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Reduction of NO_X Emission in CI Engine Using SCR (selective catalytic reduction) Technology

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ABSTRACT:

In diesel engines the combustion process high temperatures and pressures which result in significant production of gaseous nitrogen oxides (N O_x), an air pollutant that constitutes a unique challenge with regard to their reduction. Diesel cars still produce nitrogen oxides at a similar level to those bought a decade and a half ago under real world tests; hence, diesel cars emit around 20 times more nitrogen oxides than petrol cars. Modern on-road diesel engines typically use selective catalytic reduction (SCR) systems to meet emissions laws, as other methods such as exhaust gas recirculation (EGR) can adequately reduce NO_x to meet the newer standards applicable in many jurisdictions .CI Engines for the present stringent emissions norms (Euro-V) – is the promising SCR (Selective catalysitc reduction) technology for Reduction of the NOx emission. It is advanced active emissions control technology system that injects a liquid – reductant agent thorugh a special catalyst into the exhaust stream of a diesel engine.SCR technology is designed to permit nitrogen oxide (NOx) reduction reactions to takes place in an oxidizing atmosphere. This paper gives the study of the SCR technology working principle, construction and its advantages & disadvantages.

KEY WORDS: CI Engines, EGR System, Euro Norms, NOx emissions, SCR Technology

1. INTRODUCTION:

In the late 1970s, the SCR Technology was first applied in thermal power plants in Japan followed by wide spread application in Europe since the mid-1980s. The SCR systems were introduced for gas turbines in the 1990s, in the USA, with increasing potential for NOx control from Coal-fired power plants.

Applications of SCR also include plant and refinery heaters and biolers in the chemical processing industry. Such as Furnaces, Coke ovens, as well as municipal waste plants and incinerators. The list of fuels used in these applications includes industrial gases, natural gas, curde oil, light or heavy oil, and pulvarized coal.

The application of SCR for mobile diesel engines requires overcoming several problems, which are discussed later.

Reduction system of Nox is based on the (SCR) selective catalytic reduction technology are being developed fro a number of mobile diesel engine applications in the EU, Japan and the USA. The use of ammonia has been practically rule out, due to safety concerns and urea (in water solution) is the preferred reductant.

Approaching the SCR tehcnology is commercialization in Europe, where a number of heavy duty vehicle manufactureres selected urea-SCR for meeting Euro IV (2005) and Euro V (2008) emisison standards. The first commercial urea-SCR system was introduced by Nissan Diesel on its Quon heavy-duty truck launched in November 2004 in Japan.

SCR has been used for decades to reduce stationary source emissions. In addition, marine vessels worldwide have been equipped with SCR technology, including cargo vessels, ferries and tugboats. With its superior return in both economic and environmental benefits, SCR is also being recognized as the emissions control technology particularly helpful in meeting the U.S. EPA 2010 diesel engine emission standards for heavy-duty vehicles and the Tier 4 emissions standard for engines found in off-road equipment. SCR systems are also found in the growing number of diesel passenger vehicles.

2 WORKING PRINCIPLE:

Selective Catalytic Reduction (SCR) technology was proven, existing engine architecture, a diesel oxidation catalyst and diesel particulate filter, plus SCR hardware, to meet EPA 2010 emission standards. This is allows the engine to function at optimal combustion temperatures, which increases fuel efficiency and reliability.

2.1 SELECTIVE CATALYTIC REDUCTION (SCR)

There are two main classes of SCR system, defined by source of the reluctant used. These are ammonia – SCR (of which urea – SCR is the most common) and hydrocarbon – SCR (lean Nox Reduction).

Ammonia – SCR

Hydrocarbon - SCR

2.1.1 BASICS OF SCR:

Worked by the selective catalytic reduction systems is chemically reducing Nox (No and NOz) to nitrogen (Nz)

The selective catalylic reduction process allows to reduce NOx (NO and NOz) selectively in the presence of high concentration of oxygen.

The process requires the use of nitrogen containing reducing agent like e.g. ammonia (NH_3) (or) urea (NHz-Co-NHz)

2.1.2 SCR Basic Chemistry:

Ammonia: $4No+4NH_3+O_2 \longrightarrow 4N_2+6H_2O$

Ammonia: $2No_2+4NH_3+O_2 \longrightarrow 3N_2+6H_2O$

Catalyst: Tiozalloy, Zeolite, Platinum

Partial efficiency 70-90%

Temperature Range : 450^0 to 840^0F

Generally, a 1:1 mole ratio of NH_3 to NO is used. The actual ratio is slightly higher to account for unreached ammonia carry over from the reactor, referred to as NH_3 slip. This is particularly true during abrupt bioler load changes.

As a result, a schematic representaion of the actual SCR process is as followed.

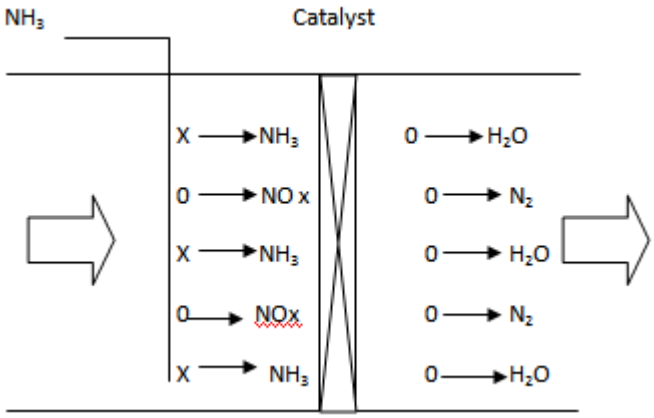

Fig.2.1.1

Studies with NH_3- SCR is reveal that, the Nox conversion is greater than 80% are achieved them engine manufacturers can tune engines for higher Nox while achieving the lower fuel consumption. Commensurate with higher NOx is lower particulate, the well known NOx particulate trade off in diesel engines.

