Volume 3, Issue 6, June-2016, pp. 284-290 ISSN (O): 2349-7084

International Journal of Computer Engineering In Research Trends

Available online at: www.ijcert.org

Experimental Study on Automobiles Exhaust Emission Control

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1. Abstract: The biggest question today before the metropolitan population of our country in particular is, "Pollution is, snuffing us out" and pollution ever be controlled? There are no doubts that the progress was achieved in the last few decades in some areas in very negligible in comparison with the overall picture. For the controlling of automobile exhaust emission, the honorable Supreme Court of India, in June 1999 ruled that vehicular emission had to be reduced at a much quicker pace than planned so far. Engine manufactures was facing the challenging task to quality find solutions that are production feasible, technological explained with Euro norms, and therefore, they have been changing the concept of IC engine design, multipoint fuel injection system, Catalytic Converter and incorporation of Exhaust Gas Re-circulation (EGR) remarkably. To reduce the automobile exhaust emission the several control equipment's are:

1. Catalytic Converter,
2. Exhaust Gas Re-circulation (EGR),
3. Air Aspiration System,
4. Positive Crankcase Ventilation, etc.

NOx control system that recycles a small part of the inert exhaust gas back through the manifold to lower the combustion temperature and this system is called Exhaust Gas Re-Circulation system. Catalytic converter converts harmful gases to harmless gases. A catalyst is a material that causes a chemical change without entering into the chemical reaction. For example, in the Catalytic converter converts harmful gases to harmless gases. A catalyst is a material that causes a chemical change without entering into the chemical reaction.

Key Words: Exhaust Emission, Combustion Temperature, EGR, Catalytic Converter.

2. INTRODUCTION:

As per Central Pollution Control Board of India is findings in about 69 cities of our country i.e. air quality is moderately, highly and critically polluted. However, problems are still belongs to I.C. engine due to maintaining of clean air. In recent times, the I.C engine powered vehicles have come under heavy attack due to various problems created by them.

As per experimental study, it was found that more than 50% to 60% automobiles were contribution by exhaust emission to the atmosphere.

The main pollutants are contributes by carbon mono-oxide (co), Unburned hydrocarbon (UBHC), Oxides of Nitrogen (NOx) and other suspended particulate (SPM) matter, etc. The basic reasons for automobile exhaust emission in India which is contribution to air Pollution:

1. Poor Quality Design,
2. No pollution preventive step taken.
3. Uncontrolled growth of vehicle performance, etc.
4. High vehicle density in India Urban centers,
5. Older vehicles predominant vehicle design,
6. Inadequate inspection and maintenance facilities,
7. Predominance of two stroke two wheelers,
8. Adulteration of fuel and fuel products,
9. Improper traffic management system and road conditions,
10. High level of pollution at traffic intersection,

11. Absence of effective mass transport system and inter-city railway networks,
12. High population exodus to the urban centers, etc.

It is true that pollutants from one don't amount to much say half kg of pollutants for a single day, but if we consider the very large number of automobiles in India, arising very rapidly, hence it will cause health problems for children and others.

For example, the following observations were obtained during a trial on a single cylinder 4 stroke engine.
Duration of trial: 1 hour
Cylinder bore : 30 cm
Stroke : 45 cm
Total Fuel used: 8 kg
Calorific value of the fuel: 10,500 kcal/kg
Total no. of revolution: 12600
Brake Mean effective pressure: 6.5 kg/cm^2
Brake load: 160 kg
Drum radius: 1m
Total weight of cooling water: 550 kg
Temperature rise of cooling water: 45°C
Total weight of air consumed by engine: 364 kg
Temperature difference of exhaust gases through the calorimeter: 280°C
Special heat of exhaust gases: 0.24

Calculate i.h.p. (indicate horse power), b.h.p. (Brake horse power) and draw heat balance sheet for the engine on minute basis.

The solution the example:

Heat supplied by fuel per minute =
$\frac{8}{10} \times 10{,}500$
= 1,400 kcal

i.h.p. = $\frac{PLAN/2}{4500}$ p
= 6.5 kg/cm^2
A = $\frac{\pi}{4}$ D^2
= $\frac{\pi}{4} \times (3)^2$
= 706 cm^2
= $\frac{Pm\ LAN}{2\times4500}$, Here, L = 45 cm = 0.45 cm^2

$N = \frac{12600}{60} = 210$ r.p.m.

i.h.p. = $\frac{6.5\times0.45\times706\times210}{2\times4500}$
= 48.18

Heat to i.h.p. per minute = $\frac{B.M.P.\times4500}{J}$
(BMP= Brake Mean Effective Pressure) J
= 427kg.m/kcal

$= \frac{48.18\times4500}{427}$
= 508 kcal

Heat to cooling water per minute:

$W_w (t_1-t_2) = \frac{550}{60} \times 45$
= 412.5 kcal

Weight of exhaust gases issued per minute:
$= \frac{8+364}{60}$

$= \frac{372}{6} = 6.2$ kg.

