

Review on Nanoparticles in CI Engines with a New and Better Proposal on Stabilisation

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ABSTRACT: Emission control is one of the major challenges observed in IC Engines and in the field of automobiles. Various theories have been proposed to reduce emission and still at present research is on-going to achieve emission control as per zero emission standards all over the world. Emission cannot be completely eradicated from automobiles but instead can be minimised to the lowest level. The need to minimise emissions at the lowest level is to ensure safety for the public and also to the vehicle. Nanoparticles have been found to be well efficient in emission control. But some defects are observed in the use of Nano-particles and their nature of reactions. A newly proposed method is introduced so as to reduce those defects and achieve the near zero emission from automobiles with enhanced performances.

KEYWORDS: CI Engines, Exhaust, EGR, Nano-particles, Applications, Emissions

I. INTRODUCTION

Diesel is a commercially available fuel and provides a higher mileage than Gasoline. The Diesel emissions are different from Gasoline emissions. CI engines use a injector for fuel ignition and Exhaust patterns vary in nature over time. Exhaust Gas Recirculation is a very useful mechanism to reduce emissions and harness the exhaust for useful purposes. Nano-particles thought miniscule in nature act as a single unit and a combination of particles together form a bigger unit with the same particle. The zig-zag Brownian Movement of the Nano-particles need to be maintained at the normal level and particles should not be put to rest. Brownian Movement ensures active presence of excited motion of Nano-particles in Diesel Medium.

II. CI ENGINES

Combustion in a CI engine is an unsteady process occurring simultaneously at many spots in a very non-homogeneous mixture at a rate controlled by fuel injection. Air intake into the engine is unthrottled, with engine torque and power output controlled by the amount of fuel injected per cycle. Because the incoming air is not throttled, pressure in the intake manifold is consistently at a value close to one atmosphere.

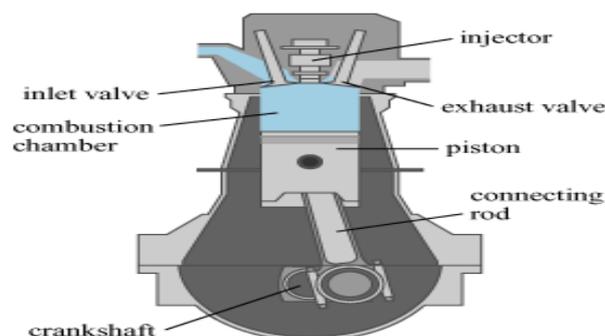


Fig.1 CI Engine

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Fig.2 Experimental Apparatus

Only air is contained in the cylinder during the compression stroke, and much higher compression ratios are used in CI engines. Compression ratios of modern CI engines range from 12 to 24. Fuel is injected into the cylinders late in the compression stroke by one or more injectors located in each cylinder combustion chamber. Injection time is usually about 20° of crankshaft rotation, starting at about 15° TDC and ending about 5° TDC. Ignition delay is fairly constant in real time, so a higher engine speeds fuel injection must be started slightly earlier in the cycle.

After injection the fuel must go through a series of events to assure the proper combustion process:

1. Atomization. Fuel drops break into very small droplets. The smaller the original drop size emitted by the injector, the quicker and more efficient will be this atomization process.

2. Vaporization. The small droplets of liquid fuel evaporate to vapour. This occurs very quickly due to the hot air temperatures created by the high compression of CI engines. High air temperature needed for this vaporization process requires a minimum compression ratio in CI engines of about 12:1. About 90% of the fuel injected into the cylinder has been vaporized within 0.001 second after injection. As the first fuel evaporates, the immediate surroundings are cooled by evaporative cooling. This greatly affects subsequent evaporation. Near the core of the fuel jet, the combination of high fuel concentration and evaporative cooling will cause adiabatic saturation of fuel to occur. Evaporation will stop in this region, and only after additional mixing and heating will this fuel be evaporated.

3. Mixing. After vaporization, the fuel vapour must mix with air to form a mixture within the AF range which is combustible. This mixing comes about because of the high fuel injection velocity added to the swirl and turbulence in the cylinder air shows the non-homogeneous distribution of air-fuel ratio that develops around the injected fuel jet. Combustion can occur within the equivalence ratio limits of $cP = 1.8$ (rich) and $cP = 0.8$ (lean).

4. Self-Ignition. At about 8° bTDC, 6_8° after the start of injection, the air-fuel mixture starts to self-ignite. Actual combustion is preceded by secondary reactions, including breakdown of large hydrocarbon molecules into smaller species and some oxidation. These reactions, caused by the high-temperature air, are exothermic and further raise the air temperature in the immediate local vicinity. This finally leads to an actual sustained combustion process.

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5. Combustion. Combustion starts from self-ignition simultaneously at many locations in the slightly rich zone of the fuel jet, where the equivalence ratio is 1 to 1.5. At this time, somewhere between 70% and 95% of the fuel in the combustion chamber is in the vapor state. When combustion starts, multiple flame fronts spreading from the many self-ignition sites quickly consume all the gas mixture which is in a correct combustible air-fuel ratio, even where self-ignition wouldn't occur. This gives a very quick rise in temperature and pressure within the cylinder. The higher temperature and pressure reduce the vaporization time and ignition delay time for additional fuel particles and cause more self-ignition points to further increase the combustion process. Liquid fuel is still being injected into the cylinder after the first fuel is already burning. After the initial start of combustion when all the air-fuel mixture that is in a combustible state is quickly consumed, the rest of the combustion process is controlled by the rate at which fuel can be injected, atomized, vaporized, and mixed into the proper AF. This rate of combustion, now controlled by injection rate, in the slower pressure rise that occurs after the initial fast rise. Combustion lasts for about 40° to 50° of engine rotation, much longer than the 20° of fuel injection.

