Effect of thermal barrier coating by nano particle on IC engine for various bio fuels - Review

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Abstract:
Present days Nano coatings envelop various benefits over other traditional coatings, track the nano meter (nm) scale structure and synthesis to control the products due to one of the ultra low-size properties. The significant difficulties confronting preceded with development of nanotechnology based coatings are scattering, characterization, material cost, health and safety. Cutting edge advancements have focused on the low emission, higher performance and efficiency of engine applications. This review considers the fundamental outcomes accomplished up to now, and is centered around the issue looking in emissions of the engine with nano coating worked on bio-diesel blends.

Key words: Nano particle, thermal barrier coating, alternative fuel, emission.

1. Introduction

Nanotechnologies are currently broadly considered to can possibly acquire benefits regions as differing as medication advancement, water disinfecting, data and communication technologies, and the production of much stronger and lighter materials. Nanotechnologies include the creation and control of materials at the nano meter scale, either by scaling up from the single group of particles or by refining or lessening mass materials [1]. While the improvement of nano technologies is a cutting edge multi-disciplinary science including the fields of materials
science, chemistry, engineering, science and technology and the production of nano particles (NPs), both in nature and by people, dates from the pre-Christian era. For instance, the Romans invented metals with nano metric measurements in glass-production; the popular Lycurgus Cup (as of now showed at the British Museum), which shows an alternate shading relying upon whether it is illuminated externally (green) or internally (red), contains NPs of silver and gold [2]. In 1857, Faraday announced the union of colloidal gold (and different metals, for example, Cu, Zn, Fe and Sn) and its interaction with light [3].

All through the only remaining century, the field of colloid science has grown immensely and has been utilized to deliver numerous materials, including metals, oxides and natural items [4, 5]. One of the first and most easily prepared magnetic colloidal systems was developed by Stephen Papell of the National Aeronautics and Space Administration in the early 1960s [6]. Papell's colloid comprised of finely isolated particles of magnetite suspended in paraffin. To avoid the particle–particle agglomeration or sedimentation, Papell included oleic acid as a scattering agent. In this way, same magnetic suspensions have also been incorporated with various nanometers estimated particles of pure components, for example, iron, nickel and cobalt, in a wide scope of carrier fluids [7, 8]. The nano powder coating technique is shown in figure1

![Fig1. Nano powder thermal spray coating technique](image)

Normal materials, when diminished to the nano scale, frequently display novel and uncertain attributes, for example, remarkable strength, chemical reactivity, electrical conductivity, super paramagnetic performance and different attributes that a similar material doesn’t have at the micro scale or macro scale. The nano particles are primarily classified by their size. Ultrafine particles are estimated somewhere in the range of 1 and 100 nm, Somewhere in the range of 100 and 2500 nm, small particles are measured, and coarse particles fall between the range from 2500 to 10000 nm. Due to their enhanced properties, NM-sized particles are of great importance
for a wide variety of applications [14]. Nano particles are additionally discovering the use in unconventional energy production, repository, and transformation and this can significantly diminish the dependence on petroleum fuel ignition and emission [15]. An enormous scope of nano materials is right now being delivered at a mechanical scale, while others are being created at littler scopes as they are still under development work shown in table 1.

Table 1 A non-exhaustive list of nano materials, either used in industry or under investigation [9]

| Aluminium oxide | dimethyl siloxide | polyethylene |
|-----------------|-------------------|-------------|
| Aluminium hydroxide | dysprosium oxide | polystyrene |
| Antimony oxide  | fullerences        | praseodymium oxide |
| Antimony pentoxide | germanium oxide | rhodium |
| Barium carbonate | indium oxide      | samarium oxide |
| Bismuth oxide   | iron and iron oxides | silanamine |
| Boron oxide     | lanthanum oxide   | siliccon dioxide |
| Calcium oxide   | lithium titanate  | silver |
| Carbon black    | manganese oxide   | carbon nanotubes |
| Cerium oxide    | molybdenum oxide  | tantalum |
| Chromium oxide  | nanoclays         | terbium oxide |
| Cluster diamonds| neodymium oxide   | titanium dioxide |
| Cobalt and cobalt oxide | nickel | tungsten |
| Colloidal gold  | niobium           | yttrium oxide |
| Copper (II) oxide | palladium     | zinc oxide |

In a traditional IC engine, roughly 33% of the fuel supplied is converted into useful operation, for exhaust gases a large part of the energy is wasted and the remaining part of the energy is discharged in the form of heat through the cooling system [10]. Through reducing heat losses the diesel engine efficiency can be increased. Reducing the flow of heat through the internal combustion engine walls is the main objective of adiabatic engines [11] which are also known as low heat rejection engines. We also named this kind of engines as coated engines with thermal barriers. Because of the cylinder wall insulation, the heat transfer to the cooling system
through the cylinder walls is decreased which affects the diesel engine's combustion characteristics. Thermal boundary coatings monitor the thermal fatigue of underlying metallic surfaces and further decrease CO, smoke, hydrocarbon emissions [12] inside chamber heat rejection. The diesel engine with its ceramic-insulated combustion chamber walls, cylinder head, lining, and piston crown is known as the LHR engine [13].

The objective of the paper is to study about the effect of thermal barrier coating by nano particle on IC engine for various bio fuels.

2. NANO PARTICLES PREPARATION METHODS:

There are various types and methods for preparation of nanoparticles available which is shown in figure 2.