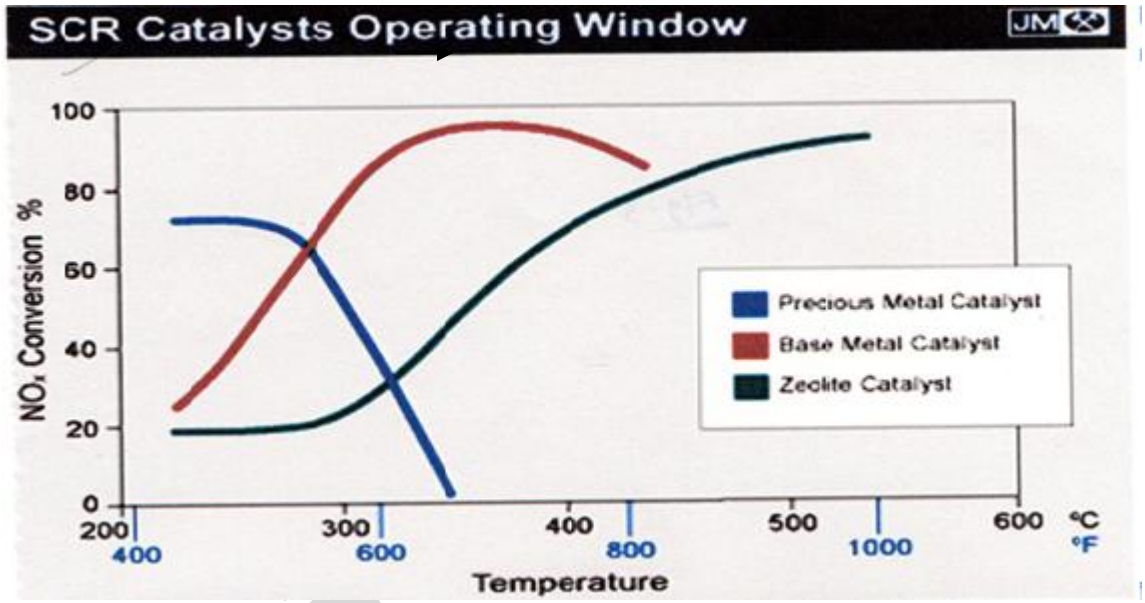

Fig.2.1.2

3. CHEMICAL REACTIONS:

The large merine engines and the stationary engines are to reduce the NOx emission with the injection system that the sprays NH_3 into exhaust flow.

In presence of catalyst, to occuring the following reactions.

$6No_2+8NH_3 \longrightarrow 7N_2+12H_2O$

$4NH_3+4No+O_2 \longrightarrow 4N_2+6H_2O$

$2NO_2+4NH_3+O_2 \longrightarrow 3N_2+6H_2O$

$No+NO_2+2NH_3 \longrightarrow 2N_2+3H_2O$

NH_3 itself is an undesirable emission in this ammonia injection systems are not practical in automobiles or other smaller engines.

This is because of needed NH_3 storage and farly to complex injection and to the control system.

3.2 Urea:

Due to the toxicity and handling problems with ammonia, there has been a need for more convenient SCR reduction.

Urea, $Co(NH_2)_2$, which meets the criteria of non-toxicity and safety and is commercially available, became the reductant of choice for use in mobile SCR applications.

Water solutions are preferred from urea. The use of solid urea has been suggested but the idea appears to have gianed little acceptance. Alternatives to urea that were considered include carbanate salts (e.g.) ammonium carbonate, NH_2CooNH_4) various amines have been also evaluated as SCR reductants, which potentially could be generated from diesel fuel and nitrogen.

Today, urea is produced commertially by the dehydration of ammonium carbamate at elevated temperature and pressure.

Urea is commodity, produced in large scale.

4. ADVANTAGES and DISADVANTAGES

4.1 ADVANTAGES:

1. SCR is the process of using a chemical reaction to reduce Nox.
2. SCR major advantage is its ability to deliver excellent fuel efficiency.
3. SCR has the ability to reduce the 90% of Nox in exhaust system.
4. Especially compared to engines using higher rates of exhaust gas Recirculation (EGR) for NOx control.

4.2 DISADVANTAGES:

1. The SCR technology requires replenishment of Ad Blue at regular intervals.
2. Requires low sulfer diesel less than 15 ppm.
3. The low freezing point of urea needs adequate measures for winter – functioning.
4. The SCR technology costs are negatively influenced by the Ad blue tank and dosing system.
5. Nox storage exhaust gas after treatment process will also lead to increased HC emissions.

5. CONCLUSION

1. Selective catalytic reduction (SCR) technology is a good alternative for complying with euroly emission – legislation.
2. SCR is a well-proven and reliable technology without llimitation in horse power out put.
3. SCR is also represent the most fuet – efficient solution among the techniques available for Euro5 and Euro6.
4. The benefit of the SCR method is that it can be adapted for both Euro5 and Euro6 compatibility.
5. Better mileage due compared to other technologies.

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