∴ Heat to exhaust gases per minute:
$= C_p W_g (T_{g1} - T_{g2})$
$= 0.24 \times 6.2 \times 280$
= 416 kcal

b.h.p. = $\frac{2\pi RN\ (W-S)}{4500}$
$= \frac{2\pi\times1\times210\times160}{4500} = 46.8$

Heat to b.h.p. per minute:

$= \frac{b.h.p.\times4500}{J}$
$= \frac{46.8\times4500}{427} = 492$ kcal

Heat in friction per minute:
= 508 – 492
= 16 kcal

Heat balance sheet on minute basis may be drawn as follows:

Item	Heat units (kcal)	percent
Heat supplied by fuel	1400	100
Heat to b.h.p.	492	35.22%
Heat in friction	16	1.14%
Heat to cooling water	412.5	29.42%
Heat to exhaust gases	416	29.70%
Heat unaccounted for (by difference)	63.5%	4.52%
Total	1400	100%

Fig: 2(a) Heat balance

3. LITERATURE REVIEW:

A report of planning commission entitle, " India vision- 2020 " , the percentage of CO_2 of the atmosphere will go up by over 22.5% by 2020, as a result CO and CO_2 respectively which is effect in human blood. Similarly, the percentage of SO_2 will more than double due to the rapid growth of population and industrialization, reduce the greenhouse gas emission.

As India prepare to make the use of Catalytic Converter compulsory with a view of drastically reducing of air pollution. However, Environment Protection Agency (EPA) of USA was observed that the Catalytic Converter has become a significant and growing cause of Global Warming.

In June 1999, the honorable Supreme Court of India ruled that vehicular emission had to be reduced at a much quicker pace than planned so far. In this reaction, for increasing public complaints about the air quality in urban areas i.e. Delhi and Kolkata and Automobile engine manufacture face the challenging engineering task to quickly find solutions, which are production feasible and technology, explained with Euro norms. In this regard, in USA have been applied to control the automobile exhaust emission by OBD-II system (by California Air Resource Board from 1994) for the reduction of HC, NOx, CO etc.

Control the automobile exhaust emission, two equipments is most essential— (1) Catalytic Converter, (2) Exhaust Gas Re-Circulation System (EGR). Catalytic converter may reduce NOx (Oxides of Nitrogen) and converts to Nitrogen and Oxygen. Increasing temperature inside the cylinder, HC and CO may reduce, but does not reduce the NOx. Therefore, NOx can reduce by the application of Exhaust Gas Re-Circulation (EGR).

For Example: Instead of starting from sub-system A in our environmental model. We can start a new approach starting. Fig. Manmade Air Pollution effects on environment from the sub-System B. Nevertheless, this "Hotel Load" is difficult to regulate in a short time. This load is dependent on population control, sustainable, consumerism and industrialization. The change depends on long-term policy decision, so we would better start from the sub-System C, the uncontrolled source.
This is within the reach of policy makers. Further, any attempt to reduce pollutants from uncontrolled source is not coupled with other factors like those in the case vehicular emission. It is here that public awareness programs, education and citizens responsibilities play significant role. NGOs assisted by the corporations or municipalities are very essential for this. Automobile

Last, priority could be sent to the sub-system A. the vehicular pollution control. Again, here the starting point would be clean fuel infrastructure and the inspection/maintenance program has to ensure low emission performance. Finally, when all these supporting requirements are satisfactory, emission norms can be formulated and legislated. This plan should not be constructed as a drag on our industrial policy of up gradation to excellent quality in terms of emission norms. It is only for domestic market that an extension be granted for compliance to the stringent emission norms since the benefits of this cannot be transferred to improve the air quality.

