

Mitigation of Pollution by Exhaust Gas through Study of Emission from Two Wheelers

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ABSTRACT: IC ported/two stroke engines are a major source of pollution in every city throughout the country. An attempt has been made to obtain CO and HC emissions from different types of IC ported/two stroke engines and the data analysed for the effect of various parameters involved. Cold idling and hot idling conditions also influence emission rates. This study indicates that emission decreases with travel time and proper maintenance reduces emission significantly. Exhaust Gas Recirculation (EGR) is studied as a possible mitigating measure and its effectiveness on 2 stroke engines. The performance of engines can be simulated with LabVIEW controls in practical applications for the two wheelers.

KEYWORDS: Deterioration factor, EGR ratio, Four Stroke Engine, HC/CO Emission, Two Stroke Engine.

I. INTRODUCTION

Air pollution are solid, liquid or gaseous substances that changes the natural composition of air. Emissions are from a source causing air pollutions. There are three distinguished sources, namely, point, line and area sources. Line sources such as road and vehicle columns are predominant at present and therefore must be critically looked at. From moderate liberalisation in the 1980s with de-licensing, de-regulation and globalisation, the annual passenger vehicles production has grown from 0.05 million to about 3 million vehicles. Thus, the number of vehicles plying on the roads are increasing at an exponential rate.

Due to the ever-growing numbers, automobiles are a major source of atmospheric pollution and the emission from automobile engines is a serious concern. In the Indian context, of all the automobiles, two wheelers contribute a major share and are operated in accelerating and decelerating conditions under various loads. Also, Bharath Stage III norms for emission from 2 and 3-wheeled vehicles for the entire country was applicable from 1st April 2010 and therefore is of paramount importance to study the emission from vehicles and improve vehicle performance in the interest of the nation.

The main constituents in the exhaust emissions are carbon monoxide (CO), unburned hydro carbons (HC), nitrogen oxides (NO_x), carbon dioxide (CO₂), water vapour and traces of sulphur dioxide. The emission of CO in the atmosphere exceeds those of all other pollutants combined and is the most dangerous pollutant formed by incomplete combustion. Unburned hydrocarbons are produced by unburned fuel escaping from the chamber. The formation of NO_x usually takes place at very high engine temperatures.

In the present Indian scenario, two wheelers/(two stroke/ported engines) being the most common vehicle contribute about 60% of the total vehicle population, and is a major source of air pollution. The present study addresses emission from two stroke/ported engines of different models under different conditions to find out the effect of various parameters on it.

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II. RELATED WORK

Predicted CO concentration at the end of expansion stroke compared with measured exhaust concentrations were discussed by Heywood^[1] in his earliest studies.

B.P. Pundir has enunciated^[2] that the combustion generated emissions from internal combustion engines are significant sources of air pollution and analysed the genesis and formation of pollutants.

^[3]A study conducted based on the data obtained from vehicles by V.Suresh et al correlate the emission levels for various operating conditions to conclude that proper servicing and emission control system can considerably reduce the emission levels.

^[4]N.Prabhakaran et al have successfully tested performance of different configurations of two stroke engines and suggested a new twin cylinder engine designed for best performance.

^[5] Alan N Drew et al have confirmed the usefulness of relatively simple 1-D gas analysis approach that requires modest computational resources. Use of application as a part of control software would help minimise engine-out emissions.

^[6] S.Swaminathan et al have reported the possibility of operating homogeneous charge combustion ignition (HCCI) engine with reasonably high thermal efficiencies in a wide range of loads using alternate fuel.

^[7] M.Aliante et al have reported in their analysis that both improved efficiency and reduced emissions are possible using advanced fuelling like air assisted direct injection systems at 4,5 to 5,5 bars.

^[8] Dr.P.V.K. Murthy et al, have described the two zone and multizone models for prediction and compared the performance with experimental values. Multizone model is 7% closer to actual values as compared to 9% in the case of two zone model.

^[9] Akira Kikusato et al have developed a non-dimensional two zone SI combustion model an auto ignition model in unburned gas and a heat transfer model in the combustion chamber wall. This model helps to predict the performance of an SI engine.

The authors have earlier reported^[10] the effect on emission characteristics for different throttle conditions on a two stroke hub engine and^[11] the performance evaluation of exhaust gas recirculation in two stroke engines. Exhaust gas recirculation has an appreciable effect on reducing emission levels at certain throttle conditions.

