УНИВЕРСИТЕТ ИТМО

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Theme :

«Aftertreatment systems and technologies to catch and clean the emission gases escaping from cars pipes»

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The purpose of this paper it's a brief description of the abatement strategies, aftertreatment systems and technologies which reduce the harmful emission gases fllowing from cars pipes.

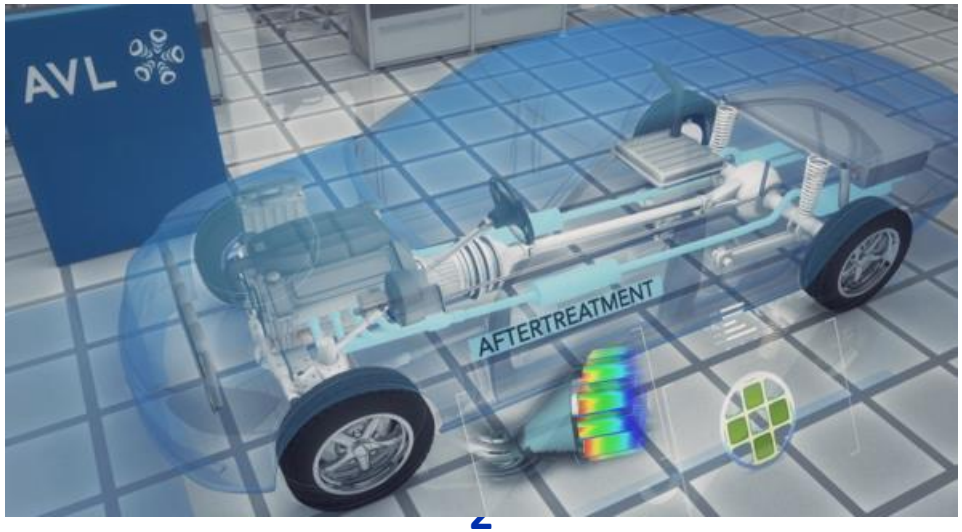
With emission norms becoming more and more stringent, industries are using technologies to reduce NOx emissions, Hydrocarbons (HCs) , Carbon Monoxide (CO) and particulates matters (PM) and so on.
Nitrous Oxides (NOx for short) are one of the most harmful pollutants produced by automobiles, damaging the ozone layer and the environment. Hence, countries like U.S, Japan and those in the European Union have come up with more stringent emission norms to reduce the impact on the environment. Serious efforts are being made to reduce the amount of these harmful gases emitted by automobiles, especially those using Diesel Engines.

Keywords : Automobile, Exhaust gase, cars pipes, Aftertreatment systems.

Engine Exhaust Aftertreatment Systems :

What is an aftertreatment system ?

- **A system that treats post-combustion exhaust gases prior to tailpipe emission.**
- **Differs from emission reduction techniques in the combustion process.**
- **Allows for greater power from the engine without worrying about emissions increasing.**



As for as techniques and aftertreatment systems available to reduce those gases are concerned :

- EGR – Exhaust Gas Recirculation
- DOC– Diesel Oxidation Catalyst
- DPF – Diesel Particulate Filter
- SCR – Selective Catalytic Reduction
- WIS- Water Injection System

Background and Theory :

NOx Formation : NOx (oxides of Nitrogen) formation from atmospheric Nitrogen in any combustor porceeds via the Zeldovich Mecanism.

$$O + N_2 = NO + N$$

$$N + O_2 = NO + O \qquad (1)$$

$$N + OH = NO + H$$

Strategies and applied ways :

1/ EGR – Exhaust Gas Recirculation :
THE EFFECTS OF EGR:
The addition of Exhaust-Gas has many effects on diesel engine combustion and pollutant formation.
They are:
1. Decreased flame temperature due to increased heat capacity of the intake charge.
2. Lower O2 concentration due to dilution of the intake charge. Exhaust gas contains much lower O2 levels than ambient air.
3. Increasing the inlet temperature due to introduction of hot combustion products
4. Changes in Ignition Delay and combustion characteristics like flame structure
5. Increased inlet concentration of pollutants due to re-circulation, leading mainly to greater in-cylinder wear-rates.
6. 'Thermal throttling' effect: the hot exhaust-gases mix with cooler air in the intake manifold. This reduces the density of the intake mixture and hence the mass of the inducted charge decreases. This causes an overall increase in cylinder temperatures.[1]

