Modification of Exhaust System of Two Wheeler for Emission Control

P.Deepika[1], M.Naren Kumar[2]
[1,2] *U.G-B.E Student, Dept.of.Mechanical Engineering, Angel College of Engineering and Technology*

***Abstract*- Automobiles play vital role to 'Set the World in Motion'. But emissions from them are nowadays becoming major in the life of human beings and environment. Automobile emissions mainly contributes CO, NOx, and HC that is carbon monoxide, nitrogen oxide and hydrocarbons respectively and some particulate emissions. The increasing emission is resulting into the international threat like 'Global Worming'. So it is now necessary to focus on the ways to reduce these pollutants.**

***Index Terms*- Back Pressure, CO, HC, Exhaust Gas Recirculation (EGR), NOx.**

I. INTRODUCTION

Over recent past years, very strict legislation have been imposed on NOx, CO, particulate emissions, coming from vehicles or any petrol engine. Hence in order to meet the environment legislation, it is highly desirable to reduce NOx percentage in the exhaust gases. Predominantly, petrol engine is used to drive two-wheeler, cars, some engines acting as prime mover, etc. As the use of two-wheelers is increasing drastically, the emission is also increasing vigorously. So, technology like exhaust gas recirculation must be emphasized to deal with pollution problems. When the temperature inside the combustion chamber is high enough for long time, the nitrogen and oxygen combines to form Nitrogen Oxides. Reduced cylinder temperature can be achieved by reducing the amount of oxygen in the cylinder. Exhaust Gas Recirculation technique will help to reduce the cylinder temperature.

II. OBJECTIVE

We are intended to achieve the followings:

a. To reduce NOx and CO2 emissions.
b. To reduce the temperature in combustion chamber.
c. To reduce back pressure acting on the engine.

III. COMBUSTION PRODUCTS OF S. I. ENGINE

The emissions from the S. I. Engine mainly consist of CO, HC, NOx and some particulate matter.

A. Mechanism of CO Formation

The hazardous gas CO, which has high affinity to react with the haemoglobin in the RBCs, can also slow down mental and physical activities. CO is intermediate product of combustion of carbon and oxygen (O2). CO further combines with O2 to form CO2 i.e. carbon dioxide.

$CO + ½ O_2 + CO_2 + Heat$ (1)

CO is generally formed due to the combustion of rich mixture i.e. rich in fuel. Also, even the lean mixture forms small amount of CO. CO formation also represents the loss in heat energy which reduces the break thermal efficiency of engine.

3.2 Mechanism of NOx Formation:

NOx formed during the combustion of fuel depends on the local conditions of air and nitrogen content in fuel. Generally NOx is formed at the end of combustion when the desired temperature for its formation is achieved. The reaction of NOx formation is:

$½O2 + N_2 \rightarrow NO + N$ (2)

"Equation (2)" shows oxygen combines with nitrogen (N2) to form nitrogen oxide (NO) and nitrogen ion.

IV. TECHNIQUE OF EGR

EGR is an efficient method to reduce NOx emissions from the engine. It works by recircuating certain quantity of exhaust gases back to the engine combustion chamber. Mixing of recirculated gas with incoming air reduces the amount of available O2 in combustion chamber and lowers the peak temperature of combustion. Recirculation is done by

connecting exhaust manifold to intake manifold by a pipe. When the part of exhaust is recirculated to the cylinder, it acts as dilutent to the air fuel mixture. This reduces the O2 concentration in combustion chamber, thus decreasing the temperature for the same heat release. As the formation of NOx is a function of temperature, reduction in combustion temperature causes the reduction in NOx formation.

4.1 Engine Exhaust Back Pressure Effects

Increased back pressure can cause following adverse effects on engine:

a. Increased pumping work
b. Reduced intake manifold boost pressure
c. Cylinder scavenging

At increased back pressure, engine has to compress exhaust gases to a higher pressure for which additional mechanical work is required. Increased back pressure also effects the change in air to fuel ratio. As the back pressure increases mechanical work required to push exhaust gases outside the mufflers increases it reduces the efficiency of engine and increases the fuel consumption also it increases exhaust emissions.

4.2 Effect of Modification of Pipe on Engine Performance

Increase in length of the exhaust causes increase in path travelled by the exhaust gases, as the gases travelling have to move longer path, velocity developed in the pipe decreases so the pressure inside pipe increases as the velocity and pressure are inversely proportional. So it causes the increase in back pressure on engine. Also more bends in the exhaust pipe causes flow restriction and frictional losses in the gas flow. This causes choking of exhaust and increases back pressure on engine.

V. EXPERIMENTAL SET UP FOR EGR

5.1 Experimentation of EGR

In this hot type of exhaust gas recirculation technique, the exhaust gas is recirculated to the intake manifold. There are the three main basic components of EGR system viz. EGR flow control valve, EGR pipe and EGR filter.As to optimize the percentage amount of EGR which should be recirculated we are using EGR flow control valve. Optimizing the percentage of EGR will optimize the gradual reduction in NOx and drastic increase in HC. To filter out soot particles which when recirculated may block engine or carburetor, use of filter is must in EGR setup. The diameter of the EGR pipe can be selected by the continuity equation. This cross section area gives us the diameter of the EGR pipe.
Selection of maximum EGR flow
diameter,

D = 45% of Exhaust pipe diameter i.e. 25mm.