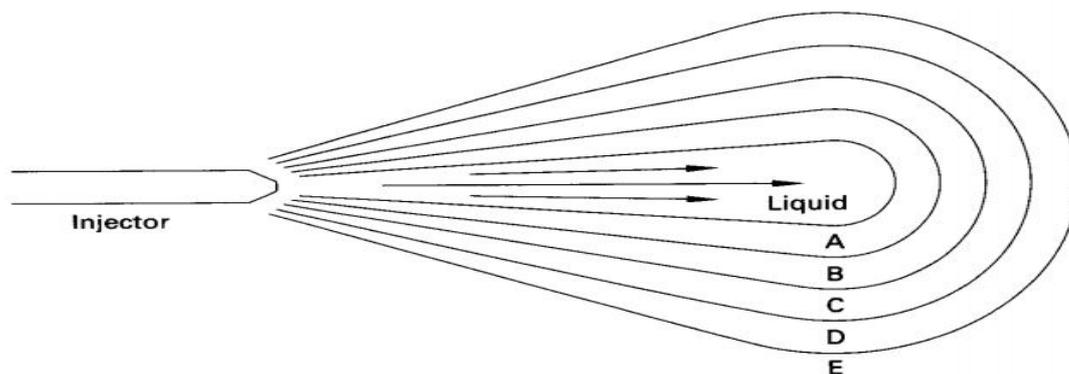


Fig.3 Combustion Layers of Fuel

(A) too rich to burn, (B) rich combustible, (C) stoichiometric, (D) lean combustible, and (E) too lean to burn. Self-ignition starts mainly in zone B. Solid carbon soot is generated mostly in zones A and B.

III. EXHAUST FROM CI ENGINES

Catalytic converters are used with CI engines but are not efficient at reducing NO_x due to their overall lean operation. HC and CO can be adequately reduced, although there is greater difficulty because of the cooler exhaust gases of a CI engine (because of the larger expansion ratio). This is counter-balanced by the fact that less HC and CO are generated in the lean burn of the CI engine. NO_x is reduced in a CI engine by the use of EGR, which keeps the maximum temperature down. EGR and lower combustion temperatures, however, contribute to an increase in solid soot. Platinum and palladium are two main catalyst materials used for converters on CI engines. They promote the removal of 30-80% of the gaseous HC and 40--90% of the CO in the exhaust. The catalysts have little effect on solid carbon soot but do remove 30-60% of the total particulate mass by oxidizing a large percent of the HC absorbed on the carbon particles. Diesel fuel contains sulfur impurities, and this leads to poisoning of the catalyst materials. However, this problem is

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being reduced as legal levels of sulfur in diesel fuels continue to be lowered.

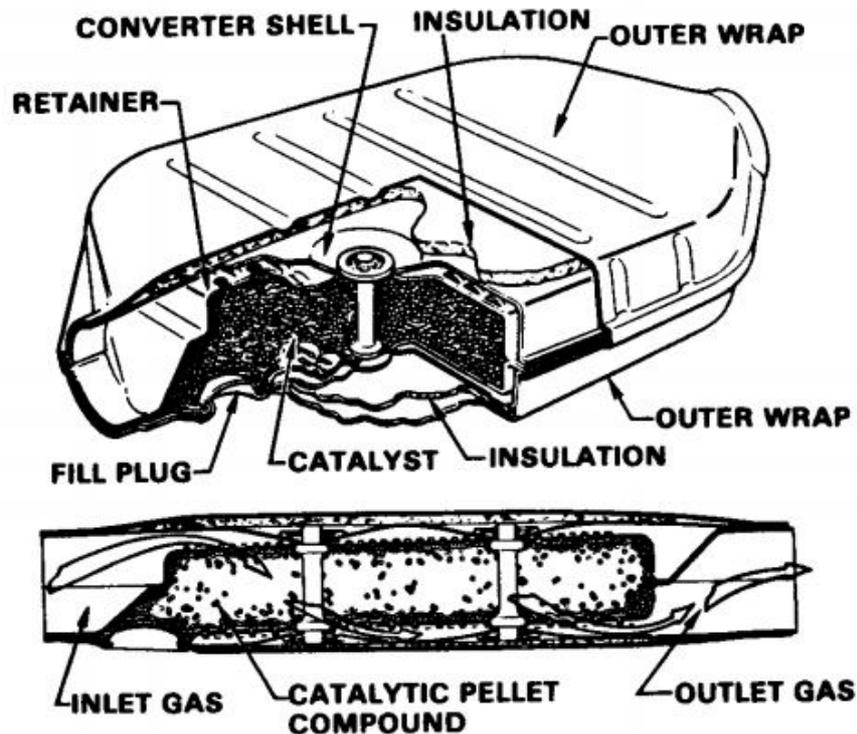


Fig.4 Catalytic Converter

Carbon soot particulate generation has been greatly reduced in modern CI engines by advanced design technology in fuel injectors and combustion chamber geometry. With greatly increased mixing efficiency and speeds, large regions of fuel-rich mixtures can be avoided when combustion starts. These are the regions where carbon soot is generated, and by reducing their volume, far less soot is generated. Increased mixing speeds are obtained by a combination of indirect injection, better combustion chamber geometry, better injector design and higher pressures, heated spray targets, and air-assisted injectors. Indirect injection into a secondary chamber that promotes high turbulence and swirl greatly speeds the air-fuel mixing process. Better nozzle design and higher injection pressures create finer fuel droplets which evaporate and mix quicker. Injection against a hot surface speeds evaporation, as do air-assisted injectors. Some modern, top-of-the-line CI automobile engines (e.g., Mercedes) have reduced particulate generation enough that they meet stringent standards without the need for particulate traps.