^[12] Dr.K.C.Vora has published an extensive research analysis on emission mechanisms as well as control measures to reduce emissions and improve efficiency of S.I.engines.

III. DATA COLLECTION

Data regarding CO and HC can be taken from any two stroke/ported engines by extending the Infrared emission analyser probes. About 100 vehicles tested at different times in service stations. The range of vehicles include 2 stroke and 4 stroke models of almost all brands. To study the effect of proper servicing on emissions a few readings have been taken before and after engine servicing from vehicles tested at service stations. The data from different vehicles at different conditions are tabulated as per the criteria for analysis and report.

A typical two-wheeler engine was taken on an experimental basis and the emission performance was observed with modification and reported, using Exhaust Gas Recirculation (EGR). EGR works by recirculating a portion of an engine's exhaust gas back to the engine cylinders. This dilutes the O₂ in the incoming air stream and provides gases inert to combustion to act as absorbents of combustion heat to reduce peak in-cylinder temperatures. NO_x is produced in a narrow band of high cylinder temperatures and pressures. Gases re-introduced from EGR systems contain near equilibrium concentrations of NO_x and CO; the small fraction initially within the combustion chamber inhibits the total net production of these and other pollutants when sampled on a time average. Most modern engines require exhaust gas recirculation to meet emissions standards.

$$\%EGR = \frac{\text{Volume of EGR}}{\text{Total intake charge into the cylinder}} \times 100; \text{ EGR ratio} = \frac{\text{CO}_2 \text{ intake} - \text{CO}_2 \text{ ambient}}{\text{CO}_2 \text{ exhaust} - \text{CO}_2 \text{ ambient}}$$

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The performance was then simulated using LabVIEW software. Real time control for optimum performance of automobile engines in operation at various load conditions was possible with simulated LabVIEW components.

The study conducted on various two-wheeler engines (two stroke/ported engines) gives the variation of exhaust emission with parameters like stroke, time of travel, operating conditions and service conditions.

IV. RESULT AND ANALYSIS

The data obtained for several vehicles are averaged for consideration in the analysis. The data obtained are tabulated and presented here.

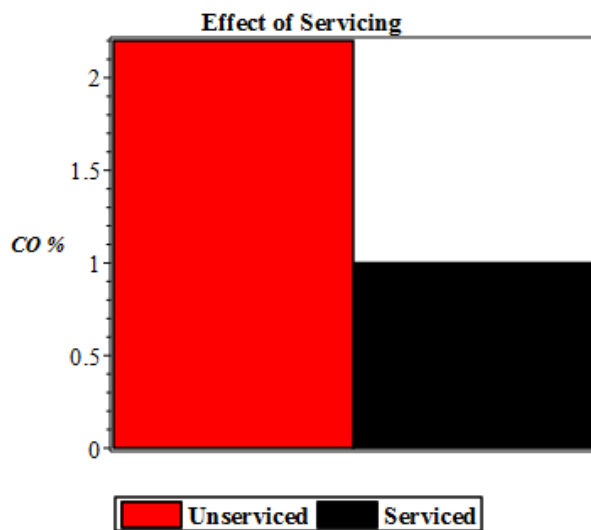


Chart 1. Effect of Servicing on CO % emission

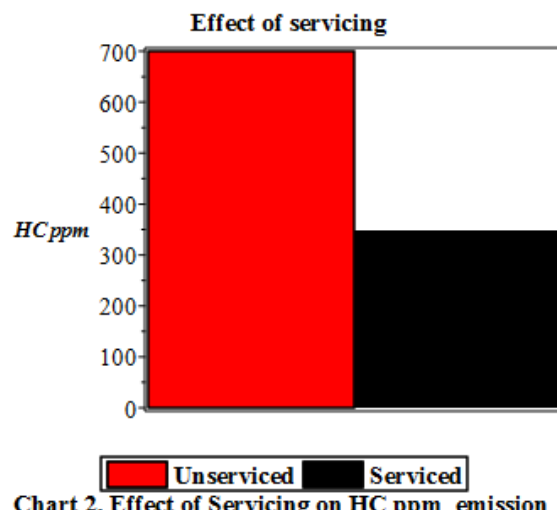


Chart 2. Effect of Servicing on HC ppm emission

Chart 1 depicts the CO % emission on a typical 2 stroke engine after running for a period of 3 months and after servicing. The percentage level has come down from 2.3 % to around 1 %. The CO emission is reduced by half for serviced 2 stroke engines.