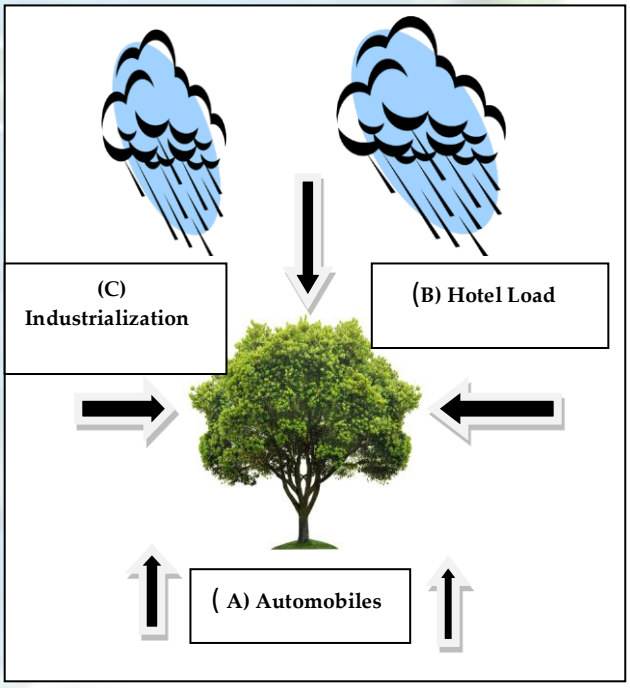

Fig: 3(a) Man Made Air Pollution (a new approach

4. METHODOLOGY:

4.1. Exhaust Gas Recirculation:

Increasing temperature inside the cylinder, HC and CO may reduce, but does not reduce the NOx. Therefore, NOx can reduce by the application of Exhaust gas Re-Circulation (EGR). While the throttle valve is open that time air entire and mixed with fuel and these air fuel

mixture reached in the combustion chamber through intake manifold. During the combustion process burn gases goes to atmosphere through the exhaust manifold as well silencer pipe. While vehicular speed is high that time some inert gases has to burn and these inert gases come back to the combustion chamber through the EGR valve and again burn. In this way, the lesser percentage of NOx gases has to burn.

Oxides of Nitrogen (NOx), that control system, which is recycles a small part of the inert exhaust gas back, through the intake manifold to lower the combustion temperature, and this system is called Exhaust gas Re-circulation (EGR). Increasing temperature inside the cylinder, HC and CO may reduce, but does not reduce the NOx. Therefore, NOx can reduce by the application of Exhaust gas Re-Circulation (EGR).

4.1» Throttle valve,
4.2 » Intake Manifold,
4.3» Exhaust Gas,
4.4» Vacuum Port,
4. 5» Vacuum Tube,
4.6» Diaphragm arm
4.7» Vacuum Chamber,
4.8» EGR Valve etc.

While the throttle valve is open that time air entire and mixed with fuel and these air fuel mixture reached in the combustion chamber through intake manifold. During the combustion process burn gases goes to atmosphere through the exhaust manifold as well through the silencer pipe. While vehicular speed is high that time some inert gases has to burn and these inert gases come back to the combustion chamber through the EGR valve and again burn. In this way, the lesser percentage of NOx gases has to burn. However, when car speed reaches a certain level, the speed sensor sends a signal to the electronics amplifier. This cause the amplifier to close the solenoid valve. Now the vacuum line is closed, the EGR stops. It uses vacuum amplifier to increase the vacuum enough to operate the EGR valve. A wide open throttle, recirculation is eliminated by a dump diaphragm inside the amplifier.

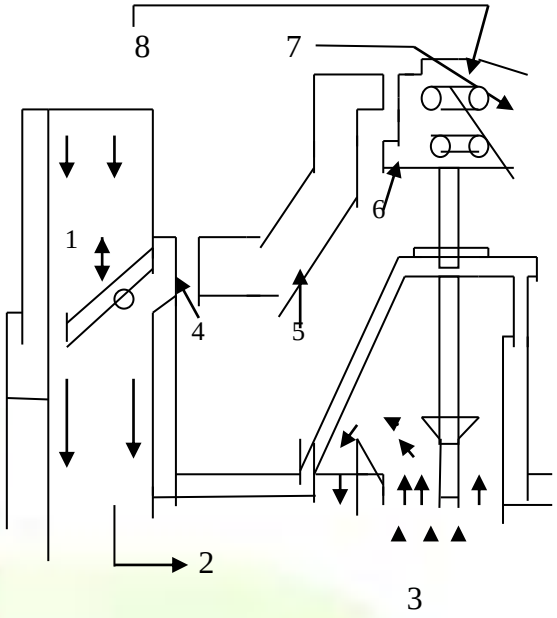

Fig: 4(a) Exhaust Gas Recirculation System:

EGR delay timber and EGR delay solenoid delay EGR action for 35 seconds after starting a cold engine. After the engine has begun to warm up, EGR can begin without upsetting the operation of the engine. If EGR started immediately after the engine began to run, the engine could stumble and even stall. The EGR delay system prevents this.

