall performance of the filtration of the existing fuel filter by coating them with cerium oxide nanoparticle.*

Key Words: Fuel Filter, nanoparticle, cerium oxide, engine emissions, IC engine.

1. INTRODUCTION

A fuel filter is a component in the fuel line that collects contaminants and moisture from the fuel and allows clean filtered fuel. They are normally in the form of cartridges containing a filter paper.

Fuel Filters plays an important role in present day which have tight-tolerance fuel systems. Several types of contaminants are present in the unfiltered fuel such as paint chips and rust formed due to presence of moisture in steel tank. Dirt and moisture may also be present, which will cause rapid wear and failure of the fuel pump and injectors, due to the abrasive action of the particles on the high-precision components used in modern injection systems. The filters help in improving performance of the engine by eliminating contaminants present in the fuel. This helps to achieve complete combustion.

Types of fuel filters:

i) Fuel Filter Types According to filter element:
a. Pleated Filter Element: In a typical filter assembly, a filter element is located within housing in such a manner that the relevant fluid flows through the filter element and particles are removed from there. In this type of filter element, the filter media comprises a cylindrical construction with pleated material. It can be either coreless (i.e., the media's inner radius is self-supporting or it can include an integral support tube.

b. Slot Depth Filter Element: In this type, the fluid flow usually takes a radial path through the filter media and the filtering path is a relatively short one.

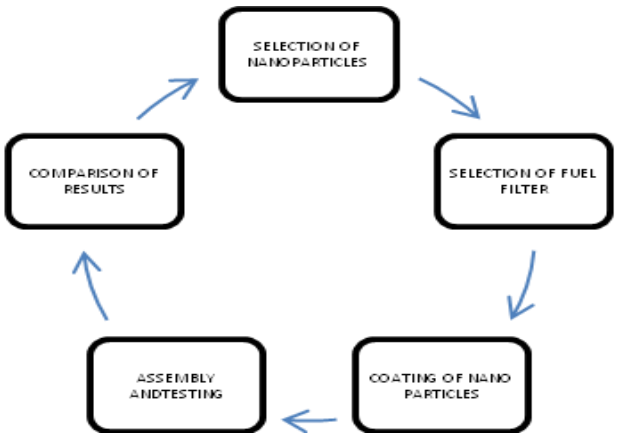
ii) Fuel Filter Types According to Structure:

According to the structure, fuel filters are classified as
a. Spin on- Filter consist of Filter Head, Filter Can and bowl. Filter media is inside of the filter can.
b. Cartridge- Cartridge Filters consist of Filter head, Bowl and filter media

1.1 Cerium Oxide Nanoparticles

Cerium oxide, or cerium dioxide, is a very abundant material. Cerium oxide in nanoparticle form has been used in various applications in the automobile industry. It has the ability to catalyze combustion reactions, by donating oxygen atoms from its lattice structure. It has also been shown that cerium oxide decreases the pressure in the combustion chamber, which reduces the production of NO and makes combustion reactions more efficient. Research has shown adding cerium oxide nanoparticle to fuel can help in decomposition of unburnt hydrocarbons and soot, reducing the amount of these pollutants emitted in the exhaust and reducing the amount of fuel used. Cerium oxide nanoparticles have been used treating particulate filters in diesel engines. The nanoparticles have been found to help clear away soot which clogs up the filters, and help in improving the performance of the filters. Because of these properties, Cerium oxide nanoparticles were used for coating the filter.

2. METHODOLOGY



Stage 1: Selection of Nanoparticles

In this stage different nanoparticles were studied for fuel filtration purpose based on their properties such as catalysis, accumulation of dust, absorption of moisture etc. cerium oxide nanoparticle are selected because of their availability, cost and desirable filtration properties. The Cerium Oxide of 99.9% purity 20-30nm size spherical nanoparticles is selected.

Stage 2: Selection of Fuel Filter

In this stage fuel filters of different vehicles are studied for structure and filtration properties and for the experimental studies, pleated type fuel filter is selected considering the ease of coating nanoparticles.

Fig 1: Pleated Fuel Filter

Stage 3: Preparation of Coating Mixture

In this stage mixture of low viscous epoxy(Bisphenol A) and cerium oxide nanoparticles are mixed to obtain binding mixture, experiment is conducted in various stages by varying the proportion of nanoparticles in coating mixture.

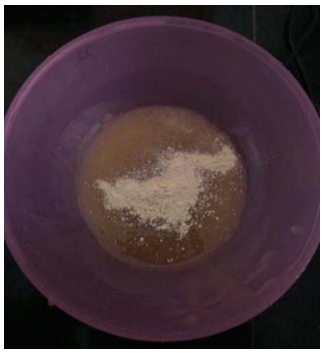


Fig 2: Coating Mixture

Stage 4: Coating of Nanoparticles

The coating mixture is coated on to fuel filter, using brush coating method and coating thickness is measured by using coating thickness gauge. The thickness measured for five samples were, 193.5 µ, 259.75 µ, and 291.5µ respectively.

Stage 5- Assembly and Testing

The coated nanofilter is dried in a room temperature for about 24hrs and assembled into filter assembly and emission tests are conducted.

