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REVIEW OF EXHAUST EMISSION AND ITS CONTROL TECHNIQUES

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Abstract

Reduction of toxic substances emission from combustion engines can be achieved in automotive exhaus treatment process is applied based on oxidation and reduction processes which are takes place in catalytic co Generally catalytic converter uses platinum group of metals like Pt, Pd and Rh Exhaust system, the least co section by the people has the most effective role on the environment as it is that portion of an automobile t which exhaust gases get out from the combustion chamber to pollute the air by their contaminated contents Th pollutants contributed by I.C. engines are CO, NOX unburned hydro-carbons (HC) and other particulate em Other sources such as Electric power stations industrial and domestic fuel consumers also add pollution like SO2 and particulate matters. In addition to this, all fuel burning systems emit CO2 in large quantities and this concerned with the Green House Effect which is going to decide the health of earth. Lot of efforts are made to the air pollution from petrol and diesel engines and regulations for emission limits are also imposed in USA a few cities of India. An extensive analysis of energy usage and pollution shows that alternative power systems a long way behind the conventional ones. Further developments in petrol and diesel engines, combine improvements in the vehicles, will make fuel consumption reduction of 40% or more in the future cars. This, will reduce the CO2 emissions, a gas which is responsible for greenhouse effect.

Keywords: Exhaust pollution, Hydro-carbons, NOx emission, Petrol engines, diesel engines, CO Emission Emissions, CO2 Emissions, Particulate matters, Greenhouse effect .

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.(1) Due to incomplete combustion in the engine, there are a number of incomplete combustion products CO, HC, NOx, particulate matters etc. These

pollutants have negative impact on air quality as well as on human health also on environment that leads in stringent norms of pollutant emission. Numbers of alternative technologies like improvement in engine design, fuel pre-treatment, use of alternative fuels, fuel additives, exhaust treatment etc. are being considered to reduce the emission levels of engine. Among all the types of technologies developed so far, use of catalytic converters is the best way to control automotive exhaust emissions.Exhaust pollutants from the automobiles engines have negative impact on air quality as well as on human health. In previous section we have studied how emissions are produced by an automobile and effect of automobile exhaust emission on human as well as on environment and also discussed about exhaust emission control techniques.(2)

2. "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

3. EXHAUST EMISSION

Due to incomplete combustion in the engine, there are a number of combustion products like HC, CO, NOx, etc. 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. Nitrogen oxides, like hydrocarbons, are precursors to the formation of ozone. They also contribute to the formation of acid rain. Carbon monoxide reduces the flow of oxygen in the blood stream and is particularly dangerous to person with heart disease. Carbon dioxide does not directly impact human health, but it is a "greenhouse gas" that traps the earth's heat and contributes to the potential for global warming. (3)

4. EVAPORATIVE EMISSIONS

Evaporative emissions regulations apply to emission of hydrocarbon from locations other than the tailpipe, when the vehicle is operating or parked. Three categories of evaporative emissions are typically considered: running loss, hot-soak and diurnal breathing loss (DBL) emissions (4). Running losses include any vapor that escapes through seals, valves, etc. in the fuel system. Another consideration while running is crankcase emissions, which contain small particles of oil (5). These emissions have been regulated since the early 1960's (6) and are typically controlled with a positive crankcase ventilation (PCV) system. This is passive system that diverts the ventilation gases to the intake manifold for combustion. Hot soak is the period just after a hot engine is shut down. Hot soak emission sources are similar to running loss sources, but also include any fuel vapor remaining in the engine after combustion has stopped. DBL emissions occur while the vehicle is parked (4). The most prominent source of DBL emissions is the fuel system.

A canister system is typically used to control emission of fuel vapors that develop in the fuel tank, generally as a result of temperature changes or during refueling (7). These vapors are stored in the canister and later burned as part of a normal combustion event. The hydrocarbons in the canister are purged into the intake manifold for induction into the cylinder. A/F control during canister purge is challenging due to uncertainty in the quantity of vapor released. DBL in the system can break through in several locations (8). These include the air intake, the canister, the fuel tank and any piping or connection in the system that contain gaseous hydrocarbon. A proposed passive solution for the air intake system is a hydrocarbon filter located with the air filter (8). Improved canister systems (7)and fuel systems (4) are also considered for improved DBL emission control.