Chart 2 depicts the HC emission (ppm) on the 2 stroke engine after running for a period of 3 months and after servicing. The percentage level has come down from 700 ppm to around 360 ppm. The HC emission also is reduced by half for serviced 2 stroke engines.

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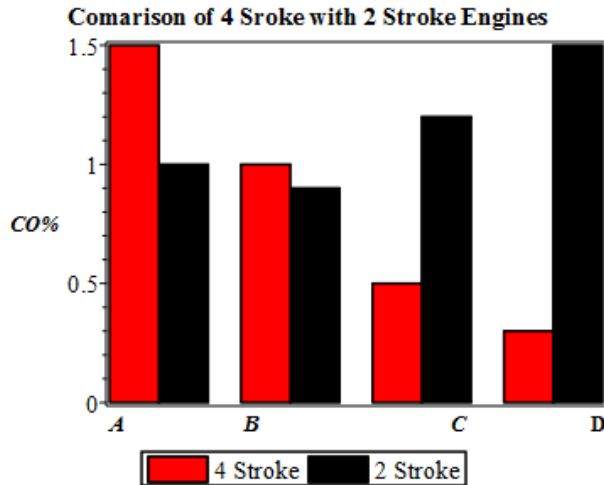


Chart 3 Comparison of similar models (CO %)

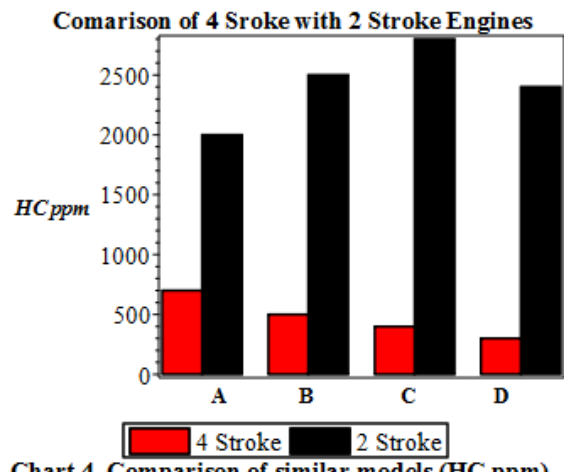


Chart 4. Comparison of similar models (HC ppm)

Chart 3 compares 2 stroke and 4 stroke engines of similar sizes for CO % emission. The emission from 2 stroke engine is lower than that of 4 stroke engine at smaller sizes and tend to be more with increasing size (ratings).

Chart 4 compares 2 stroke and 4 stroke engines of similar sizes for HC emission. The emission from 2 stroke engines are always higher than that of 4 stroke engines.

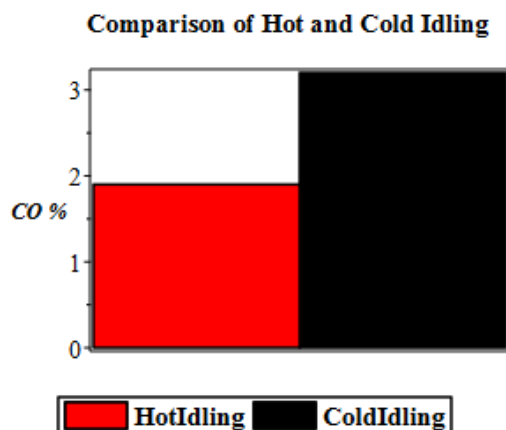


Chart 5. Comparison of Hot and Cold Idling (CO%)

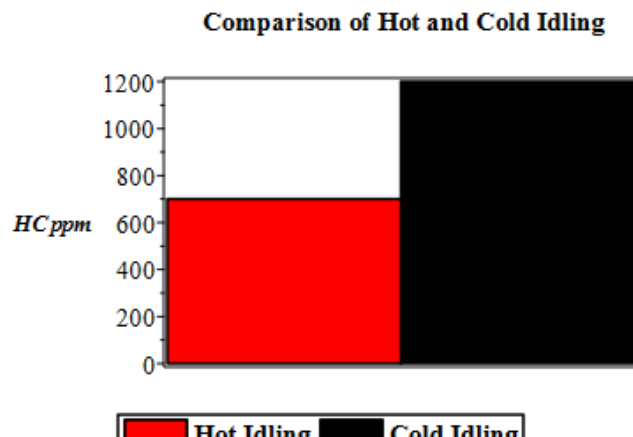


Chart 6. Comparison of Hot and Cold Idling (HC ppm)

The engine emission performance is bound to vary upon the operating temperatures of the engine and therefore a comparison is made between cold idling conditions and hot idling conditions. Chart 5 shows the comparison for CO % emission between cold idling and hot idling conditions.

