Pollution Prevention from Diesel Engine based Automobiles using Nano-Particles

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***Abstract*—This research paper is based on the pollution prevention from the diesel engine based automobiles using nano-particles which act as a catalyst and reduce the concentration of the exhaust emissions from the tail pipe of automobiles. Light has been thrown on the effectiveness of nano-particles and nano-technology in the field of automobile pollution control. Diesel engine based automobiles have become one of the major contributors in the degradation of the environment. So, this research paper opens a pathway on the scope of utilization of nano-particles in automobile pollution prevention and control.**

Keywords- Automobile pollutiont; diesel engine; nano-particles.

I. NANOTECHNOLGY AND ITS APPLICATIONS IN AUTOMOBILES

Nano-technology is a general term to define a wide range of technologies concerned with structures and processes on the scale of a nanometer (one billionth of a meter). It is a collective term for tools and techniques that permit the atoms and molecules that comprise all matter to be manipulated [1]. Nano-science and nano-technology are two new approaches to research and development that focus on controling the environmental pollution and reduction of energy consumption [2].

The applications of nanotechnology are widespread, increasing day by day and soon, it will have a great impact on the life of every individual. Using the nanotechnology tools and techniques, it is possible to change the size-dependent properties of materials structured on the sub-100 nanometer scale, which can be assembled and organized to produce nano-devices and nano-systems that have new or improved properties [3]. Materials manufactured on a nanometer scale behave differently from similar materials produced on a larger scale. Nanotechnology will not only influence technological development in the near future, but may also have a vital impact on the economic, ecological and social sectors [4]. In the automobile sector, nanotechnology applications can be found in areas like light-weight construction, pollution sensing and reduction, wear reduction, interior cooling, energy conversion, driving dynamics and surveillance control [5].

II. EFFECTIVENESS OF NANO-PARTICLES IN AUTOMOBILE POLLUTION CONTROL

Due to the very small dimensions of nano-particles, their physical and chemical properties like stability, hardness, conductivity, reactivity, optical sensitivity and melting point can be altered to modify the overall properties of the conventional materials. Nano-particles are being preferred for potential use in catalytic converters due to excellent catalytic reactivity. This property can be used for decreasing the concentration of the exhaust emissions coming out of the automobiles [6].

The environmental pollution from vehicles is due to the tail-pipe exhaust emissions and it depends on the changes in driving cycles, engine condition, fuel composition and air-fuel ratio. Any malfunction of the engine devices mainly, the fuel injection system, increases the concentration of the main exhaust components [7]. Vehicular emissions include Carbon dioxide, carbon monoxide, nitrogen oxides, hydrocarbons, lead and particulate matter. Inhalation of Carbon monoxide disrupts the oxygen supply from blood into the tissues by combining with the iron in hemoglobin, giving way to a variety of ailments. Carbon dioxide leads to global warming [8]. Unburnt hydrocarbons are produced in the exhaust emissions as a result of incomplete combustion of fuel. The level of unburnt hydrocarbons is generally specified as parts per million (ppm) carbon atoms [9]. Coolants use nano-particles and nano-powders to improve the efficiency of heat transfer and significantly reduce the size of the automobile cooling equipment [10].

III. CATALYTIC CONVERTER WITH NANO-PARTICLES COATING

To solve the problem of air pollution due to automobiles states and government create clean-air-laws that restrict the amount of pollution that vehicles can produce. Over the years, automakers have made many refinements to car engines and fuel systems to keep up these laws. One of these changes came about in 1975 with a very interesting device known as a catalytic converter. A catalytic converter works as a vehicle emissions control device that converts toxic pollutants in exhaust gas to less toxic pollutants by catalyzing a redox reaction (oxidation or reduction) [11].

Catalytic converters are employed in internal combustion engines fueled by either petrol (gasoline) or diesel—including lean burn engines. The catalytic converter was invented by Eugene Houdry, a French mechanical engineer and a specialist in catalytic oil refining. Catalytic converter generally consists of a core (which is usually a ceramic monolith with a honeycomb structure) and washcoat (which is a carrier for catalytic materials and is used to disperse the materials over a large surface area) [12]. The catalyst used in catalytic converter is most often a mix of precious metals. Platinum is the known to be the most active catalyst and is also widely used, but it is not apt for all applications owing to unwanted

additional reactions and high cost. Palladium and Rhodium are the two other precious metals [13]. Rhodium is used as a reduction catalyst whereas palladium is used as an oxidation catalyst and platinum is used both for reduction and oxidation. Manganese, iron and nickel are also used, although each has limitations [14].

