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NOx Reduction by Recirculation of Water from Exhaust

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Abstract— The increased number of automobiles in recent years has resulted in great pollution from fossil fuel. That causes the serious air pollution by emitting the CO,HC and NOX, by the burning of the fossil fuel like gasoline and diesel. Much research, efforts and time have been expended to produce more efficient exhaust systems," Bharathstages" and "Euro" are the some of the emission norms in the nation and international level automotive field respectively. Secondary air supply or steam supply reduces the amount of such poisonous gases from the exhaust and also reduces the backpressure from the engine cylinder which result the improvement of engine efficiency as well._Exhaust (burnt) gas already has water in the form of steam that can be reuse by condensation process to reduce the emission rate with urea. In condensation method the steam convert into water that water is used to mix urea (here no need of separate water for mixing urea). By resupplying this water and urea mixture again into the exhaust manifold, has the ability to reduce air pollution (especially NOx reduction) as well as engine backpressure. The present exhaust system has catalytic converter (cat-con) with secondary air supply for reducing the pollution, even though it hasn't ability to reduce the backpressure and also cat-con causes backpressure as well. The exhaust manifold convert the water again into steam from the condenser and reduce pollution by combining the Hydrogen ,Oxygen and urea that present in water with the exhaust gas , that gives reduced NOx , back pressure , exhaust manifold temperature as well.

I. INTRODUCTION

A. EXHAUST SYSTEM

An automobile exhaust system comprises of various devices or parts of an automotive engine, which are used for discharging burned gases. The major components used in a typical automobile exhaust system are exhausted manifold, resonator, catalytic converter, exhaust pipe, muffler, tail pipe. All of these components are especially designed for providing suitable and effective exhaust flow, silencing, and emission levels.

Exhaust Pipes are explicitly engineered to carry or transmit various toxic and noxious gases away from the users of the machine Catalytic Converters are the devices used for converting toxic and harmful hydrocarbons, carbon monoxide, and nitrogen oxides into harmless compounds.

Exhaust Manifold Gaskets consists of strong network of pipes that are used for collecting gases from cylinders and passes them directly to the exhaust pipe.

Air Components includes variety of devices or equipment like air hoses, air tubes which are used for carrying air under pressure to different destinations. The net result is lower auto exhaust backpressure, more horsepower, more torque, and a much hotter sound, all while staying perfectly legal. However, cheap exhaust system always sounds awesome.

B. WHY NOx REDUCTION? NOx REDUCTION IS IMPORTANT?

NOx is a component in ground-level ozone and smog, and it contributes to acid rain. NOx is also an indirect greenhouse gas that contributes to global warming and climate change. Furthermore it leads to oxygen depletion in bodies of water, upsets chemical balance to aquatic wildlife, and creates acidic lakes and streams. NOx damages lung tissue and causes respiratory problems such as asthma, emphysema and bronchitis. NOx is a suspected carcinogenic and it is known to aggravate existing heart disease.

C. NOx REDUCTION METHOD

Exhaust (burnt) gas already has water in the form of steam that can be reuse by condensation process to reduce the emission rate with urea. In condensation method the steam convert into water that water is used to mix urea (here no need of separate water for mixing urea). By resupplying this water and urea mixture again into the exhaust manifold, has the ability to reduce air pollution (especially NOx reduction) as well as engine backpressure. The present exhaust system has catalytic converter (cat-con) with secondary air supply for reducing the pollution, even though it hasn't ability to reduce the backpressure and also cat-con causes backpressure as well.

D. VARIOUS PROCESSES

- Airless injection of urea solution
- Conversion of urea to ammonia (NH3) into the exhaust gas
- Reduction of NOx with ammonia through SCR
- Output of harmless nitrogen (N2)

II. DESIGN METHODOLOGY

This system works by injecting a cheap harmless substance, urea, into the exhaust gas and passing the mixture through exhaust pipe.

The process transforms the toxic NOx gasses into harmless nitrogen (79% of our natural atmosphere is nitrogen). There is no need for compressed air.