Chart 6 shows the comparison for HC emission between cold idling and hot idling conditions. The emission under cold idling conditions is double the emission under hot idling conditions.

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Thus hot idling shows an improved performance over cold idling conditions. It is for the same reason vehicles taken to testing stations are taken after running for a couple of hours before testing to show improved performance.

Comparison of performance of a base engine with EGR modified engine

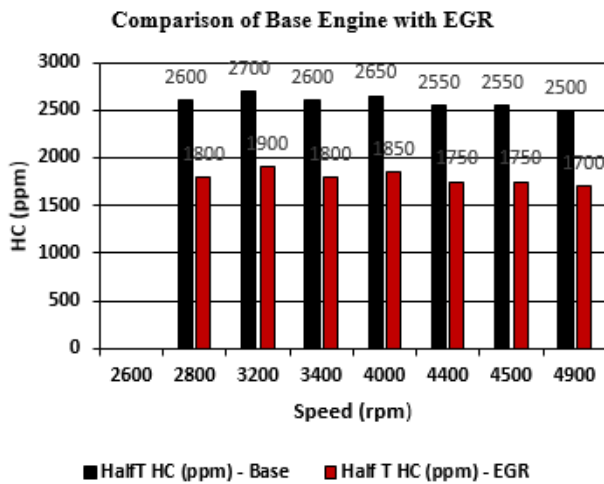


Chart 7 Improvement with EGR HC ppm emission

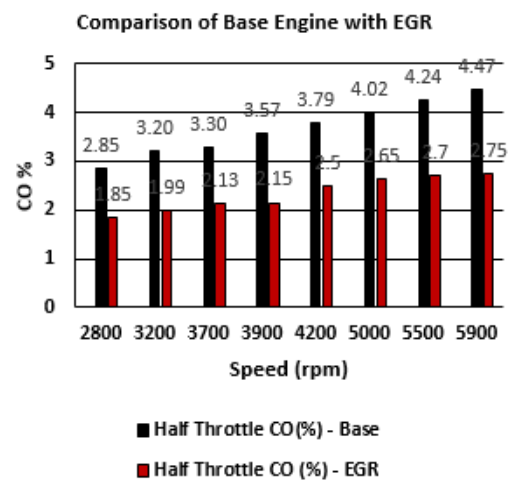


Chart 8 Improvement with EGR on CO% emission

One of the control measures to reduce emission is controlled exhaust gas recirculation. Too much of recirculation affects the efficiency due to poor combustion. Approximately 10 to 15 % of recirculation prove to be the range in which the emission performance improves with efficiency.

Chart 7 shows comparison of CO % emission for a base engine and engine attached with EGR (Exhaust Gas Recirculation) system. The EGR system has reduced the CO % emission from 2.65 % to 4.02 % at rated speed.

Chart 8 shows comparison of HC emission for the base engine and the engine attached with EGR (Exhaust Gas Recirculation) system. The EGR system has reduced the HC emission from 2500 to around 1700 ppm at 5000 rpm speed.

V. SIMULATION IN LABVIEW SOFTWARE

LabVIEW is a computer application, commonly used for data acquisition, instrument control and automation of variety of operating systems. LabVIEW includes extensive support for interfacing devices, instruments and other devices. Users interface to hardware by device specific drivers provide function nodes for controlling the engine operation. Advanced LabVIEW development systems offer the ability to build stand-alone applications. The data is simulated in LabVIEW software and reproduced here.