2/ SCR – Selective Catalytic Reduction :

SCR is another technology to reduce NOx emissions and especially improved for high-duty vehicles. Because of low exhaust temperature, it has not been used widely for light-duty vehicles. But nowadays, it is being developed for light-duty passenger vehicles and a few light-duty vehicle manufacturers like Audi have been using this technology in their automobile. SCR is used to minimize NOx emissions in the exhaust gas to utilize ammonia (NH3) as the reductant Water and N2 are released as a result of catalytically conversion of NOx in the exhaust gas as shown in the following equation.[2] NOx +NH3 ---------- N2 + H2O (2)

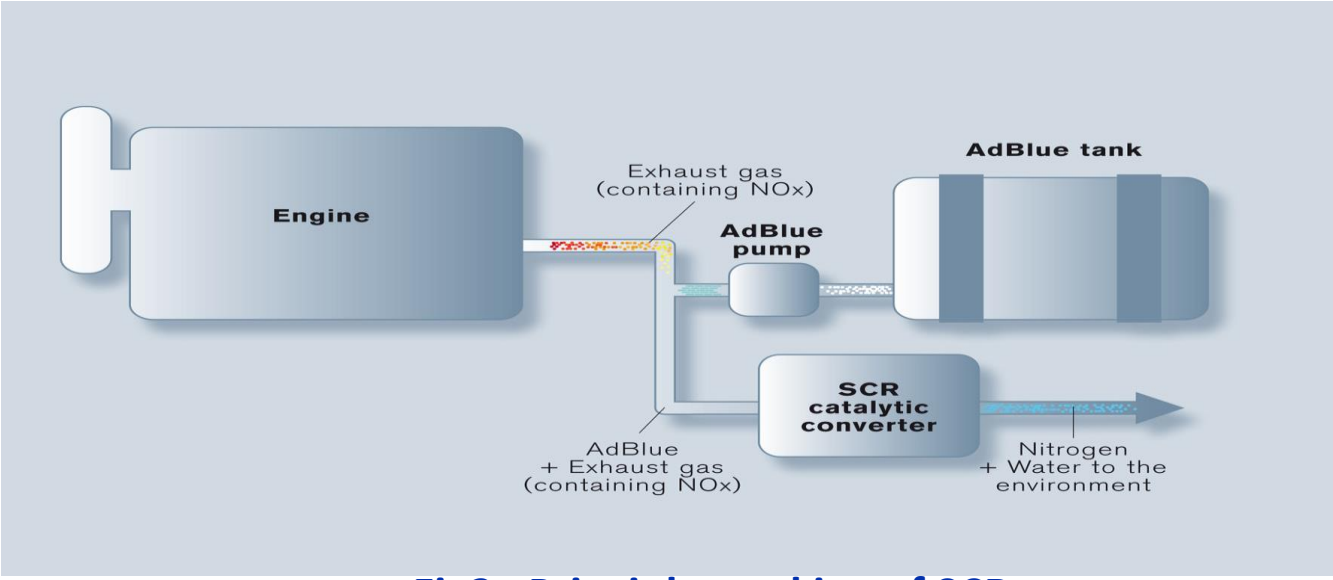


Fig2 . Principle working of SCR.