3. NANO COATINGS IMPACT ON ENGINE PERFORMANCE

From the study of numerous articles, it has been observed that use of different types of coating materials and coating technologies, and an engine is fuelled by different biofuels. Several articles discussed the engine performance, SFC, and exhaust gas emissions. Senthil Ramalingam et al [16] throughout his research the performance and pollution of a direct injection diesel engine is investigated using nano-catalyst nano-coated piston. By using the plasma spraying technique, the piston and its top, the nanoparticles were coated with copper and cadmium. The engine’s emissions and output characteristics were compared with normal values. It has been seen that the performance and decrease of various emissions had been significantly improved. The brake thermal efficiency and specific fuel consumption were enhanced in the
piston coated by copper nanocatalyst. Among the pistons coated with copper chromium nanocatalyst the copper nanocatalyst piston reduces hydrocarbon, smoke particulate and nitrogen oxides to a greater degree than other pistons coated with metal catalyst.

On top of the piston, copper and nickel nanocatalyst coatings were used by Senthil et al [17] in his study. Hydrocarbon emissions have been lowered by 64%, smoke levels have decreased to 21%, NOx emissions have also decreased to 45%. Copper nanocatalyst coated pistons have increased the thermal brake efficiency and basic fuel consumption.

Shivakumar et al [18] Experimental examination are completed under various loading parameters in a three-chamber diesel engine with a piston crown coated with Yttria Stable Zirconia (YSZ) to consider the output and emission characteristics of the thermal barrier (TBC) were compared with base values of the diesel engine. In standard test cycle protocol, the test results showed a 5–10 percent reduction in heat loss in cooling water and a 3–5 percent increase in thermal efficiency with BSFC decreasing by up to 28.29 percent. Test findings further found that HC emissions decreased by up to 35.17%, carbon dioxide decreased by up to 2.72%, and CO2 rose by up to 5.6%.

Mohammed musthafa et al [19] has used plasma spray coating technique to take Al2O3 nano-ceramic material for thermal barrier coating on the engine combustion chamber with a thickness of 200 micrometres. The Al2O3 coating was used in the subsequent stage. At last, the engine power decreased, and Specific fuel consumption is decreased, and except NOX emission other exhaust gas emissions are decreased.

Selman Aydin et al [20] performed a trial using 100 mm of NiCrAl as a coating film, covering identical surfaces with 400 nm of the 88% ZrO2, 4% MgO and 8% Al2O3 mix. The combustibles were tested in the coated engine after the coating process. Partial increases in power, engine noise, and exhaust manifold temperature were observed, while a partial reduction was seen in specific fuel consumption (SFC). Fractional reductions have also been observed in carbon monoxide (CO), hydrocarbon (HC), and smoke discharges, but small rises have been seen in nitrogen oxide (NOx) emissions.

Dinesh et al [21] have conducted experiments on a single-cylinder direct injection diesel engine fuelled with Biofuel Cymbopogon flexuosus. He is Focusing on the coating material, YSZ (Yttria-stabilized zirconia). As a next phase YSZ was coated on the engine piston, valves, and cylinder head by the plasma spray coating technique. This was determined using the quantitative assessment of the test samples that the engine's thermal output was improved by 1.75 percent as opposed to the traditional engine with the adjusted fuel blend. In the emission perspective, fuel-based emissions like HC, CO, and smoke opacity were diminished were increases of nitrogen oxide emission.

Senthil et al.[22] used the plasma spray process to partly stabilize zirconia coating material. By using the biofuel of Nerium oil, the coated engine was tested. There is an increase in brake
thermal efficiency of the coated engine up to 3.8% compared to the uncoated engine. Compared with the uncoated engine, emissions for the coated engine were improved except for NOX.

Ravikumar et al [23] tested Mahua blends as fuel using both coated engine thermal barriers (Al-20 per cent SiC) and an ordinary engine for efficiency evaluation. There is no significant improvement in the brake thermal efficiency and specific fuel consumption between standard engine and thermal coated engine in his trial experiments. The B25 blend provides the better and lower emissions but the NOx emissions are raised in the coated engine with higher loads for the neat biodiesel.

Shakti P. Jena et al [24] tested the engine output and emission characteristics of a single-cylinder diesel engine with yttria-stabilized zirconia (YSZ) coating on piston crown and valves in a YSZ-coated engine, which increased the thermal brake efficiency by 2.7 percent and reduced brake-specific fuel consumption by 8.3 percent compared to normal uncoated diesel engine mode. Resulting in an increase in CO and NOX levels, fuel pollutants such as carbon monoxide, hydrocarbons, and toxicity of smoke reduced.

In a single-cylinder engine, Prabhu L et al [25] experimented with the yttria-stabilized zirconia (YSZ) and nickel-chrome-coated piston. The coating was achieved using a technique of plasma spray coating which improved the emissions of HC and CO in the exhaust gas and saw a subsequent improvement in the combustion and thermal efficiencies.

4. CONCLUSION

A detailed analysis of present work on the performance and emission characteristics of an IC engine with specific thermal barrier coated by nano powder was analyzed in this article. The following hypotheses are taken based on the above description.

- In terms of power, fuel consumption and thermal efficiency, almost all researchers reported improved engine performance.
- Emissions from engines such as HC and CO have been minimized with the use of coated thermal barrier engines for most oils.
- Due to higher combustion temperature, the NOx output rose.
- The exhaust temperature of nano-coated engines also decreased.

5. Reference

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