A. COMBUSTION CHEMISTRY

Basic chemical formula of burning of fuel in the combustion chamber as illustrated below

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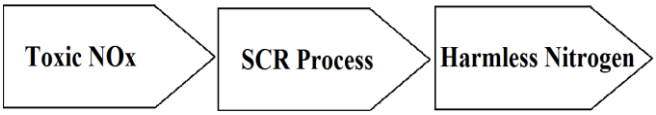
FUEL (H2, C, S) + AIR (N2, O2) = CO2 + H2O + O2 + CO + HC + NOX + SO

From the above combustion equation it is clear that there are the presents of water in the exhaust gases after burning the fuel and air mixture in an IC engine. Exhaust gas containing the various poisonous gases like HC, CO, NOx, SO, CO2 and water in the form of steam.

In this method we are going to extract the water that present in the burned gas by a condenser or radiator and mix the water with urea for reducing the poisonous NOx from the same exhaust gas.

The following chemical reaction indicates the NOx reduction by urea and water mixture.

$CH4N2O+2NO+1/2O2 \longrightarrow 2N2+2H2O+CO2$

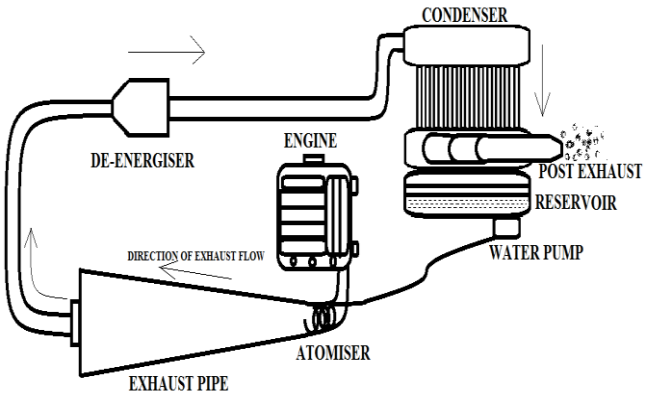


So the result of the reaction is water + carbon dioxide + nitrogen, and no much more other dangerous gases.

Here CO2 is used for the photosynthesis by plants. And water can be re use by condensation process and again it goes to mix with urea and the same process will be continued. This process is also called Selective Catalytic Reduction (SCR), but the major different of this system compare to SCR is that here the water is extract from the exhaust gas itself and mix with urea so, there is no need of separate huge storage of water compare to SCR.

B. EXPERIMENTAL SETUP

The experimental arrangement of the system as illustrated below.



ACTIVE FINAL FLOW (NOx REDUCTION TECHNOLOGY)

C. BASIC FUNCTIONS OF EQUIPMENT

1. ENGINE - Power Source
2. ATOMISER -Water Evaporation
3. EXHAUST PIPE- Directing the gases
4. DE-ENERGISER- Secondary storage of burned gases
5. CONDENSER- Extract water from exhaust
6. POST EXHAUST-Exit of burned gases
7. RESERVOIR- Water storage tank
8. WATER PUMP- Deliver water to atomizer

III. WORKING

Exhaust gases passed through the exhaust (tail) pipe from the engine by the burning of fuel inside the combustion chamber. The atomizer is placed at the exhaust manifold (because temperature is high in the exhaust manifold compare to other area) is start to evaporate the water and urea mixture because of the high manifold temperature and this evaporated gas will be mix with the exhaust gas, finally the water, nitrogen and carbon dioxides are formed and the poisonous NOx is reduced as shown below

$CH4N2O+2NO+1/2O2 \longrightarrow 2N2+2H2O+CO2$

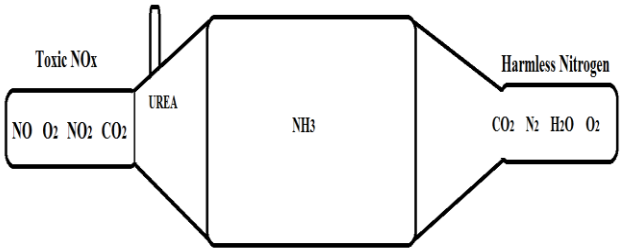


Fig .1 Working of the system in exhaust manifold

Fig 2 Atomizer in the exhaust manifold

Then the gases are passed through the De-energizer. The function of the de-energizer is to store the gases temporarily so it helps to reduce the engine back pressure and exhaust gas temperature as well.