D = 11.25m ≈ 12mm

Hence, by selecting the standard pipe diameter as 12mm

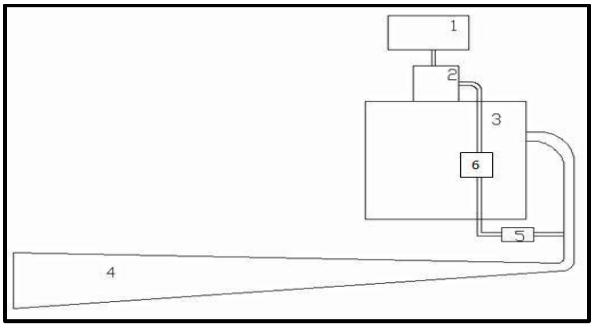

Fig. 1. Block Diagram of EGR

Sr. No.	Component Name
1.	Fuel Tank
2.	Carburettor
3.	Engine
4.	Exhaust Pipe
5.	Exhaust Flow Control Valve
6.	Filter

Table. 1. Components of EGR

5.2 Experimentation of Back Pressure

Fig. 2. Effect of change of exhaust slant on back pressure

To check the effect of slant of exhaust pipe on engine back pressure the experiment can be performed with different angles of exhaust pipe. Slant of exhaust is

increased up to 90° and the back pressure developed is measured. This experiment is performed with flexible pipe which is coupled to exhaust pipe and a pressure gauge. Slant of exhaust is changed with the help of protractor. Pressure measurement can be done as shown in following figure.

VI. OBSERVATIONS AND RESULTS

By varying the flow through EGR flow control valve, tests for different % of EGR are taken with the help of Exhaust Gas Analyzer. The Gas Analyzer shows the % of CO, CO2, and O2 present in the exhaust gases. Also amount of HC and NOx in „ppm" are shown on the display of Gas Analyzer.

Table. 2. Results of Variation in CO, HC and NOx with % EGR

Total % of EGR	CO (%)	HC (ppm)	NOx (ppm)
0	2.27	207	23
7.5	2.25	221	22
15	1.03	230	21
22.5	0.81	310	21
30	0.2	265	20
37.5	0.06	279	19
45	0.14	905	19
Optimum % of EGR With Filter	0.04	261	19

6.1 Variation of HC with Increase in EGR %:

Taking HC on ordinate and EGR % on abscissa plotted a graph as shown below:

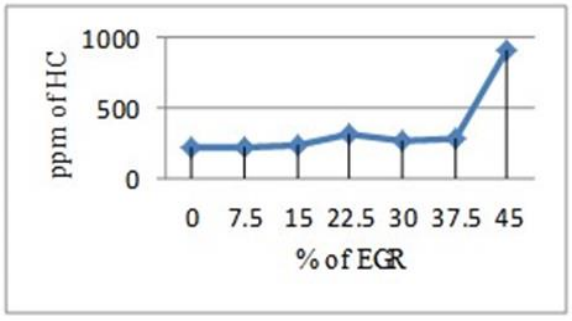

Fig. 3. Variation of amount of HC withRespect to EGR%

6.2 Variation of NOx with Increase in EGR %:

Taking NOx on ordinate and EGR % on abscissa plotted a graph as shown below

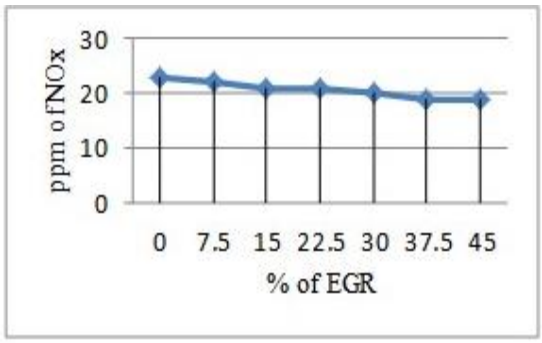

Fig. 4. Variation of amount of NOx with Respect to EGR%

While observing the graph between HC and EGR %, we can see that as EGR % increases HC emission increases gradually and above particular value of EGR %, HC emissions increases drastically. Similarly, graph between NOx and EGR %, we can see that as EGR % increases, NOx emission decreases gradually. Hence, from above graphs we came up to the result that 37.5% of EGR gives optimum results i.e. optimum reduction in NOx with well-balanced emission of HC.

6.3 Results for Various Exhaust Pipe Slants

a. The value of back pressure for 90° is approximately 3 times more than the standard value.
b. Back pressure value increases 0.1 KPa with increase in manifold angle by 1°.
c. This nature of back pressure is applicable up to 60°.
d. After 60°, the increase in back pressure turns out to be 0.4 KPa with 1° rise in manifold angle.
e. Fuel Consumption increases with increase in manifold angle.
f. HC and CO emission increases with increase in manifold angle.
g. Back pressure value decreases with decrease in manifold angle below 0°.

VII. CONCLUSION

The Exhaust Gas Recirculation Technique with optimum percentage of flow gives the desired results i.e. reduction in amount of NOx emission from the exhaust gases. As seen, Exhaust Gas Recirculation is a very simple method. It has proven to be very useful and it is being modified further to attain better standards. From results we conclude that emissions

of CO are reducing with increase in % of EGR. Also emissions of NOx decreases continuously with increase in % of EGR. In case of HC, it increases slowly up to 37.5% and then shows rapid increase. To control the amount of NOx emissions as well as amount of HC the % of EGR should be optimized to 37.5%. As the slant angle increases, the back pressure acting on the engine increases. Along with back pressure, fuel consumption and exhaust emissions are also increasing. If the slant of exhaust is decreased, the effect reverses. Hence slant of exhaust should be kept horizontal or below horizontal (5° to 10°) to ground to reduce fuel consumption and also to reduce exhaust emissions from engine.

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