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# Noise Damping, Exhaust Emissions and Control Technology for an Internal Combustion Engine

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**Abstract -** *The automobiles play an important role in the transport system. With an increase in population and living standard, the transport vehicles as well as car population is increasing day by day. In addition to this there is steep increase in the number of two wheelers during the last two decades. All these are increasing exhaust pollution and particularly in metros as density of these vehicles in metros are very high.*

*Lots of efforts are made to reduce the air pollution from petrol and diesel engines and regulations for emission limits are also imposed in USA and in a few cities of India. An extensive analysis of energy usage and pollution shows that alternative power systems are still a long way behind the conventional ones. Further developments in petrol and diesel engines, combined with improvements in the vehicles, will make fuel consumption reduction of 40% or more in the future cars. This, in turn, will reduce the CO2 emissions, a gas which is responsible for greenhouse effect.*

*Along with control on emissions, the noise emited by the exhaust are also creating a lot of problems for example NOISE POLLUTION. Many attempts are being made to keep this noise under 110 decibels at maximum throttle. Various designs are made to create minimum vibrations and thus reduce the noise produced.*

***Key Words***: Exhaust pollution, Hydro-carbons,

Petrol engines, diesel engines, (CO, CO2, SO2) Emissions, DB killer, Muffler.

## 1. INTRODUCTION

Undesirable emissions in internal combustion engines are of major concern because of their negative impact on air quality, human health, and global warming. Therefore, there is a concerted effort by most governments to control them. Undesirable emissions include unburned hydrocarbons (HC), carbon monoxide (CO), nitrogen oxides (NOx), and particulate matter (PM), we present the U.S. and European emissions standards, both for gasoline and diesel operated engines, and strategies to control the undesirable emissions. The role of engine design, vehicle operating variables, fuel quality, and emission control devices in minimizing the above-listed pollutants are also detailed. "Emissions" is a collective term that is used to describe the undesired gases and particles which are released into the air or emitted by various sources, Its amount and the type change with a change in the industrial activity, technology, and a number of other factors, such as air pollution regulations and emissions controls.

Environmental Protection Agency (EPA) considers carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO2), ozone (O3), particulate matter (PM), and sulphur dioxide (SO2) as the pollutants of primary concern, called the Criteria Pollutants. These pollutants originate from the following four types of sources. 1. Point sources, which include facilities such as factories and electric power plants. 2. Mobile sources, which include cars and trucks but also lawn mowers, airplanes, and anything else that moves and releases pollutants into the air. 3. Biogenic sources, which include trees and vegetation, gas seeps, and microbial activity. 4. Area sources, which consist of smaller stationary sources such as dry cleaners and degreasing operations.

Also when the exhaust manifolds are attached to the engine in a rigid manner, the vibrations from the engine are transmitted to exhaust directly in addition to vibrations that are produced due to flow of exhaust gases. This leads to increase in noise level.

### 1.1 Perfect Combustion

FUEL (hydrocarbons) + AIR (oxygen and nitrogen)

CARBON DIOXIDE + water + unaffected nitrogen

**Typical Engine Combustion:**

FUEL + AIR UNBURNED HYDROCARBONS + NITROGEN OXIDES + CARBON MONOXIDE + CARBON DIOXIDE + water

### 1.2 Emission Pollutants

**• HYDROCARBONS**

Hydrocarbon emissions result when fuel molecules in the engine do not burn or burn only partially. Hydrocarbons react in the presence of nitrogen oxides and sunlight to form ground-level ozone, a major component of smog. Ozone irritates the eyes, damages the lungs, and aggravates respiratory problems. It is our most widespread and intractable urban air pollution problem. A number of exhaust hydrocarbons are also toxic, with the potential to cause cancer.

**• NITROGEN OXIDES (NOx)**

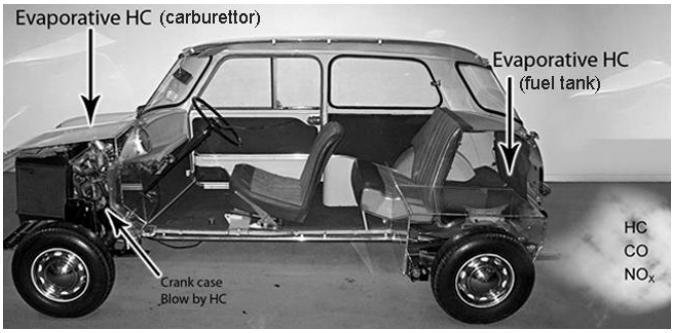
Under the high pressure and temperature conditions in an engine, nitrogen and oxygen atoms in the air react to form various nitrogen oxides, collectively known as NOx. Nitrogen oxides, like hydrocarbons, are precursors to the formation of ozone. They also contribute to the formation of acid rain.

