Arid Zone Journal of Engineering, Technology and Environment. October, 2004; Vol.4, 71-77

Print ISSN: 1596-2490, Electronic ISSN: 2545-5818
www.azojete.com.ng

DEVELOPMENTS IN AUTOMOBILE EMISSION CONTROL

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Abstract

It is widely acknowledged that automobiles are becoming dominant contributors to atmospheric pollution in most of the world's cities. Hence, the need to find effective methods of controlling automobile emissions becomes imperative. Available automobile emissions' control measures which include various legislations and responses to legislations such as improvement in the state of the art controls, greater attention towards automobiles growth, improvement of engine design features, periodic tune-up, the use of alternative fuels and the development of non-fossil energy sources were reviewed in this paper.

1. Introduction

Emission-Control System in automotive engineering referred to means employed to limit the discharge of noxious gases from the internal combustion engines (The New Encyclopedia Britannica, 1998). According to the New Encyclopedia Britannica (1998), pollutants are things that cause pollution while pollution is the addition to the environment of any substances or energy form at a rate faster than the environment can accommodate by dispersion, breakdown, recycling or storage in some harmless form. In the area of man made emissions into the atmosphere, automobiles are dominant and growing source of several atmospheric pollutants. This is because the demand for automobiles as a means of transportation has been growing as the population increases over time coupled with the growing urbanization across the world.

Most of the available automobiles use fossil fuels, hence automobiles account for a significant consumption of petroleum products since it produces power from the combustion of a mixture of petroleum product and air in an enclosed space. The products of this combustion process constitute some of the known atmospheric pollutants. Pollutants emitted from automobiles depend on a number of factors which includes the type of fuel, air – fuel ratio, ignition timing, engine speed and operation temperature (Spalding and Cole, 1973; Rogers and Mayhew, 1980 and Walsh, 1992). Combustion of fuel and air in automobile made it major source of carbon dioxide and unburnt hydrocarbon. It has also been a major source of leads into the atmosphere of many cities because of the burning of gasoline with leads compounds as additive (Novikov, 1990).

Evaporation of gasoline leads to hydrocarbons escaping from the tank, the carburetor and the crankcase. Also, because of the high pressures in the cylinder above the piston during combustion process, some of the unburnt gasoline and other organic compounds find their way past the piston rings into the crankcase. Emission also comes from the tail pipe. All these contribute greatly to the level of atmospheric pollution (Avallone and Baumeister, 1997). The contributions of these combustion products and other pollutants released by automobiles, and their effects have been established. The introduction of harmful substances into the

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environment has been shown to have many adverse effects on human health, agricultural productivity and natural ecosystems (Harrison, 1990 and Murley, 1995).
Early recognition of the significance of vehicle exhaust emissions occurred in California, where a combination of geography and atmospheric conditions both trapped the emissions in Los Angeles basin and exposed them to the strong California sunlight. The resulting photochemical smog was recognised as having an adverse impact upon human health, crop and vegetation growth, and is visually offensive (Eastop and McConkey, 1993). Many of the gases emitted by automobiles contribute to greenhouse warming either directly or indirectly, acid precipitation, ozone depletion and they also contribute directly to adverse health effects. For example, pollutant can be washed out of the air by the natural scrubbing action of rain, snow and all other forms of precipitation as it falls to the ground, usually referred to as acid precipitation; this made some of the known emissions from automobiles to be sources of acid precipitation (Hesketh, 1972).

Moreover, the average temperature of the earth's surface is known to be rising. The evidence to date support the view that the globe as a whole has warmed by between 0.3-0.60C since the end of 19th century (Carson, 1998) even though some are still sceptical for the fact that record in the 20th century also indicates that while some regions have recorded a slight surface warming trend for decades, some regions have experienced a slight global cooling trend for decades (Ladd, 2003).