IV. EXHAUST GAS RECIRCULATION

The most effective way of reducing NO_x emissions is to hold combustion chamber temperatures down. Although practical, this is a very unfortunate method in that it also reduces the thermal efficiency of the engine. We have been taught since infancy in our first thermodynamics course that for maximum engine thermal efficiency, Q_{in} should be at the highest temperature possible. Probably the simplest practical method of reducing maximum flame temperature is to dilute the air-fuel mixture with a non-reacting parasite gas. This gas absorbs energy during combustion without contributing any energy input. The net result is a lower flame temperature. Any non-reacting gas would work as a diluent. Those gases with larger specific heats would absorb the most energy per unit mass and would therefore require the least amount; thus less CO₂ would be required than argon for the same maximum temperature. However, neither CO₂ nor

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argon is readily available for use in an engine. Air is available as a diluent but is not totally non-reacting. Adding air changes the AF and combustion characteristics. The one non-reacting gas that is available to use in an engine is exhaust gas, and this is used in all modern automobile and other medium-size and large engines.

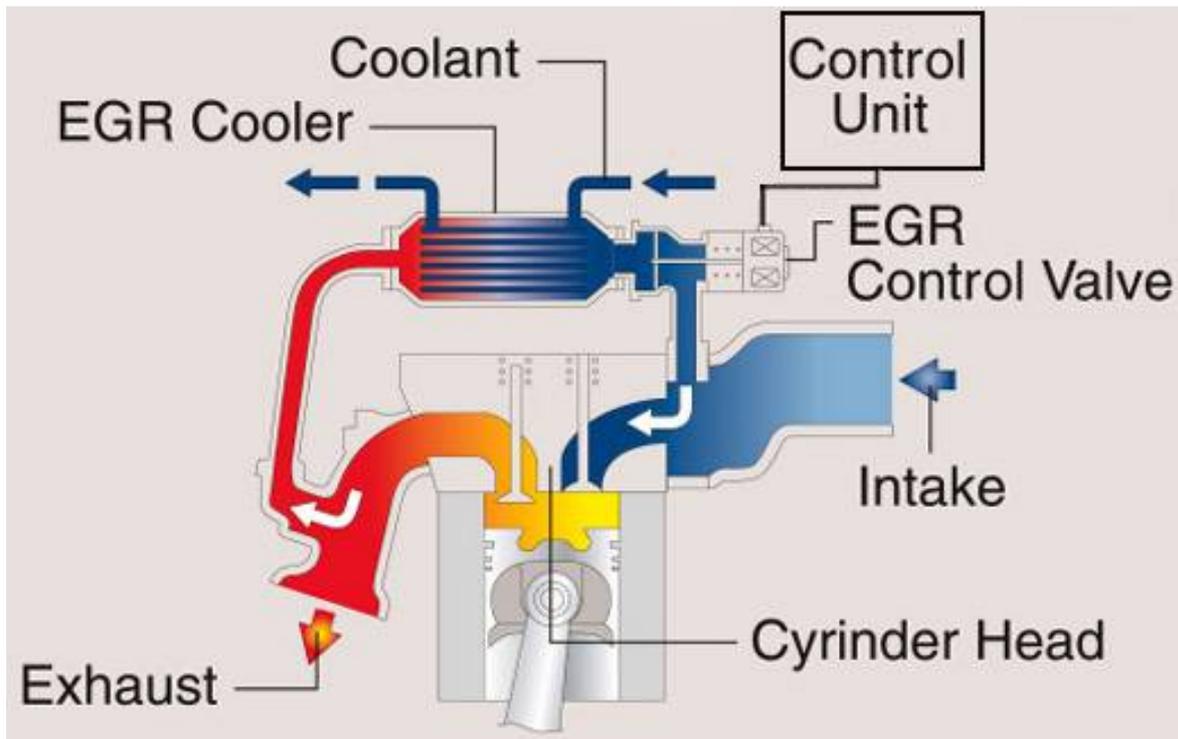


Fig.5 Overview of Exhaust Gas Recycle

Exhaust gas recycle (EGR) is done by ducting some of the exhaust flow back into the intake system, usually immediately after the throttle. The amount of flow can be as high as 30% of the total intake. EGR gas combines with the exhaust residual left in the cylinder from the previous cycle to effectively reduce the maximum combustion temperature. The flow rate of EGR is controlled by the EMS.

EGR is defined as a mass percent of the total intake flow:

$$EGR = \frac{m_{EGR}}{m} (100)$$

where m ; is the total mass flow into the cylinders.

After EGR combines with the exhaust residual left from the previous cycle, the total fraction of exhaust in the cylinder during the compression stroke is;

$$x_{ex} = (EGR/100) (1 - x_r) + x_r$$

where x_r is the exhaust residual from previous cycle.