**• CARBON MONOXIDE**

Carbon monoxide (CO) is a product of incomplete combustion and occurs when carbon in the fuel is partially oxidized rather than fully oxidized to carbon dioxide (CO). Carbon monoxide reduces the flow of oxygen in the blood stream and is particularly dangerous to persons with heart disease.

**• CARBON DIOXIDE**

In recent years, the U.S. Environmental Protection Agency (EPA) has started to view carbon dioxide, a product of "perfect" combustion, as a pollution concern .Carbon dioxide does not directly impair human health, but it is a "greenhouse gas" that traps the earth's heat and contributes to the potential for global warming.




**2. Control of emission from SI engines**

To reduce atmospheric pollution, two different approaches are followed:

1. To reduce the formation of pollutants in the emission by redesigning the engine system, fuel system, cooling system and ignition system.

2. By destroying the pollutants after these have been formed.

**3. Catalyst Control Technologies**

The principle behind a catalyst for control of the gaseous emissions of a stationary IC engine is that the catalyst causes chemical reactions without being changed or consumed. An emission control catalyst system consists of a steel housing, size is dependent on the size of the engine for which it is being used, that contains a metal or ceramic structure which acts as a catalyst support or substrate.

There are no moving parts, just acres of interior surfaces on the substrate coated with either base or precious catalytic metals such as platinum (Pt), rhodium (Rh), palladium (Pd), and vanadium (V) depending on targeted pollutants. Catalysts transform pollutants into harmless gases by causing chemical reactions in the exhaust stream. These reactions differ depending on the technology being used which further depends on whether the engine is operating rich, lean, or stoichiometric. In any case, emission control catalysts all serve to eliminate NOx, CO, and NMHC to varying degrees.

**3.1 Nonselective Catalytic Reduction (NSCR) and Three-way Catalysts**

NSCR has been used to control NOx emissions from rich-burn engines for over 15 years. The systems have demonstrated the ability to achieve greater than 98 percent reduction. Over 3000 rich burn IC engines have been equipped with NSCR technology in the U.S. alone. Engines in excess of 250 hp have been equipped with NSCR. In the presence of CO and NMHC in the engine exhaust, the catalyst converts NOx to nitrogen and oxygen, NSCR reduces NOx, CO, and NMHC emissions if an engine is operated stoichiometrically. NSCR used in this manner is defined as a three-way conversion catalyst. In order for conversion efficiencies to remain high, the air to fuel ratio must remain within a fairly narrow window of the stoichiometric point (ë=1). NOx conversion efficiency drops dramatically when the engine is run in the lean regime, while NMHC and CO conversion efficiency also declines somewhat. Three-way catalysts are installed on over 1000 stationary IC engines in the U.S. and have been in use for over 10 years.

**3.2 Selective Catalytic Reduction (SCR)**

SCR is a method of controlling NOx emissions from lean-burn stationary IC engines. The technology was first patented in 1959 in the U.S. and has been used on over 700 NOx generating sources worldwide, some of which are stationary IC engines. Lean-burn engines are characterized by an oxygen-rich exhaust, thereby making the reduction of NOx virtually impossible using NSCR catalyst technology. However, introducing a reducing agent such as ammonia, urea, or others makes the necessary chemical reactions possible. The reactions that occur over the catalyst bed using ammonia are as follows: NOx emissions can be reduced by greater than 90 per cent. This approach is called selective catalytic reduction (SCR) because with the reducing agent present, the catalyst selectively targets NOx reduction alone. A schematic of a typical SCR system is shown in Figure 4. As shown, the reducing agent is injected upstream of the catalyst bed. The amount of reagent injected is calibrated by measuring the NOx concentration upstream of the catalyst (and possibly downstream) or by its predicted concentration knowing the engine's operating parameters.

**4NO + 4NH 3+ O2 -----4N2 + 6H2O**

**2NO2 + 4NH3 + O2 ---3N2 + 6H2O.**

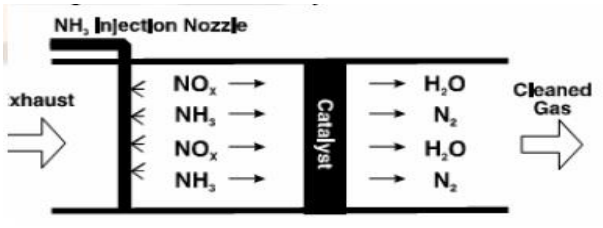



Figure 4: Selective Catalytic Reduction

Both precious metal and base metal catalysts have been used in SCR systems. Base metal catalysts, typically vanadium and titanium, are used for exhaust gas temperatures between 450EF and 800EF. For higher temperatures (675EF to 1100EF), zeolite catalysts may be used. Both the base metal and zeolite catalysts are sulphur tolerant for diesel engine exhaust. Precious metal SCR catalysts are useful for low temperatures (350EF to 550EF). When using precious metal SCR catalysts, attention should be paid to the fuel sulphur content and the appropriate formulation selected.