The converter employs two different types of catalyst namely, reduction and oxidation catalyst. The concept behind the work is to develop a structure that exposes the maximum surface area of catalyst to exhaust emissions, also minimizing the amount of catalyst required. The exhaust gases are made to pass through a bed of catalyst and the catalytic action takes place at surface of Cu which is porous and the higher catalytic activity towards the oxidation of CO and HC could be due to the higher catalytic surface area of small nano-particles. It is presumed that the electrophilic nature of the catalyst surface renders a weak bond between the CO and vacant the system of copper atoms [15].

There are two methods of control of pollution namely; pre-pollution control and post pollution control. Many environmentalists are focused in employing precious metal nano-particles as exhaust filters, both for vehicles as well as for power plants [16]. In vehicles, particularly those that are diesel-powered, the nano-particles have proved to be effective in oxidizing harmful hydrocarbon compounds that are released in their exhaust leading to a reduction their negative impact on the atmosphere [17]. Platinum, gold and palladium are the most commonly used when it comes to diesel filtering. A study on nano-particle reveals that the ratio of surface area of nano-particle to the volume of the nano-particle is inversely proportional to the radius of the nano-particle. So, by decreasing the radius of the nano-particle, this ratio increases leading to an increased rate of reaction and the concentration of the pollutants is decreased [18].

The nano-particle coating on the catalytic converter of automobiles can be very helpful in the reduction of pollutant concentration and thus reduce the pollution level in atmosphere. Amongst main metals like gold, palladium, platinum, towards which nanotechnology research is directed, copper as well as copper based compounds are the most important. Copper performs a significant role in modern electronics circuits due to its excellent electrical conductivity and low cost nano-particles [19].

IV. Experimental Procedure For Measurement Of Exhaust Emissions From Diesel Engine Automobiles

First of all for the analysis of the emission of exhaust gases from the tail pipe are being determined by an instrument, known to be as the Multi Gas Analyzer which is shown in Fig. 1. It is mainly used for the measurement of exhaust emissions like Carbon monoxide, Hydrocarbons and Nitrogen oxides. Many different models of a Multi Gas Analyzer are available in the market. Any one model can be chosen suitably. The concentration of the exhaust emissions is determined at different loads, i.e., quarter load, half load, three-fourth load and full load. Speed is also varied accordingly.

1) To measure the concentrations of exhaust emissions using nano-coated catalytic converter, the experimental procedure is as follows:
2) Connect the instrumentation power input plug to a 230 V, 50 Hz single phase AC supply. Now all the digital meters namely, rpm indicator, temperature indicator display the respective readings.
3) Fill up the diesel to the fuel tank mounted side of the panel.
4) Check the lubricating oil level in the oil sump.

Fig. 1: Multi Gas Analyzer

5) Start the engine with the help of given attachments.
6) Allow the engine to stabilize the speed
7) Apply ¼ load, i.e. slowly vary the load attachment.
8) Note down all the required parameters.
9) Increase the load on the engine step by step with the use of load attachment such as,
   a) $\frac{1}{4}$ load
   b) $\frac{1}{2}$ load
   c) $\frac{3}{4}$ load
   d) Full load
10) Repeat the above procedure for different speed and load conditions.

V. Results And Conclusion

The problem of environmental pollution from the diesel engine automobiles has become a serious concern. Many researchers have done analysis on various techniques that can be used for exhaust emissions reduction. The use of nano-particles is becoming very popular in the area of automobile pollution control due to their small size and special characteristics. Various nano-particles that are used for automobile pollution control include copper, platinum, palladium and rhodium out of which copper is widely used

due to its low cost. Catalytic converters coated with nano-particles are emerging as one of the most effective means to reduce the concentration of the exhaust emissions coming out of the tail-pipe of diesel engine automobiles. This research work opens a pathway for further investigation on the design of catalytic converter to effectively reduce the concentration of exhaust emissions from the diesel engine automobiles. This research work can be very helpful especially, for rural development and welfare as the employment of nano-particles coated catalytic converters in automobiles will prevent the fast degradation of the rural environment and greenery due to the exhaust emissions from automobiles.

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