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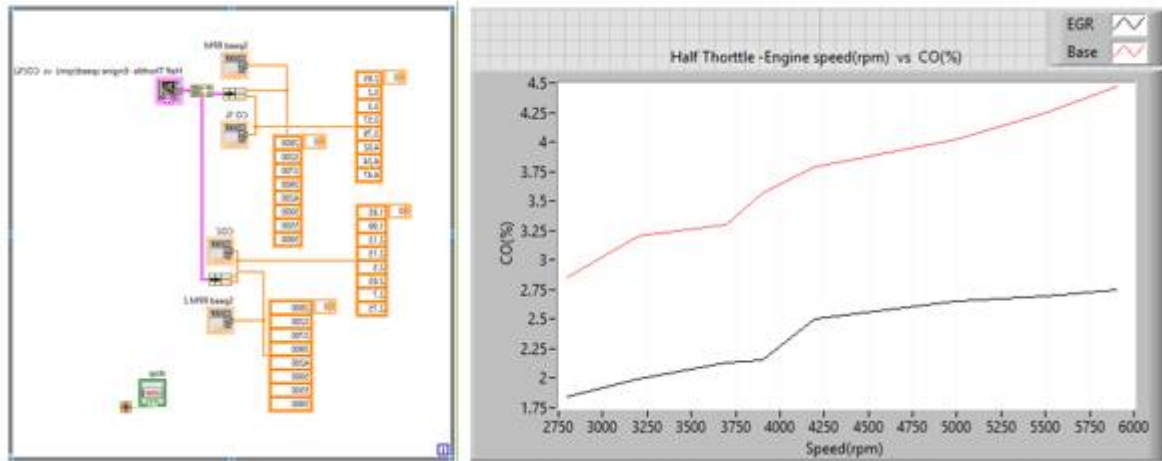


Fig.1 Effect of EGR on CO % emission

Fig.1 shows the variation in CO % emission at varying speeds for base engine and engine EGR system using LabVIEW software. An improvement of about 1 % point is observed using EGR system at rated conditions.

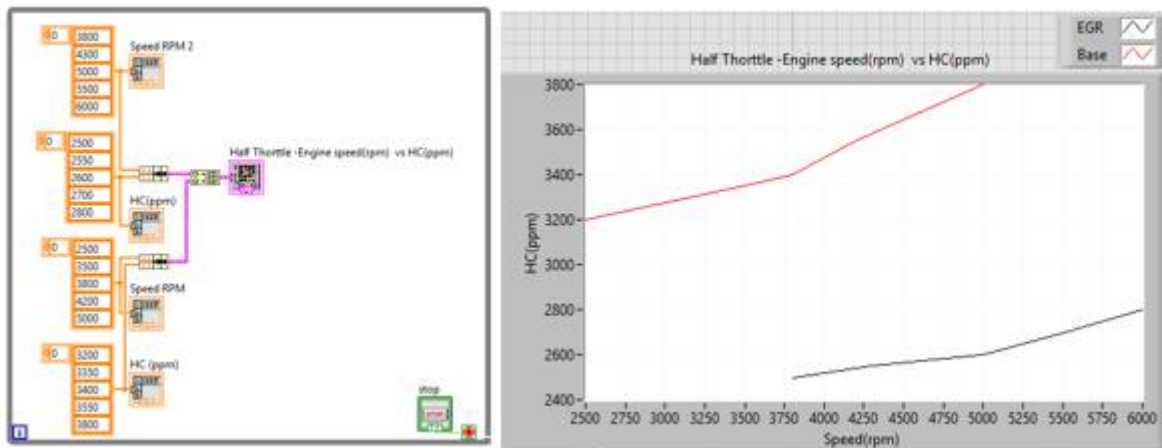


Fig.2 Effect of EGR on HC emission

Fig.2 shows the variation in HC emission at varying speeds for base engine and engine EGR system using LabVIEW software. An improvement of about 500 ppm is observed using EGR system at rated conditions.

VI. CONCLUSION

Lower emission levels are observed in four stroke engines compared to two stroke engines. Emission control system effectively reduces the exhaust emissions. EGR, during the preliminary studies, shows that HC emissions are reduced by about 20 to 25% and CO emissions are reduced by about 30 to 40%, indicating that it is effective in

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mitigating the pollution to a substantial degree. There is also a need to install emission control system with proper maintenance at regular intervals.

The study emphasises the need for advanced emission control system in vehicles.

LabVIEW hardware components with interfacing components can be put into use for best operating performance. Control of emission characteristics also provide for improved efficiency and fuel saving. Implementation with proper maintenance at regular intervals will certainly improve the deterioration factor.

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