While the throttle valve is open that time air entire and mixed with fuel and these air fuel mixture reached in the combustion chamber through intake manifold. During the combustion process burn gases goes to atmosphere through the exhaust manifold as well silencer pipe. While vehicular speed is high that time some inert gases has to burn and these inert gases come back to the combustion chamber through the EGR valve and again burn. In this way, the lesser percentage of NOx gases has to burn. and again burn. In this way, the lesser percentage of NOx gases has to burn.

4.1. Catalytic Converter:

Catalytic converter converts harmful gases to harmless gases. A catalyst is a material that causes a chemical change without entering into the chemical reaction. For example, in the Hydrocarbon (HC), carbon Monoxide (CO), catalytic converter the catalyst encourages carbon monoxide (CO) to change to carbon dioxide (CO_2). The catalyst in the NOx converter splits the nitrogen from the Oxygen. The NOx

therefore, becomes harmless nitrogen and oxygen.

For the controlling Oxides of Nitrogen (NOx) rhodium is used as a reducing catalyst. It changes NOx to harmless N_2. For the dual bed catalytic converter, having two separate catalytic converters, in the exhaust system.

Instead of having two separate catalytic converters in the exhaust system i.e. one for Hydrocarbon (HC) and Carbon Mono-Oxide (CO) and the other for Oxides of Nitrogen (NOx). Most manufactures use the following catalytic converter:

4.1.1. Dual bed Catalytic Converter,
4.1.2. Three ways catalytic converter.

Dual Bed catalytic converter, having two bed type converters which in one housing with an air chamber between them. The exhaust gas first passes through the upper bed, hence reducing the Oxides of Nitrogen (NOx) and oxidizing some HC and CO. Three way catalytic converter is used to reduce all the three major pollutants simultaneously. A three ways catalyst is a mixture of platinum and rhodium. It acts on all three of the regulated pollutants (HC, CO, and NOx), but only when the air fuel mixture ratio is precisely controlled. Three ways catalyst based on the use of palladium have proved highly effective at meting the most stringent emissions legislation around the world. This has to lead to a rapid increase in the amount of palladium used in auto catalyst application which has contributed to an increase in the palladium price.

There are two types of three ways catalyst converter. The front sections handle NOx and partially handled HC and Co respectively. The partially treated exhaust gas then flows through the air chamber into the rear section of the converter. There the gas mixes with the air being pumped in by the air pump. This is called secondary air.

5. RESULT AND DISCUSSION:

In this connection, experiments was completed on a single cylinder of four stroke spark ignition engine, variable compression ratio, to study the effect of Exhaust Gas Re-Circulation system. As a result, vehicles is high speed does not control the Oxides of Nitrogen (NOx), because NOx emission is more in higher speed and in this way can reduce CO emission.

Engine run at 1200 rpm, recycling 0%, 10%, 20%, 30% etc observation were noticed. Engine run at 1800 rpm and 2400 rpm were observed. At 2400 rpm, 90% could not be employed due to excessive speed fluctuation.

Engine is directly connected to DC electric Dynamometer (Dynameters as a device for determine the power of an engine) and maximum power developed the engine the all speed and collected exhaust gas sample and analyzed by suitable exhaust gas analyzer method.

5.1. Exhaust Gas Analyzer, it is used for sampling the exhaust gas from an engine to find out the amounts of pollutants in the exhaust gas. Most of the analyzer used in the automotive shop check HC and CO, where as those used in testing laboratories may also check NOx.

From the above discussion, to control of NOx to reduce acid rain and protect the green house gas effect, the following suggestion may important aspects-

5.1.1. For high octane number CO2 emission increases. It is not necessary for 2-stroke engine.
5.1.2. Oxygen content reduces CO emission. However, it will be stop 2005 by the Ministry of Environment ruled that (oxygen limit maximum 2.7%) for underground water pollution.
5.1.3. Benzene reduces from 5% to 1%.
5.1.4. Aromatic caused increase NOx. Therefore, aromatic in gasoline reduce from 42% to 35%, in this regard NOx increase 1.6%.
5.1.5.Sulfur content reduces efficiency of catalytic converter, 300ppm in 2005 reduces and 150 ppm in 2010 reduces.
5.1.6. Olefins caused HC. It deposits lead to engine head and create lead smog. 30% reduces in 2005 and 2010.

5.2. Gas Turbine:

The gas turbine is now being used to automobiles, boats and aero plane as well as other stationery power plant. The operation of gas turbine is basically not very different from

that of the Internal Combustion (I.C.) Engine. Gas turbine is a rotary machine. The open system of the gas turbine most commonly used.