The main concern about the relatively small temperature increases occurring in the earth due to the increased greenhouse effect is in the increase in the melting of the polar ice-caps. Greenhouse effect on the earth is caused by the absorption of the sun's rays by gases such as carbon dioxide, halocarbon compounds (CFCs), nitrous oxide and ozone. Ozone gas (O_3) is one of the byproducts of photochemical smog. The action of sunlight on a trapped layer of car and chimney exhaust fumes produces the chemical reactions to convert oxygen to ozone. It is known that ozone is positively harmful at ground level, it is present in the layer of the earth's atmosphere known as the stratosphere, about 11-50 Km above the surface of the earth. At these altitudes, it is formed by the action of sunlight on oxygen and decomposes back to oxygen plus a free oxygen atom also due to sunlight. The free oxygen atom combines with ozone to form two molecules of oxygen gas. Due to this continuous reaction in the stratosphere, ultraviolet light from the sun is being absorbed in the process thus partially shielding the earth from the sun's harmful radiation. Ozone is destroyed when combined with certain reaction atoms, or free radicals such as H, OH, NO and Cl; such reactions are catalytic and cause ozone depletion. It was found that the natural annual cyclic thinning of the ozone layer over the Antarctic appeared to be increasing and a "hole" had been created causing fears of skin cancer due to increased intensities of ultraviolet-B from the sun's rays (Eastop and McConkey, 1993).

As public awareness of environmental risk grows, there have been concerns from almost every quarter on the increase rate of pollutants emission. Hence, pressures increase both in the introduction of new laws and to extend the scope of existing legislation on automobile emission. In the same line various agencies have also been put in place in order to monitor the implementation of policies derived from these various legislations. Concern of protecting environment for the benefit of the present and the future generation is now at the centre of the international agenda. The process of reduction of man-made emissions of atmospheric pollutants from automobiles is becoming increasingly global. Government of various

countries now thought it wise to make long–term policies. The goal being to design preventive, adaptive and remedial measures, in combating atmospheric pollutants from automobiles.

In the light of the above, some stakeholders have taken various steps in order to reduce pollutants from automobiles (EPA, 1994; Clean Car Campaign, 2000; Ganske, 2003 and Abdulrahim, 2003), while others still lack awareness on the roles expected to be played in combating atmospheric pollutant emissions from automobiles. Hence, the needs to provide information on the contribution of various organs of the society towards automobile emissions control cannot be overemphasized. This will bring about awareness on the role being played by various stakeholders, and what is still expected from others. In view of the above, the present study seeks to review developments in automobile emissions control.

2. Review of automobile emission control measures world wide

2.1 Legislation

If no environmental protection measures are taken against the increased rate of pollutants emitted into the atmosphere from automobiles, the result is detrimental effects on nature and in the long run on the national economy. It was against a background of increasing public nuisance and distress that in 1960, the state of California legislated against the motor vehicle and stated the procedures against which vehicles would be tested and the levels of pollutants which would have to be met by vehicle to be sold in that state. The procedures were extensive and covered the types of emission to be controlled i.e. hydrocarbon (HC) and carbon monoxide (CO), the sources of emissions (exhaust, crankcase, carburettor, and fuel tank), the test procedures, the instrumentation and the test equipment to be used (Eastop and McConkey, 1993). Automobile source of pollutants rapidly became the target of a series of legislative actions seeking to reduce emissions throughout the United States and Canada in recognition of uniquely severe problem. Since those early days, the application of exhaust emission legislation has steadily widened in the US, Japan and some European countries (Hawkins, 1992). In Europe, the most significant effort has been to reduce the use of leaded fuels as a means of raising the knock rating of petrol.

Since developing countries also account for a growing proportion of global emission of various pollutants because of the growing number of imported used vehicles, their governments are also responding to current risks and uncertainties through prudent action to slow the emission of pollutants from automobiles (Abdulrahim *et a*l., 2003). For example, in 1988 the Federal Government of Nigeria established the Federal Environmental Protection Agency (FEPA) to protect, restore and preserve the ecosystem of the Federal Republic of Nigeria. Decree 58 of 1988 requires FEPA to establish environmental guidelines and standards for the abatement and control of all forms of pollution (FEPA, 1991).