Not only does EGR reduce the maximum temperature in the combustion chamber, but it also lowers the overall combustion efficiency. As EGR is increased, the percent of inefficient slow-burn cycles increases. Further increase in EGR results in some cycle partial burns and by using EGR to reduce NO_x emissions, a costly price of increased HC emissions and lower thermal efficiency must be paid. The amount of EGR is controlled by the EMS. By sensing inlet and exhaust conditions the flow is controlled, ranging from 0 up to 15-30%. Lowest NO_x emissions with relatively good fuel economy occur at about stoichiometric combustion, with as much EGR as possible without adversely affecting combustion. No EGR is used during WOT, when maximum power is desired. No EGR is used at idle and

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very little at low speeds. Under these conditions, there is already a maximum exhaust residual and greater combustion inefficiency. Engines with fast-burn combustion chambers can tolerate a greater amount of EGR. A problem unique to CI engines when using EGR is the solid carbon soot in the exhaust. The soot acts as an abrasive and breaks down the lubricant. Greater wear on the piston rings and valve train results.

Modern automobile engines use exhaust gas recycle (EGR) to reduce nitrogen oxide emissions. Some gas is routed from the exhaust system back into the intake system. This dilutes the intake gas mixture with non-combustible, which then lowers the maximum combustion temperature and consequently reduces the generation of nitrogen oxides. The amount of EGR can be as high as 15-20% of the total mass and is regulated according to engine operating conditions. Under some conditions, such as starting or WOT, no EGR is used. In addition to reducing the maximum combustion temperature, EGR increases the intake mixture temperature and affects fuel evaporation.

In all modern automobile engines and in many other engines, some exhaust gas is recycled (EGR) into the intake system to dilute the incoming air. This reduces combustion temperatures in the engine, which results in less nitrogen oxides in the exhaust. Up to about 20% of exhaust gases will be diverted back into the intake manifold, depending on how the engine is being operated. Not only does this exhaust gas displace some incoming air, but it also heats the incoming air and lowers its density. Both of these interactions lower the volumetric efficiency of the engine. In addition, engine crankcases are vented into the intake systems, displacing some of the incoming air and lowering the volumetric efficiency. Gases forced through the crankcase can amount to about 1% of the total gas flow through the engine.

V. NANOPARTICLES

Nanoparticle is defined as an aggregate of atoms between 1 and 100 nm viewed as a subdivision of a bulk material, and of dimension less than the characteristic length of some phenomena. Because nanoparticles have 10^6 atoms or less, their properties differ from those of the same atoms bonded together to form bulk materials. nanoparticles themselves had been around and studied long before the words were coined. For example, many of the beautiful colours of stained-glass windows are a result of the presence of small metal oxide clusters in the glass, having a size comparable to the wavelength of light. Particles of different sizes scatter different wavelengths of light, imparting different colours to the glass. Small colloidal particles of silver are a part of the process of image formation in photography. Water at ambient temperature consists of clusters of hydrogen-bonded water molecules. Nanoparticles are generally considered to be a number of atoms or molecules bonded together with a radius of < 100 nm. A nanometre is 10^{-9} m, so particles having a radius of about < 1000 Angstroms, can be considered to be nanoparticles.

VI. APPLICATION OF NANOPARTICLES

Nanoparticles are used, or being evaluated for use, in many fields. The list below introduces several of the uses under development.

a) Nanoparticle Applications in Medicine

The surface change of **protein filled nanoparticles** has been shown to affect the ability of the nanoparticle to stimulate immune responses. Researchers are thinking that these nanoparticles may be used in inhalable vaccines.

Researchers at Rice University have demonstrated that **cerium oxide nanoparticles act as an antioxidant** to remove oxygen free radicals that are present in a patient's bloodstream following a traumatic injury. The nanoparticles absorb the oxygen free radicals and then release the oxygen in a less dangerous state, freeing up the nanoparticle to absorb more free radicals.

Researchers are developing ways to use carbon nanoparticles called nanodiamonds in medical applications. For example, Nano diamonds attached can be used to increase bone growth around dental or joint implants.

Researchers are testing the use of **chemotherapy drugs attached to nanodiamonds** to treat brain tumours. Other researchers are testing the use of chemotherapy drugs attached **tonanodiamonds to treat leukaemia**.

b) Nanoparticle Applications in Manufacturing and Materials

A synthetic skin, that may be used in prosthetics, has been demonstrated with both self-healing capability and the ability to sense pressure. The material is a composite of nickel nanoparticles and a polymer. If the material is held together after a cut it seals together in about 30 minutes giving it a self-healing ability. Also the electrical resistance of the material changes with pressure, giving it a sense ability like touch.

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Silicate nanoparticles can be used to provide a barrier to gasses (for example oxygen), or moisture in a plastic film used for packaging. This could slow down the process of spoiling or drying out in food.

Zinc oxide nanoparticles can be dispersed in industrial coatings to protect wood, plastic, and textiles from exposure to UV rays.

Silicon dioxide crystalline nanoparticles can be used to fill gaps between carbon fibers, thereby strengthening tennis racquets.

Silver nanoparticles in fabric are used to kill bacteria, making clothing odour-resistant.

c) Nanoparticle Applications and the Environment

Researchers are using photocatalytic copper tungsten oxide nanoparticles to **break down oil** into biodegradable compounds. The nanoparticles are in a grid that provides high surface area for the reaction, is activated by sunlight and can work in water, making them useful for cleaning up oil spills.

Researchers are using **gold nanoparticles embedded in a porous manganese oxide** as a room temperature catalyst to breakdown volatile organic pollutants in air.

Iron nanoparticles are being used to clean up carbon tetrachloride pollution in ground water.