After that the burned gases are passed to the condenser. Here the condenser core is made up of copper pipes for the perfect heat transfer to the atmosphere. Because of the high heat transfer through the condenser core steam that present in the exhaust gases are start to turn into water. And this water is stored in the reservoir.

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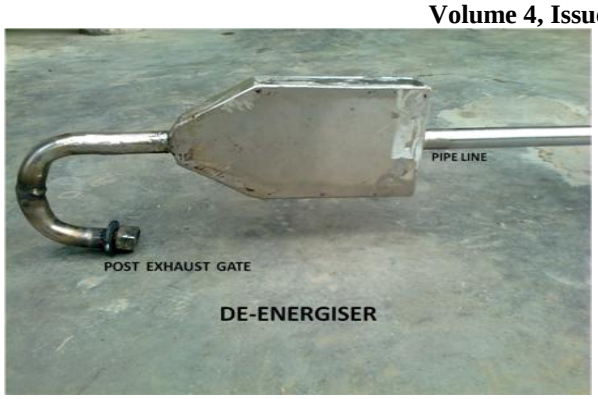

At the middle of the reservoir, there is a layer of urea has been located and this layer is help to the proper mixing of the water and the urea very well. And also there is a layer of filter located over the urea layer for filtering the Black Carbon (CB) or particulates matter (PM).

Finally the mixture of both water and urea is being pumped by a small pump to the atomizer through a proper piping arrangement and the mixture start to evaporate by the exhaust manifold temperature and the cycle remain continue.

Fig 3 System with working condition

IV. OTHER IMPROVEMENT APPART FROM THE NOx REDUCTION

The followings are the other parameters were improved during the NOx reduction as follow.

Reduced particulates matter (PM) or black carbon

The Black Carbon (BC) that presented in the exhaust to be washed out by the injected water in the exhaust manifold and the BC reached in the reservoir, inside the reservoir there is a filter is implemented to separate the BC from the water. So this system is arrest the delivery of black carbon in to the atmosphere and reduces the pollution.

Reduced engine back pressure

Engine back pressure is defined as the return of burned (exhaust) gas again in to the engine cylinder at the valve overlapping period is called engine back pressure. So this causes the serious delay of engine performance especially in the heavy load or high speed conditions. We can be obtain the improved engine performance by reducing the back pressure up to 0.35 to 0.40 psi.

Reduced engine heat

Engine heat is to be reduced up to 5°C-8 °C, because of the water injection in to the exhaust manifold. So the system is also cool the engine as well.

Reduced sound and vibrations

The overall sound and vibration of the engine can be cut out by this system. So that it gives a more quite and smooth driving experience for the driver and passengers.

BENIFITS

No Extra Fuel Consumption

Unique to the DAM SCR System, it has neither the need for compressed air for urea spray nor the need for an exhaust gas mixer. These facts give a SCR system with very low counter pressure and energy usage resulting in no extra fuel consumption.

Easy and Low Cost Installation - Low Weight and Highly Compact

SCR System is designed to be low in weight and highly compact compared to traditional SCR systems. Also the system integrates silencer and catalyst so no extra space is needed compared to the existing/traditional silencer, which can be removed/eliminated. Finally, the absence of compressed air and an exhaust gas mixer naturally gives a very compact and low weight system.

Remarkable Noise Attenuation

SCR System provides remarkable noise attenuation. Noise frequencies can be targeted and eliminated.

No Adverse Effects of Running without Urea Dosing

SCR System will not be damaged nor will it affect engine performance when running without dosing urea. This is important should the urea supply be exhausted or when choosing not to reduce NOx.

Potential for 6-9% Saving in Fuel and CO2 Emission

Today's engines compromise on fuel efficiency to keep NOx emissions moderate; by tuning the engine and thereby producing more NOx, which subsequently can be removed by the SCR System, the fuel savings potential can be achieved.

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Low Maintenance Requirements

The system does not required any separate maintenance because of the simplicity in design and fabrication of the SCR system.

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