3/ DPF – Diesel Particulate Filter :

DPFs have been applied in the production of vehicles since 2000. They are used to remove particulates matters (PM) emissions from the exhaust gas by physical filtration and usually made of either cordierite ($2MgO–2Al_2O_3–5SiO_2$) or silicon carbide (SiC) honeycomb structure monolith with the channels blocked at alternate ends . The plugged channels at each end force the diesel particulates matters through the porous substrate walls, which act as a mechanical filter . As soot particles pass through the walls, they are transported into the pore walls by diffusion where they adhere. This filter has a large of parallel mostly square channels. The thickness of the channel walls is typically 300–400 lm. Channel size is specified by their cell density (Typical value: 100–300 cpsi).[3]

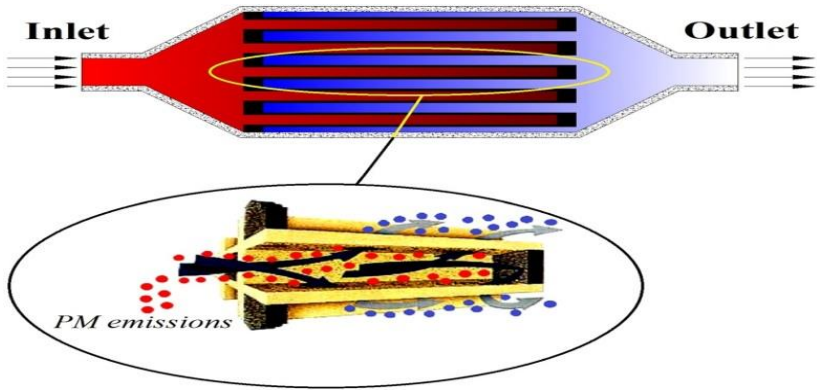


Fig. 3 Diesel Particulate Filter .

4/ DOC – Diesel Oxidation Catalyst:

The main function of DOCs is to oxidize HC and CO emissions. Besides, DOCs play a role in decreasing the mass of diesel particulate emissions by oxidizing some of the hydrocarbons that are adsorbed onto the carbon particles. DOCs may also be used in conjunction with SCR catalysts to oxidize NO into NO2 and increase the NO2:NOx ratio. [4]

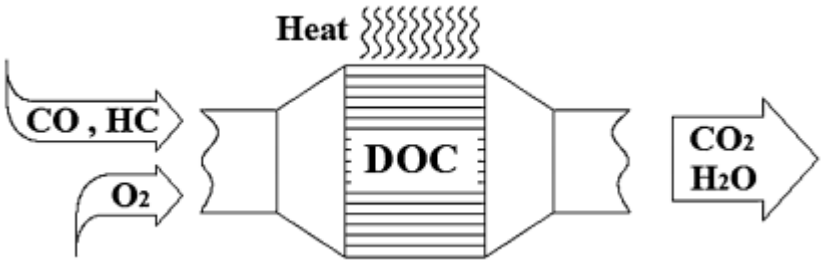


Fig. 4 Diesel Oxidation Catalyst.

5/ WIS : Water Injection System :

Finally, conducted tests SAE showed that an effective way to reduce emissions of nitrogen oxides (up to 90%) and in general toxic gases can be achieved by injecting water into the combustion chamber. Therefore, we will make a broader explanation.

Water injection An air-fuel mixture of internal combustion engines is used for additional cooling of the engine and temporarily increasing its characteristics (afterburner). The injection of water (more precisely a mixture of 50% water and 50% alcohol-methanol) has become quite widespread, including the engines of military aircraft. Typically, water or a mixture is injected into the intake manifold in the proportioned proportions to the fuel-air mixture (usually from 12.5% to 25%) and the flow is entrained in the combustion chambers, which provides a reduction in the detonation threshold due to the large heat capacity of the water that cools the working mixture and the heated engine parts. The mixture was used, for example, on the Saab 99 Turbo and on the BMW M4. A certain interest in water injection systems arises in the recent time in connection with the possibility of reducing harmful emissions thanks to better computer-controlled injection of the water.