Iron oxide **nanoparticles are being used to clean arsenic** from water wells.

d) Nanoparticle Applications in Energy and Electronics

Researchers have used nanoparticles called nanotetrapods studded with nanoparticles of carbon to develop **low cost electrodes for fuel cells**. This electrode may be able to replace the expensive platinum needed for fuel cell catalysts.

Researchers at Georgia Tech, the University of Tokyo and Microsoft Research have developed a method to print prototype circuit boards using standard inkjet printers. **Silver nanoparticle ink** was used to form the conductive lines needed in circuit boards.

Combining gold nanoparticles with organic molecules creates a transistor known as a NOMFET (**Nanoparticle Organic Memory Field-Effect Transistor**). This transistor is unusual in that it can function in a way similar to synapses in the nervous system.

A **catalyst using platinum-cobalt nanoparticles** is being developed for fuel cells that produces twelve times more catalytic activity than pure platinum. In order to achieve this performance, researchers anneal nanoparticles to form them into a crystalline lattice, reducing the spacing between platinum atoms on the surface and increasing their reactivity.

Researchers have demonstrated that sunlight, concentrated on nanoparticles, can produce steam with high energy efficiency. The "**solar steam device**" is intended to be used in areas of developing countries without electricity for applications such as purifying water or disinfecting dental instruments.

A lead free solder reliable enough for space missions and other high stress environments using **copper nanoparticles**.

Silicon nanoparticles coating anodes of lithium-ion batteries can increase battery power and reduce recharge time.

Semiconductor nanoparticles are being applied in a low temperature printing process that enables the manufacture of low cost solar cells.

A layer of closely spaced palladium nanoparticles is being used in a hydrogen sensor. When **hydrogen is absorbed, the palladium nanoparticles swell**, causing shorts between nanoparticles. These shorts lower the resistance of the palladium layer.

VII. NANOPARTICLE EMISSIONS

Natural and man-made nanoparticles are present in our atmosphere. There could be between 20,000 to 100,000 nanoparticles per cubic centimetre in your everyday environment. When looking to assess the risk to health from exposure to certain levels of nanoparticles from the use of nanotechnology, the information about these background levels could be invaluable. Recent research has suggested that inhaled nanoparticles can come into contact with 140 square meters of lung surface area and from this contact enter the fine blood vessels in the lungs. This would then allow the nanoparticles to circulate in the blood around the body.

The nanoparticles in the atmosphere may be present due to being released direct from a source (primary emissions) as nanoparticles or due to being formed as a result of reactions in the atmosphere (secondary emissions). Natural sources of nanoparticles in the atmosphere include volcanic eruptions, physical and chemical weathering of rocks, precipitation

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reactions, and biological processes. Looking at an atmospheric sample of particulates may therefore show a combination of carbon, minerals, sea salt, ice, solid sulphuric acid, viruses and pollen. There are few studies with measurements of these individual components on a nanoscale. Man-made sources of nanoparticles can be categorised under the titles nanotechnology, industrial, domestic and vehicle. The use of nanotechnology will generate nanoparticles in the environment from manufacture through to use of the nanotechnology goods. Industrial sources are predominately from combustion processes whereas domestic sources can be from simple tasks such as cooking and vacuuming.

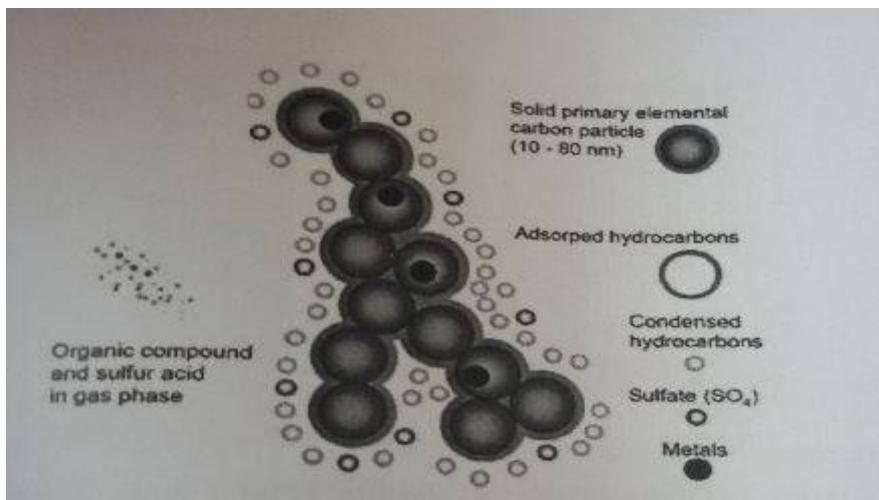


Fig.6 Emission Adsorption by Nano-particles

Vehicle sources are the most studied. They can include non-exhaust emissions from tyres and brakes but are predominately from the combustion of fuels by the vehicle. The different types of fuel (petrol, diesel and aviation) have different possible emissions. There are many studies for example on the emission of sulphur and sulphates from diesel engines. However not many studies separate nanoparticles from the general PM10 or PM2.5. There are different methods by which a nanoparticle may grow after it has been released. Condensation can occur on the nanoparticle from gaseous species in the atmosphere or there may be coagulation where two or more nanoparticles combine to form a bigger particle. The nanoparticle may therefore be trapped with other particles and the risk of this new particle would have to be assessed, however the question would also need to be answered as to what happens if the aggregated particle could break up under certain conditions to be present again as a nanoparticle. Particulate matter can be referred to in relation to these processes.