The prevention of global ecology catastrophe thus becomes an inalienable part of the process forming comprehensive environmental security. The Montreal protocol of 1987 on substances ruining the ozone layer, together with the Vienna convention of 1985 on protection of the ozone layer, lays the international legal basis for solution of the most important global problems of our time (Novikov, 1990). Other international efforts include those being made by International Governmental Panel on Climate Change (IPCC), and of particular

significance is the third conference of the parties (Cop-3) held in December, 1997 in Kyoto, Japan, where the Kyoto protocol was released (Okorodudu-Fubara, 2000).

2.2 Responses to legislation

In order to comply with the various legislations world wide for limiting the emissions from automobiles, a number of steps have already been taken while many others are still on the way by the automobile manufacturers, users and many other related groups. These include improvement in the state of the art controls, their wide spread applications, greater attention towards constraining automobile growth, improvement of engine design features, periodic tune-up of older vehicles, the use of alternative fuels and the development of non-fossil energy sources for automobiles, among others. Some of these steps are briefly reviewed below:

2.2.1 Positive crankcase ventilation (PCV) system

First of the emission controls adopted by automotive industry, and still in use is the crankcase ventilation system that routes blow-by gases, condensation vapours and crankcase fumes to the combustion chamber of the engine.

2.2.2 Evaporative emission control system

Evaporative emission control systems prevent the escape of gasoline vapours from the fuel tank and carburettor, whether or not the engine is running. All late model engines use an activated charcoal canister to trap the vapours when the engine is shut off. On restoring, a flow of filtered air through the canister purges the vapours from the charcoal.

2.2.3 Exhaust emission control

In order to comply with regulations for the control of exhaust emission, car manufacturers and their suppliers developed and installed many different systems and devices, which can be grouped into two, namely; pre-combustion controls and post-combustion controls. Pre-combustion control includes the various engine modifications that affect compression ratio, combustion chamber, redesigns of piston in crown contour, intake manifolds, camshaft, valve port, cylinder head gaskets, spark plug port location changes and exhaust gas recirculation incorporated in manifolds. Other pre-combustion controls are thermostatically controlled air cleaners, early fuel evaporated system, manifold heat control valve, ignition timing and fuel mixture control. Post–combustion control includes exhaust gas recirculation system, air injection system and catalytic converters.

2.2.4 Service and maintenance solution

Since the on-going advances in vehicle exhaust emission control technology have considerably reduced the amount of emissions from new vehicles, policies are made, most especially by government of developing world, to lower the emission from older vehicles by periodic tune–up, because it has been found to reduce pollutant emission from automobiles considerably.

2.2.5 Improving transportation system

Additional reductions in vehicular emissions can be achieved by reducing dependence on individual cars and trucks, and by making greater use of van, car pools, buses and trains. Improving urban traffic management by installing synchronized traffic lights, reducing on-

street parking, banning truck unloading during the day and introducing electric toll collector can also improve transportation system fuel efficiency.

2.2.6 Development and use of alternative energy sources

While technological improvements in petroleum powered vehicles are essential to achieving short term increases in fuel efficiency, they will not be sufficient in the long run because the number of vehicles continues to grow. For this reason, efforts to develop new transportation energy sources that emit less or no carbon dioxide have been intensified. Research, development and demonstration programmes are presently put in place by some major automobile manufacturers. These alternative sources of energy include natural gas, fuel cells, battery and solar energy.

(i) Natural gas is promoted as an alternative fuel that could reduce the dependence on oil and also reduce pollutants emitted from automobiles. It has been used to power automobiles with a view to improving the cleanliness of the exhaust products because it is a clean-burning fuel with low carbon monoxide and hydrocarbon emissions. It is also plentiful and relatively cheap. Natural gas test by Auto Oil Emission Testing Programme (run by a group of automakers and oil companies that include General motors, Ford, Chrysler, Arco, Amoco, and Shell) has been on course for some time now. The program studies advanced technology vehicles to gather information on emissions and optimized combustion (TechNews, 1991).