In our research work, we, together with the scientific leader, Professor KN. Voinov studied the improved version of the use of the water, which does not reduce the power of the engine, does not damage it, but almost completely stops the release of carcinogenic gases into the atmosphere for any car and any other types of fuel.[5],[6],[7]

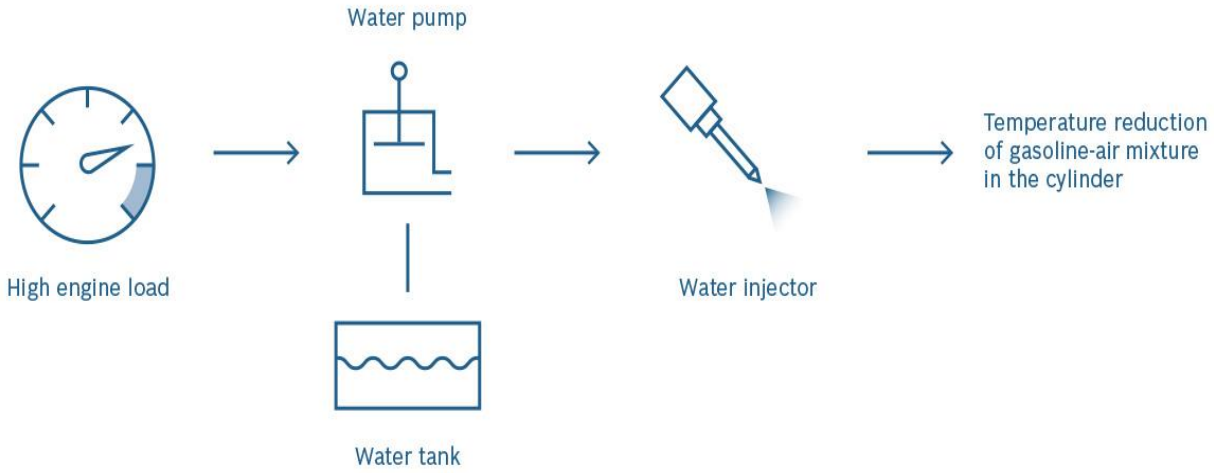


Fig. 5 Principle working of WIS.

Fig. 6 Principle working of WIS.

Conclusion :

With the aftertreatment emission control systems, it is possible to reduce the damage of the pollutant emissions on air pollution, to meet emission standards and requirements, and to prevent the harmful effects of pollutant emissions on environment and human health. Due to these missions, emission control systems are utmost importance worldwide. For the complete destruction of polluting emissions from diesel engines, further studies and researches on the aftertreatment emission control systems should be intensified and continued.

References :

[1] : Arjun Krishnan[1], Vinay C. Sekar, Mechanical Engineering Department, Indian Institute of Technology Madras./ Balaji J, S.M Boopathi, Ashok Leyland Ltd., Hosur, Tamil Nadu.

[2]: Biswas S, Verma V, Schauer JJ, Sioutas C (2009) Chemical speciation of PM emissions from heavy-duty diesel vehicles equipped with diesel particulate filter (DPF) and selective catalytic reduction (SCR) retrofits. Atmos Environ 43: 1917–1925.

[3]: Kuki T, Miyairi Y, Kasai Y, Miyazaki M, Miwa S (2004) Study on reliability of wall-flow-type diesel particulate filter. SAE, 2004-01-0959

[4]: Chen M, Schirmer K (2003) A modeling approach to the design optimization of catalytic converters of I. C. engines. In: Proceedings of ICEF03: 2003 fall technical conference of the ASME internal combustion engine division, ICEF2003-729.

[5]: Voinov K.N., Ghellab Yahia. On air pollution by automobile gases / / Tribology: International Encyclopedia - 2017. - T. XII. - P. 127-129.

[6]: Voinov KN, Hildayati A., Ghellab Y. METHODS OF PROTECTION OF THE AIRBORN FROM GAS OF ENTERPRISES AND OUTPUT FROM CARS OF CARS // Proceedings of articles the international scientific conference of the Czech Republic, Karlovy Vary - Russia, Moscow, June 29-30, 2017 - 2017. - C. C 71-75.

[7]: Voinov KN, Vasiliev VA, Hildayati A., Ghellab Y. New approach to air pollution pollution reduction // Tribology: International Encyclopedia - 2017. - T. XII. - P. 130-133.

Thank you for your attention