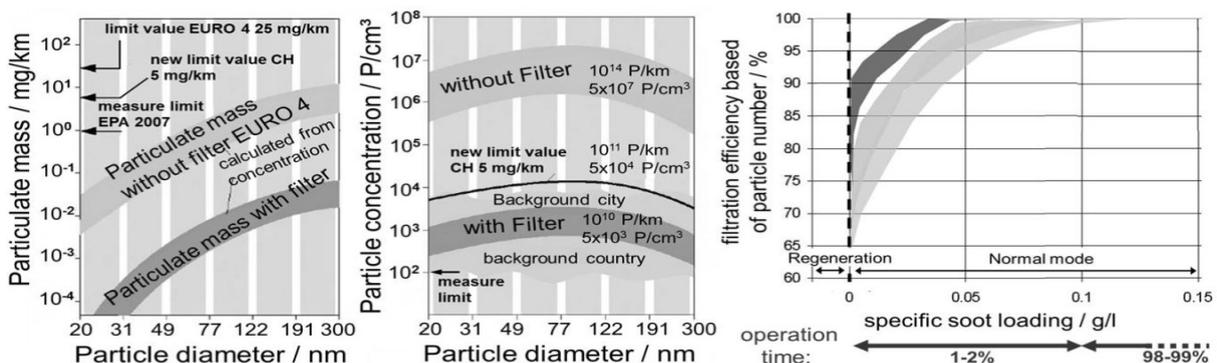


Fig.7 Particle reduction through DPF(left,mid) & particle number reduction based on filter load(right).

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Particles with diameter 0.01 – 0.1 μ m (10 – 100nm) are referred to as being in the nucleation mode. They will have rapid growth due to coagulation and condensation. 0.1 - 2 μ m is the accumulation mode and >2 μ m is the coarse mode. Particles in the accumulation mode will not grow or be lost as fast, may travel further and have a longer atmospheric lifetime than those in the nucleation mode. (The nucleation mode may also be referred to as particles with diameter.

VIII. EMISSION STUDIES

Vorbau et al (2009)(a) have recently published a study to look at the release of nanoparticles into the atmosphere from the typical handling of surface coatings using nanoparticle technology. The study simulated the abrasion process and used aerosol measurement techniques to look at released nanoparticles. Controls were established with coatings with no added nanoparticles and different types of coating and substrate were used. The authors noted no significant released particle concentration <100nm was detected. It was found that the added zinc oxide nanoparticles were embedded in larger particles released in the generated wear of the coatings. However, the authors questioned their own results due to the restrictions of the aerosol measurement techniques and believed the question of the release of nanoparticles from the abrasion of the coatings was still unanswered. Another study (Koehler et al, 2008) (b) looking at the release of nanoparticles into the environment from the use of nanotechnology found that carbon nanotubes (CNTs) could be released as dust into the atmosphere. The nanotechnology applications of CNTs studied were in lithium-ion secondary batteries and synthetic textiles. Possible release of CNTs was thought to occur during disposal of the item in landfills or dumpsites or by lower temperature incineration. The authors called for further research to ensure the CNTs were integrated in the product in a way to prevent their release through their whole lifetime.

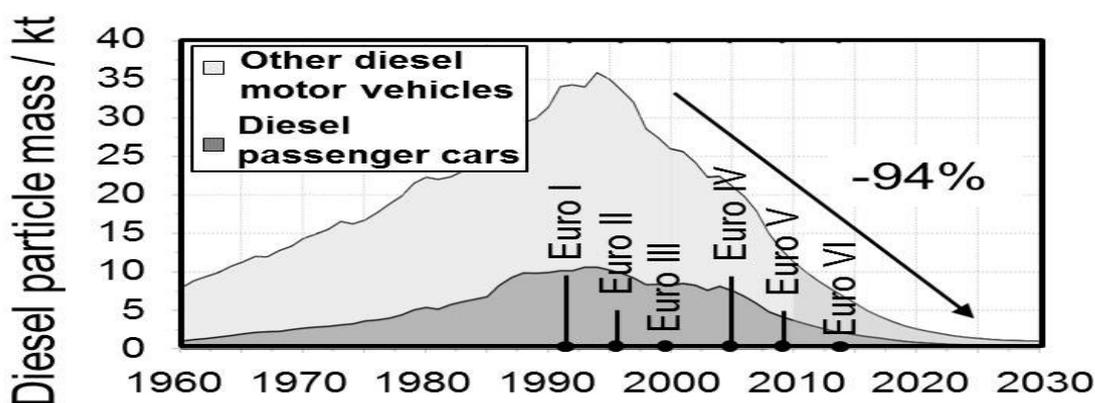


Fig.8 Development of Particulate emission through Car Traffic in Germany

Another recent study (Murr & Garza) looking at indoor as well as outdoor environmental Nano particulates aimed to characterise the collected particulate matter and look at the cytotoxicity of the collected species. The samples were collected for analysis with electron microscopy techniques in a study conducted in El Paso, Texas. For both the outdoor and indoor samples the most significant fraction of nanoparticles was carbonaceous and included multi walled carbon nanotubes (MWCNT). The indoor samples also included soot from candles, wood or other cooking species, while the outdoor also contained diesel soot, soot from fires, titanium oxide (attributed to paint wear), and natural soil and geological components (mainly iron oxide and aluminium oxide). The authors conclude that there was a tendency for environmental particulate pollutants to be found as aggregates of nanoparticles. Examples were given of the aggregates found both indoor and outdoor including MWCNT / multi concentric fullerenes and silica in outdoor samples, and gypsum (calcium sulphate) with silica (silicon dioxide) and soot in indoor samples. The study also considered the cytotoxicity of the nanoparticles found warned of the possible respiratory health effects of these environmental nanoparticles.