5. EXHAUST 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.(2)

• 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.(2)

• 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.(2)

• 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)

6. DEVICE (CATALYTIC CONVERTER)

A catalytic converter (colloquially, "cat" or "catcon") is a vehicle emissions control device which converts toxic by-products of combustion in the exhaust of an internal combustion engine to less toxic substances by way of catalyzed chemical reactions [1]. This paper presents the performance of a specific catalytic converter analyzing the emitted exhaust gases (NO, NO2, CO, CO2, O2, SO2) of a SI engine at different engine speed and torque. From different graphical representations it is very clear that the catalytic converter reduces CO2, NO2, & SO2 emission in a large extend.(9)

Fig 6.1: (a) Cutaway of a metal-core converter

(b) Ceramic -core converter

7. CONVERSION BY CATALYTIC CONVERTER SUBSTRATES

A substrate is a substance on which some other substance is absorbed or in which it is absorbed. (Catalytic conversion requires a precisely balanced air-to-fuel ratio, hence the need for oxygen sensors.) In dual-bed converter systems the exhaust gases are first reduced in order to eliminate the oxides of nitrogen; then they are oxidized with added air in order to eliminate carbon monoxide and unburned hydrocarbons (10). In more advanced three-way converters individual catalysts accomplish reduction of each species simultaneously. Catalysts are either platinum-group metals or base metals such as chromium, nickel, and copper. Platinum-group metals or noble metals are any of several metallic chemical elements that have outstanding resistance to oxidation, even at high temperatures; the grouping is not strictly defined but usually is considered to include rhenium, ruthenium, rhodium, palladium, silver, osmium, iridium, platinum, and gold. In base-metal catalysts the active surfaces are actually ceramic oxides of the metals. Because platinum metals are extremely expensive, they are deposited on ceramic catalyst supports as salts and then reduced to finely divide metal particles. For efficiency of conversion, extremely large surface areas are required. These are accomplished by ingenious micro-structural engineering of the ceramic support structure. Two types of structure are made pellets and honeycomb monoliths. The pellets are porous beads approximately 3 millimeters (1/8 inch) in diameter. With a single pellet having up to 10 square millimeters of internal pore surface area, one liter of pellets can have up to 500,000 square meters of support surface (10). The pellet material is often alumina (aluminum oxide, Al_2O_3). High internal porosity is achieved by carefully burning off the organic additives and by incomplete sintering. Honeycomb monoliths have 1,000 to 2,000 longitudinal pores approximately one millimeter in size separated by thin walls (11). The material is commonly cordierite, a magnesium aluminosilicate ($Mg_2Al_4Si_5O_{18}$) known for its low thermal expansion. The extruded cordierite structure is coated with a wash of alumina, which in turn supports the platinum catalyst particles. The surface area of the monolith is typically in the range of one square meter; however, this figure must be multiplied many times because of the porosity of the alumina on the surface. Monolith supports are much more expensive than pellet supports, but they cause a smaller pressure drop in the exhaust system. Both types of catalyst support, because of their inherent friability, are susceptible to vibrational degradation. Containment of the supports is also difficult. A good seal must be achieved and maintained without imposing external stresses on the friable structure.

Fig 2: Catalytic converter to be welded in exhaust system of the car, Toyota E-90 in MIST welding shop.