The principal of the open system is that the air from the atmosphere is taken continuously to produce hot gases, which after expansion in the turbine are let out to atmosphere. For example, in a gas turbine plant, air enters the first of the two compressors of a pressure of 1 atom and 15° C. The pressure ratio for each of the compressor in 3 to 1. The air from the second compressor is delivered to a burner where the temperature is raised to 700° C at constant pressure. The gases then enter turbine and expand adiabatically to a pressure of 1 atom. Find the efficiency of the plant and the shaft H.P. per kg of air per Second. (Take Cp =0.24).

The solution: Process 1-2, is the adiabatic compression in first compressor at a pressure of air while 2-3 is the compression of air, second Compressor 3-4 shows heating at constant pressure, (1 atom).

$$\frac{T3}{T1} = \left(\frac{P2}{P1}\right)^{r-1/r}$$

$$= (9)^{\frac{0.4}{1.4}}$$

$$\therefore\ T_3 = T_1 \times (9)^{\frac{0.4}{1.4}} = 288 \times (9)^{\frac{0.4}{1.4}}$$

$$= 540\ ^\circ K.$$

$$T_4 = 973^\circ K \text{ (given)}$$

$$T_5 = 519$$

Compressor work = $C_P (T_3 - T_4) = 0.24\ (5\ - 288)$

= 60.5 kcal/kg of air

Turbine work = $C_P (T_4 - T_5) = 0.24\ (973 - 519) =$

100 kcal/kg of air

Heat supplied in the burner = $C_P (T_4 - T_3)$

= 0.24 (973 – 540) = 103.9 kcal/kg

$$\text{Plant efficiency} = \frac{\text{Turbine Work} - \text{compressor work}}{\text{Heat supplied}}$$

$$= \frac{109 - 60.5}{103.9} = \frac{48.5}{104} = 46.6\%$$

$$\text{Shaft H.P. per kg of air per second} = \frac{48.5 \times 427}{75}$$

$$= 276$$

6. TYPE OF DATA:

6.1. EGR Troubles:

6.1.1. Poor engine performance may cause EGR trouble, example, rough engine idle could cause leaky EGR valve or valve gasket. However, a defective thermal vacuum switch could cause vacuum to operate the EGR valve when it should not.

6.1.2. Poor part throttle performance, poor fuel economy and rough running on acceleration could also be caused by a defective thermal vacuum switch, In addition, rough acceleration cause thermal vacuum switch defective. If manifold is not clean, clean out the passages.

6.1.3. Detonation causes damage valve and thermal vacuum switch. etc.

6.2.Engine idles roughly:

6.2.1. Incorrect idle adjustment of air fuel mixture Readjust idle mixture and Speed.

6.2.2. PCV or EGR valve stuck open Replace by new one.

6.2.3. No vacuum advance in any gear Transmission Controlled Spark (TCS)

7. CONCLUSION:

Environment Protection Agency (EPA), and California Air Resource Board (CARB), based in USA have mandated emission standard for automobiles. According to this stander the failure criteria for the linear EGR flow diagnostic are the following:

7.1. Liner EGR Flow rate:

Abnormal low or high flow rate exceeding the specified low and high flow rates that will result in exceeding any of the application FTP standards x 1.5., exceeding any of the application FTP standards x 1.5.

EPA regulation requires linear EGR system monitoring to determine if there is s restricted in the EGR system. The linear EGR flow diagnostic s is performed to detect any malfunction of the linear EGR system.

7.2. EGR system components:

Any component of the system performing outside of the specification that will result in EPA regulation requires linear EGR system monitoring to determine if there is s restricted in the EGR system. The linear EGR flow diagnostic s is performed to detect any malfunction of the linear EGR system. The diagnosis is based on the fact that in a properly functioning system, given all other things being constant and normal, there is a direct correlation between linear EGR flow rate and manifold air pressure (MAP) changes.

The following functions are performed by this linear EGR flow diagnostic:

1. Monitor Decel Test start criteria,
2. Monitor Decel enable criteria,
3. Perform Decel started,
4. Manage Decel Test,
5. Perform Decel intrusive testing,
6. Perform Decel open,
7. Perform Decel close,
8. Monitor Decel intrusive testing, etc.
9. Monitor Decel intrusive testing, etc.

After the experimental study, it was found that applying of EURO 1, EURO 11. EURO, 111 respectively, it is not possible to reduce NOx emission in zero level, therefore, applying OBD-II achieve NOx emission is almost zero level.

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9. DEFINITIONS/ACRONYMS/ABBREVIATIONS:

ABBREVIATIONS:

EGR: Exhaust Gas Re-Circulation,
NOx: Oxides of Nitrogen,
MAP: Manifold Air Pressure,
EPA: Environment Protection Agency.
PCV: Positive Crankcase Ventilation.