Many of the studies on air quality will look at the particulate matter found at roadsides in urban, suburban or rural locations. The majority of this will be attributed to the emissions from vehicles though measurements are often taken

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near industrial sites where there can be high levels of emissions from combustion processes. These particles will range in size from a few nanometres to 100 micrometres. There are fewer of the larger particles but they contribute the majority to the overall mass of particulate matter. Most of particles are in the nanoparticle or ultrafine range, though some will immediately grow in size. Siegmann et al (2008) (g) conducted measurements of characteristics of nanoparticles present on the road in Mexico City and Madrid in the years 1999 – 2001, and then again in Madrid in 2006. They looked at the presence of polycyclic aromatic hydrocarbons on particles and the total active surface area of nanoparticles in the samples. From the collected data a model was formed to attribute the nanoparticles to particular vehicle sources. Their findings showed a reduction in both measurements in Madrid in 2006 compared to the earlier measurements. The study then compared summer and winter results and also the kerbside with the more natural background. The later having a gradual decrease in the particle number concentration in the mode 20 – 30nm as measurements were taken moving further from the kerbside. This was attributed to the coagulation, condensation and dilution of the vehicle pollution as it is transported and dispersed. The summer time results also showed an increase in the 20 – 30nm particles during the afternoon from the increased traffic. However, this did not present itself in winter. This was attributed to photo chemically induced nucleation of new particles in the local atmosphere in summer, and the condensation of semi-volatile species in the colder winter temperatures producing particles with greater diameter.

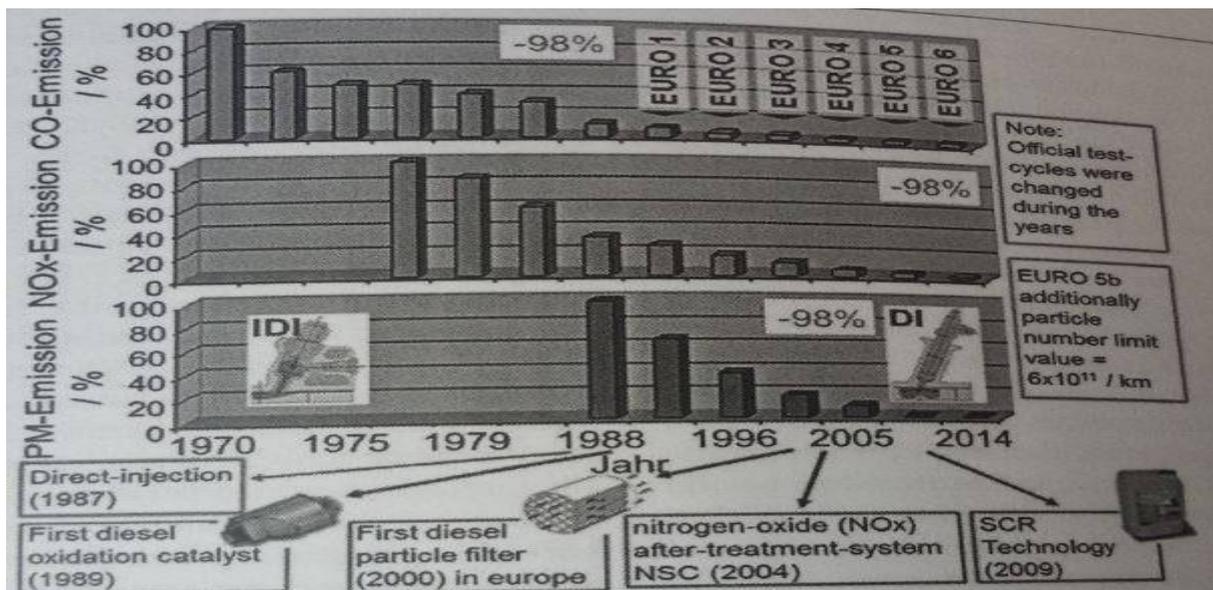


Fig.9 Euro-Emission Standards

Conclusion put forth by research from Universities all around the World:

- Korea University, situated in Seoul research states that PM emissions adversely affect human health, resulting in heart and lung diseases resulting in cancer and premature death. Euro VI emission regulations will contribute to substantial reduction of particle mass and particle number emissions from Vehicles. It can exponentially increase the human health factors.
- The University Research additionally states that bio-fuels for diesel engines may decrease the order of the nano-structure.
- Chonnam National University Korea research states that EGR reduces the particle number and mass by 24% and 16% respectively.
- SRM University research states that combustion of fuels in Engines is improved using Nano-particle catalysts.
- SDM College of Engineering and Technology states that NO_x emissions are reduced in blended fuel operations.

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- JOMT research states that a reduced particulate mass emission is always connected to a reduced particle number emission.
- Springer Article on Diesel-Water emulsions study by M. Saravanan, A. Anbarasu and B.M. Gnanasekaran states that addition of water to diesel fuel lowers particulate emissions by serving as diluents.

IX. NEW PROPOSAL

Challenges of Nanoparticles in CI Engines

1. Brownian movement of the particles is eliminated at rest conditions.
2. There is a need to prevent settling of nanoparticles inside the fuel chamber so as to keep the fuel active (colloidal action).
3. It is achieved through the addition of Anti-oxidant (BHA or BHT) and Nano-particle (Zinc Oxide, ZnO & Zirconia ZrO_2) and a Stabiliser compound (Span-Tween Emulsion).