## 4. Sound pollution and its Control

Sound is another source of pollution which creates discomfort feelings to human beings. The sound level of automobiles is always higher than the desired and therefore legislative measures are also imposed to control the sound level below a particular level to build a peaceful environment.

The noise is measured by decibel (dB) which is given by

$N = 10 \log 10 (I/Ir)$

Where N is in decibels, I is the intensity of sounds and Ir is the reference intensity whose unit is W/m2. The intensity of sound is doubled when the number of decibel goes up by about 3 as it is logarithmic function.

Engine Noise: The engine is the main source of noise. In most cases, at present control levels, exhaust and intake noise is dominant. Many individual vibrations contribute, excited by the rapid rise of cylinder pressure at the onset of combustion and by the impact of piston on the cylinder wall as it changes the direction at TDC. At rated speed and load, the differences between engine types are within about 5dB. But at comparable operating points near half speed, S.I. engine averages about 20 dB lower than the large diesel.

With cities, the traffic noise is perceived as a major detraction from amenity. The noise levels of different automobiles are listed in the following table.

| CATEGORY | DB (A) |
|---|---|
| Motor cycles above 125cc capacity | 86 |
| Private cars | 80 |
| Light good vehicles | 82 |
| Heavy goods vehicles below 200hp | 86 |
| Above 200hp | 89 |

Maximum permitted noise level at a distance of 75m from the path of the vehicles, being driven within an area providing a clear space of at least 50m radius.

### 4.1 Controlling Noise Pollution

Controlling environmental pollution is not merely a regulatory function. Noise as an environmental problem is not an exception. Of all forms of pollution, noise pollution is most carelessly neglected, consciously ignored and willingly accepted.

To add to some of the methods of controlling noise pollution, we have a small component called **'DB killer'.**

DB killers are basically an aid used to silence the exhaust sound to acceptable DB limits. It's generally a long perforated tube that stream lines the flow path of exhaust. The exhaust is passed through it, where due to narrowing of path exhaust sound is muffled.

Factory installed exhaust have DB killer is pre-installed and are designed in such a way that it silences the exhaust also helps in creating back pressure on valves which increases volumetric efficiency of engines too. A DB killer on an exhaust is used to kill the sound to an extent. It's is a small part that usually weighs less and might not significantly increase the weight on a motorcycle. If you have swapped the exhaust system for a free flow header and a race exhaust, you will have to remove the DB killer to get the full performance out of it. this only applies to bikes which are also taken to tracks. Loud aftermarket exhausts are not recommended for street use. Also removal of DB killer from stock exhaust can get you into trouble from authorities or your neighbors.

**Fig.** Db killer


**Fig.** SC Exhaust in which db killers are fitted

## 5. CONCLUSIONS

The advent of "first generation" catalytic converters in 1975 significantly reduced hydrocarbon and carbon monoxide emissions. The use of converters provided huge indirect benefit as well. Because lead inactivates the catalyst, 1975 saw the widespread introduction of unleaded gasoline. This resulted in dramatic reductions in ambient lead levels and alleviated many serious environmental and human health concerns associated with lead pollution. The next major milestone in vehicle emission control technology came in 1980-81. In response to tighter standards, manufacturers equipped new cars with even more sophisticated emission control systems. These systems generally include a "three-way" catalyst (which converts carbon monoxide and hydrocarbons to carbon dioxide and water, and also helps reduce nitrogen oxides to elemental nitrogen and oxygen), plus an on-board computer and oxygen sensor. This equipment helps optimize the efficiency of the catalytic converter. Vehicle emissions are being further reduced by provisions of the 1990 Clean Air Act. Mobile source provisions include even tighter tailpipe standards, increased durability, improved control of evaporative emissions, and computerized diagnostic systems that identify malfunctioning emission controls.

Also the noise level can be lowered for street use purposes on a daily basis to lower noise pollution. Along with benefits, a db killer is concluded to have two small disadvantages.

They are- 1. It adds up to weight.
2. It limits to engine power.

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