8. CONTROL OF EMISSION FROM S.I. 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.

In petrol engines, the main pollutants which are objectionable and are to be reduced are HC, CO and NOx. The methods used are Si engine control Crankcase Emission Control (PCV System) Evaporative Emission Control Exhaust Gas Recirculation Water Injection Crankcase Emission Control (PCV System) A small amount of charge in the cylinder leaks past piston rings into crankcase of the reciprocating engines. Near top dead centre (TDC) when the rings change their position in the grooves at the end of compression stroke, combustion has already begun and the cylinder pressures are high. A significant part of charge stored in the piston- ring-cylinder crevice leaks into the crankcase. These gases are known as 'crankcase blow by' and their flow rate increases as the engine is worn out and the piston - cylinder clearances and ring gaps increase. In the homogeneous charge engines, the crankcase blow by gas is high in HC concentration. Only a small fraction of the gas stored in the ring crevices and hence blow by gases may consist of partially burnt mixture. This source contributes about 20 per cent of total hydrocarbons emitted by an uncontrolled car. The crankcase blow by gases in the uncontrolled engines was ventilated to atmosphere under the effect of pressure difference occurring naturally between the crankcase and atmosphere. For control of crankcase emissions, the blow by gases are recycled back to the engine assisted by a positive pressure drop between the crankcase and intake manifold. When engine is running and intake charge is throttled the intake manifold is at a lower pressure than the crankcase. The blow-by gases mix with the intake charge to be burned inside the engine cylinder to CO_2 and H_2O. tube connects crankcase or cylinder head cover to the intake manifold below throttle valve, which leads the blow by gases back to the engine. Due to suction effect of intake manifold as the pressure in the crankcase falls, ventilation air from the air cleaner is drawn into the crankcase that continuously purges it. A one-way valve (PCV valve) is used to control the flow of blow by gases PCV valve restricts flow of blow by gases during idling and very light loads which otherwise would cause excessive leaning of the charge by ventilation air. Under normal engine operation, PCV valve is fully open providing free flow of the gases while under high intake manifold vacuum the flow is restricted. [1]

9. CONTROL OF EMISSION FROM DIESEL ENGINE

The need to control the emissions from automobiles gave rise to the computerization of the automobile. Hydrocarbons, carbon monoxide and oxides of nitrogen are created during the combustion process and are emitted into the atmosphere from the tail pipe. The clean air act of 1977 set limits as to the amount of each of these pollutants that could be emitted from an automobile. The manufacturers answer was the addition of certain pollution control devices and the creation of a self-adjusting engine. An oxygen sensor was installed in the exhaust system and would measure the fuel content of the exhaust stream. It then would send a signal to a microprocessor, which would analyse the reading and operate a fuel mixture or air mixture device to create the proper air/fuel ratio.PM emissions from stationary diesel engines are more of a concern than those for IC engines using other fuels. Several emission control technologies exist for diesel engine PM control. Oxidation or lean- NOx catalyst can be used to not only reduce the gaseous emissions associated with the use of diesel engines but further provide significant PM control. Likewise, diesel particulate filter systems can be used to achieve up to and greater than 90 percent PM control while in some instances, also providing reductions in the gaseous emissions. Additionally, special ceramic coatings applied to the combustion zone surfaces of the piston crown, valve faces, and head have shown the ability to significantly reduce NOx and PM emissions in diesel engines. These ceramic coatings can be used by themselves or combined with an oxidation catalyst to give even greater reduction of PM. Ceramic engine coatings change the combustion characteristics such that less dry, carbon soot, is produced. Also, when combined with an oxidation catalyst, ceramic coatings allow retarding of the engine to reduce NOx, while CO and particulates are maintained at low levels. In the case of gaseous fuels, ceramic coatings have shown the ability to allow the user to operate their engines with timing significantly advanced generating higher power levels. Also, wider ranges of fuel composition and ambient air temperature fluctuations are tolerated without the deleterious effects of pre combustion. Tests are currently underway to evaluate the effects of the coatings on specific emissions from gaseous fuelled engines .Emission control technology for stationary IC engines is currently available and can be used to provide substantial reductions in the CO, NMHC, NOx, and PM emissions from these sources in a cost effective manner[1].

CONCLUSIONS

Control has played a critical role in the dramatic reduction in tailpipe and evaporative emissions of automobiles over the last four decades. The presence of catalytic converter is must in an exhaust system as it reduces the pollutant content to a great extent except for sulphur die oxide the amount of which increases with the increase in speed even with the presence of catalytic converter. Although more study can be done with the latest designed catalytic converter along with other emission control devices. The graphical representation actually indicates the reduction of hydrocarbon and other harmful contents with the attachment of catalytic converter.

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