Aim:

To improve and maintain the Brownian movement of the nanoparticles in the fuel chamber.

Anti-Oxidant

- The compound used is BHA or BHT
- Butylated hydroxyanisole (BHA) and the related compound butylated hydroxytoluene (BHT) are phenolic compounds that are often added to foods to preserve fats.
- BHA and BHT are antioxidants. Oxygen reacts preferentially with BHA or BHT rather than oxidizing fats or oils, thereby protecting them from spoilage.
- BHA and BHT are fat-soluble. Both molecules are incompatible with ferric salts.
- In addition to preserving foods, BHA and BHT are also used to preserve fats and oils.
- We choose 1 gram/litre or 1000ppm equivalent of anti-oxidants.

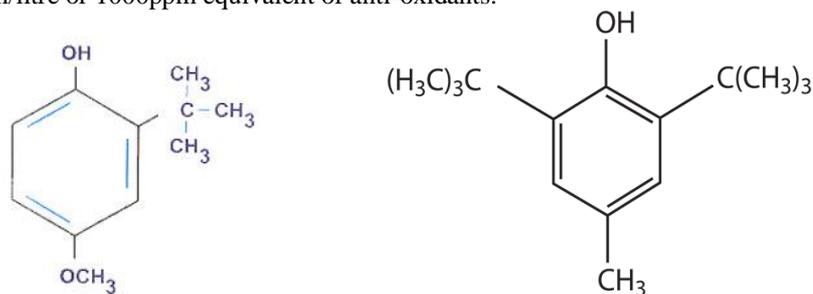


Fig.10 BHA & BHT

Nanoparticle : $ZnO + ZrO_2$

- Zinc oxide and Zirconia oxide Nano powders are available as powders and dispersions.
- These nanoparticles exhibit antibacterial, anti-corrosive, antifungal and UV filtering properties.
- We choose each of 0.5g/litre.

Stabiliser:

- It is based on HLB emulsion system theory.
- The HLB (Hydrophile Lipophile Balance) system enables one to assign a number to the emulsifier or emulsifier blend.
- This number indicates or expresses the relative simultaneous attraction of the emulsifier or emulsifier blend for water (hydrophilic), oil (lipophilic) or the two phases to be emulsified.
- Spans are based on unsaturated or branched chain fatty acids acting as effective water in oil emulsifiers. When combined with corresponding tweens, then they give a HLB value.

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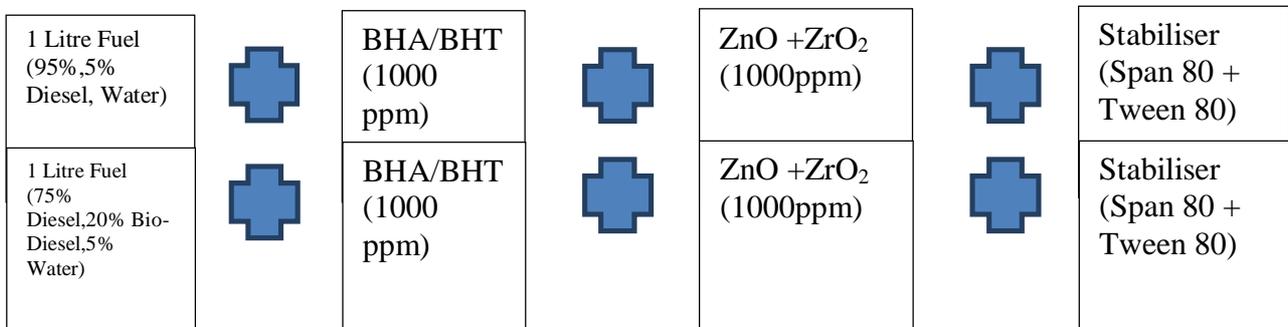
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Product Name	HLB Value	Product Name	HLB Value
Span 20	8.6	Tween 20	16.7
Span 40	6.7	Tween 21	13.3
Span 60	4.7	Tween 40	15.6
Span 80	4.3	Tween 60	14.9
Span 83	3.7	Tween 61	9.6
Span 85	1.8	Tween 65	10.5
Span 120	4.7	Tween 80	15.0

Table.1 Span,Tween concentration and their HLB values

- While the theory of the system sounds simple, in practice the task unfortunately is not so clear-cut, as emulsifier classification via HLB only permits some prediction of behaviour.
- We choose the HLB value 5 since it is the most stable emulsion found by experimental theory which is a blend of Span 80 with Tween 80.

Scheme 1:



- Nanoparticles act as the base for Brownian Movement.
- Anti-oxidants act as catalyst for initiated Brownian Movement.
- Stabiliser sustains the Brownian Movement.
- Fuel used acts as the medium for Brownian Movement.
- Fuel-water emulsions help to reduce the particulate emission and helps to prevent the particulate formation.

Thus, the Brownian Movement is sustained for a long time till the fuel is completely used and exhausted.

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BIOGRAPHY



I am a recently passed out Mechanical Engineering Graduate In Panimalar Engineering College. I am a critical Thinker, I would like to formulate a new Nano ecofriendly Fuel to reduce Automobile emission



I am working as a professor of chemistry in Panimalar engineering college Chennai, India. My area of research is Nano Materials and Polymer Nano composites. I would like to prepare new novel Nano materials