(ii) Ethanol and methanol fuels are seen as being more environmentally friendly than fossil fuels. Hence, a lot of effort is being put towards the utilization of methanol and ethanol as alternative fuels for engines. For example, methanol powered model 6V-92 turbo charged and after cooled engine was developed by Detroit. The hydrocarbon, nitrogen oxide and particulate emission standards were met for both M100 (100 percent methanol) and M85 (85 percent methanol and 15 percent unleaded gasoline) fuels when used in this model. This achievement made Detroit the first heavy–duty engine manufacturer to receive Environmental Protection Agency Emission Certification of an alternative fuel engine (Detroit, 1991).

(iii) Advancement in turbine–powered vehicles is still in progress. In this category, Toyota turbine–powered GTV experimental vehicles emerged in 1989 as probably the most advanced gas turbine-driven prototype in existence then. The advantages it has over the conventional piston engine include the ability to use any type of fuel – kerosene, petrol, diesel and even coal powder, the emission behavior is reported excellent and a good turbine will meet all current emissions standards without a catalytic converter (Kunle, 1989).

(iv) The main advantage of electric propulsion is that pollution in the form of noise and atmospheric emission is reduced almost to zero. For this and other reasons, electric propulsion has been used in city vehicles throughout the twentieth century. Public transport vehicles in the form of trams and trolley buses have drawn current from a remote supply fed along underground rails or above–ground wires. As to passenger cars, electric traction is fast becoming a major research goal all over the world. The electric car must carry its electricity supply with it, in the form of either batteries or

fuel cells (Novikov, 1990). In the newest Honda solar car, the upper surface of the body is covered with monocrystal silicon cells which are able to provide a total power output of 1.9 kW. This car emerged as a solar challenged car in the development of electric vehicles. In the area of fuel cell, which creates electricity directly from fuel (hydrogen or hydrogen-rich gas), the electricity produced can be used to power automobiles. Automakers world wide are increasingly becoming interested in fuel cell for at least three reasons, namely; energy efficiency, environmental cleanliness and international competition. Fuel cell possesses significant potential in addressing long-term regulation (Christopher, 1996). One fuel car running on hydrogen produced from natural gas emits about three times less carbon dioxide than a gasoline vehicle, if one considers the entire fuel cycle. Another achievement is the formation of the U.S advanced battery consortium which brings the big three automakers together with battery firms and the Department of Energy to develop technology for electric vehicle (TechNews, 1991).

(v) The first gasoline–electric hybrid vehicle available in U.S was the Honda Insight. It was developed by American Honda Motor Corporation utilizing its innovative Integrated Motor Assist (IMA) hybrid system. This is an advanced ultra-low emission technology capable of averaging more than 70 miles per gallon (EPA combined estimated) while meeting California stringent Ultra–Low Emission Vehicles (ULEV) standard. Toyota was the first automaker to release autos with gasoline-electric engines for commercial sale, starting with Prius in 1997, with engines driven by a combination of gasoline and electricity. The Prius is classified as a super-ultra-low-emission vehicle (SULEV) and is now available (Ganske, 2003). The Toyota Prius and the Honda Insight, with their hybrid fuel technology and radical design concepts, are examples of commitment to a cleaner environment, conservation of resources and technological ingenuity.

4. Conclusion

Automobiles have been acknowledged as dominant contributors to atmospheric pollution of most cities, with its adverse effects on the environment. Hence, automobile emission control has become a duty for everybody and no amount of contribution towards reducing emission from automobiles should be regarded as small by stakeholders. Present available automobile emission control measures include the use of legislation that has brought about the need for changes in vehicle design technology, engine technology, use of alternative fuels and better traffic management. These developments still leave room for contribution and improvement.

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