Fig 3: Fuel Filter assembly

3. RESULTS

The nanoparticle coating was prepared by mixing 5% Cerium oxide nano particles to resin and hardener mixture and 2.5g of thinner was added to achieve the suitable consistency. The coating thickness measured using digital coating thickness gauge was found to be 193.5µ.

3.1 EMISSION TEST

Emission test were conducted by using the filtered fuel using 4 stroke petrol and diesel engine. The results were compared with fuels filtered with stock filter without nano particle coating.
The results are tabulated as below:

3.1.1. Emission test results for Petrol Engine

Table 1 Fuel filter coated with nanoparticle

Components	Measured Level
CO	00.917 % Vol
HC	00094 PPM
CO_2	04.68 %Vol
O_2	13.73PPM

Table 2 Fuel filter without nanoparticle coating

Components	Measured Level
CO	01.903 % Vol
HC	00149 PPM
CO_2	06.75 %Vol
O_2	08.94 PPM

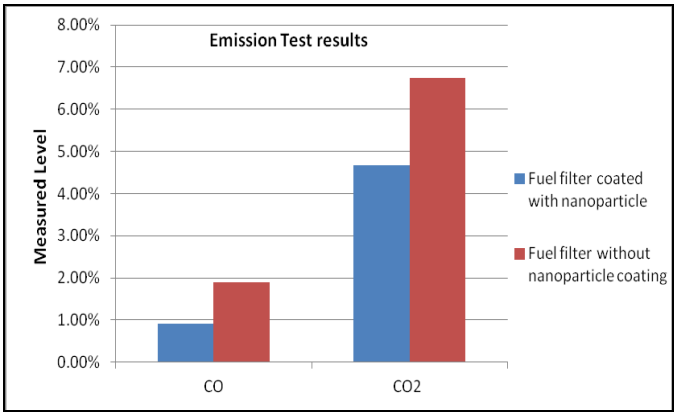


Fig 4: Comparison of CO and CO_2 emissions

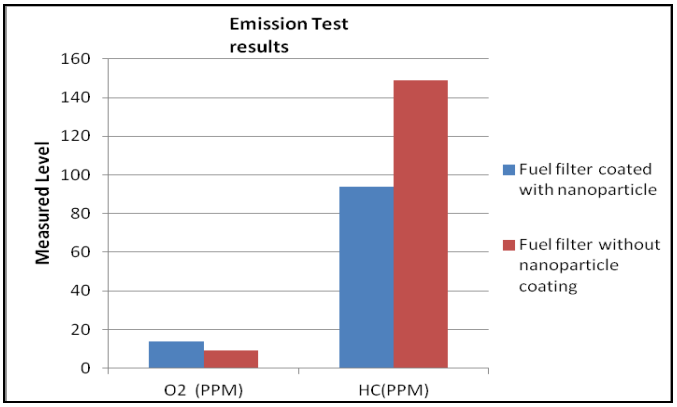


Fig 5: Comparison of O_2 and HC emissions

It is observed from the above results that, there is 51.57% reduction in CO and 30.66% reduction in CO_2 and 36.9% reduction in HC emissions.

3.1.2. Emission test results for Diesel Engine

Table 3 Fuel filter without nanoparticle coating

RPM min	RPM max	Km	HSU%
0770	3280	0.26	10.57
0770	3360	0.07	02.96
0770	3510	0.14	05.84
0770	3400	0.04	01.70
Mean		0.12	05.33

Table 4 Fuel filter coated with nanoparticle

RPM min	RPM max	Km	HSU%
0770	2790	1.74	52.67
0770	2990	0.24	09.80
0770	2810	0.04	01.70
0770	3000	0.03	01.70
0770	3010	0.03	01.28
Mean		0.08	03.58

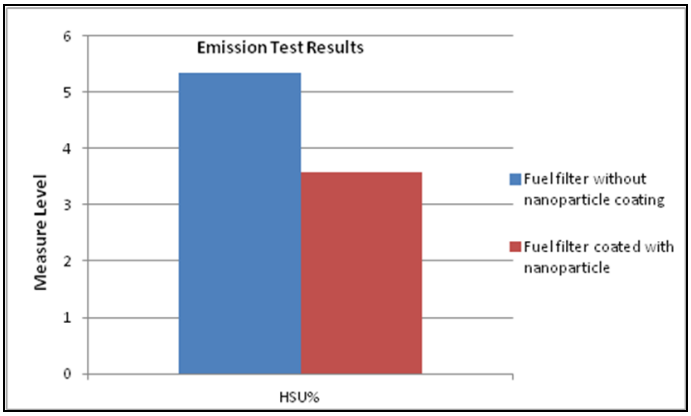


Fig 6: Comparison of HSU% for coated and uncoated filters

In case of diesel engine, the emission testing of the diesel fuel filtered through nanoparticle coated filtered showed 32.8% reduction in HSU%.

4. CONCLUSION

It is observed from the results that the fuel filters coated with cerium oxide nanoparticle showed reduction in the Co, CO2 and HC emissions in petrol engine and average HSU % in diesel engine.

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