Effect on Air-Fuel Ration of Two Wheeler Vehicle at Higher Altitudes

Anurag Dixit, Dr. H.K. Rai, Dr. D.K. Bhalla

Abstract—Th performance of an internal combustion engine is greatly depend on the air-fuel ratio supplied to the combustion chamber.an experimental investigation were carried out to study the reduction of oxygen present in the air at different altitudes. A two wheeler vehicle with PFI injector was used to carry out the experiment. In countries like India the two wheeler vehicles are mostly design to run at flat areas but when same vehicle goes at higher altitudes the behaviour of the vehicle changes and the driver start facing difficulties in driving as well as in cold start of the vehicle.In this paper some of the factors which gets affected due to change in air-fuel ratio such as emission,knocking,output power and fuel efficiency are mentioned.

Index Terms— Air-Fuel Ratio, Atmospheric Pressure , Emission, Higher Altitude,Lambda Sensor,Oxygen ,PFI Injector,Electronic Control Uinit(ECU) .

1 Introduction

The main objective of this trial is to find out the reduction of oxygen present in the air at different altitudes. By finding the reduction of oxygen in the air we can use this data to calibrate air-fuel ratio according to the altitude.

Generally, there is no Electronic Control Unit is present in the vehicle with carburetor. Most of the vehicle manufacturer with carburetor engine, tune the carburetor according to the lower altitude and the atmospheric pressure present over there. In such cases, the vehicle used to run fine at lower altitude but the behavior of the same vehicle changes as it goes on relatively higher altitude. The vehicle start losing its power generation capacity and sometimes knocking also arises.

Emission is also one of the major criteria which a vehicle must fulfill. It is very much difficult for carburetor engines to fulfill the emission norms in BSVI because of lack of artificial intelligence. The only way to maintain a continuous idling of carburetor engine on higher altitude is by tuning the grub screw of carburetor mechanically. In this case the user used to tune the grub screw without knowing the actual air-fuel ratio which can generate higher emissions than the normal case. If the air fuel ratio become too lean then engine start generating access Nitrogen Oxides and if the air fuel ratio become too rich then the engine start generating access Hydrocarbon.

- *Anurag Dixit currently pursuing masters degree program in Production engineering in Inderprastha Engineering College, India, PH-9506710122. E-mail: anurag.dixit67@mail.com*
- *Dr. H.K. Rai is Professor and Head of Mechanical Engineering department , Inderprastha Engineering College.*
- *Dr. D.K. Bhalla is a Professor in Mechanical Engineering department,Inderprastha Engineering College.*

To overcome these issues the vehicle manufacturing industries start making FI system. By using FI system these issues can be resolved, but for this, the reduction in oxygen must be known on higher altitudes. This study is made to know the actual condition on the higher altitudes.

Previous work in literature on air fuel ratio includes the work by C.T. Won[1] who descussed the effect of altitude on the performance of a spark ignition engine using an alcohol blended fuel and addressed the change in engine performance.He concluded that the enrichment of fuel was there at high altitude, both engine power output and fuel economy decrease with an increase in altitude,increase in CO emission with altitude and knocking was there for almost 40% of time.In a different work, B.A. Shannak et al.[2] looked at the effect of atmospheric altitude on a four-cylinder four-stroike petrol engine. They have tested the vehicle at engine speed 1000 to 4000 rpm and at atmospheric altitude 600 to 850 meter above the sea level with ambient pressure from 0.9 to 0.95 bar.

S. Motahari et al.[3] discussed the effects of altitude and temperature on the performance and efficiency of turbocharged direct injection gasoline engine.

For better performance of the vehicle on high altitude fuel injection system is very much famous now a days but in the countries like India, Bangladesh and all other south Asian countries the use of fuel Injectors are very limited in small motorbikes. For carburator engines it is very difficult to maintain good air fuel mixtures according to different surroundings and fulfil the emission norms. Recently BSVI is launched in India in which emission norms are very tight,.to fulfil these norms most of the botorbike manufacturing switched to the fuel injection system. The small segment engine motorbikes are using Port Fuel Injector for injecting fuel into the combustion chamber. Fig. 1 is showing a detail view of Port Fuel Injector.

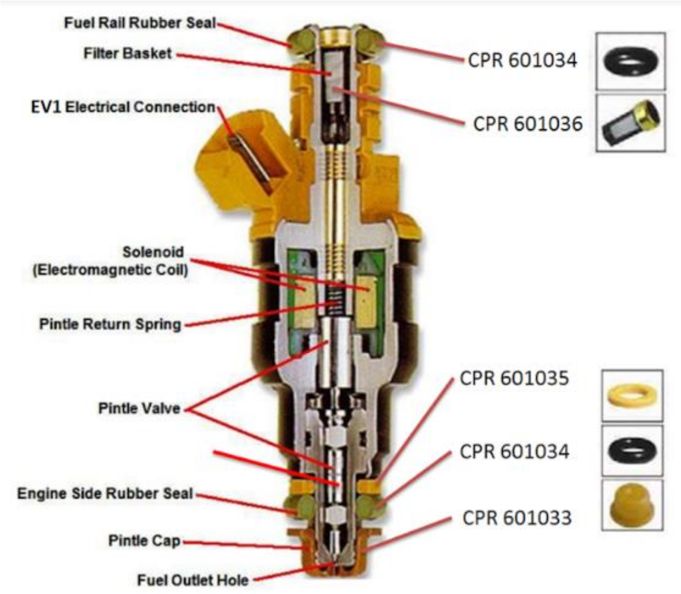


Fig.1 Cut Section of a Fuel Injector

Fuel injectors are having many benefits over carburators.Benefits of fuel injection include smoother and more consistent transient throttle response, such as during quick throttle transitions, easier cold starting, more accurate adjustment to account for extremes of ambient temperatures and changes in air pressure, more stable idling, decreased maintenance needs, and better fuel efficiency. Fuel injection also eliminates the need of mechanical choke, which on carburetor-equipped vehicles must be adjusted as the engine warms up to normal temperature. Furthermore, on spark ignition engines, (direct) fuel injection has the advantage of being able to facilitate stratified combustion which has not been possible with carburetors. It is only with the advent of multi-point fuel injection certain engine configurations such as inline five-cylinder gasoline engines have become more feasible for mass production, as traditional carburetor arrangements with single or twin carburetors can not provide even fuel distribution between cylinders, unless a more complicated individual carburetor per cylinder is used.

2. Experimental Setup

Since the original motorcycle was not having oxygen sensor so an external oxygen sensor was inserted by drilling the exhaust of the vehicle.For taking values from ECU and oxygen sensor, an OBD module and a lambda sensor module from ETAS were used.The modules and the oxygen sensor were powered up by using motocycle's battery.All other parameters like atmospheric pressure,engine rpm etc were taken from the ECU.The fuel inside the combustion chamber was delivered by a Fort Fuel Injector at a fuel pressure of 3 bar.The engine capacity of the vehicle was 125cc.Figure 1 is showing the experiment parameters used in INCA software.A circuit diagram of the experimental setup is shown in fig.2.

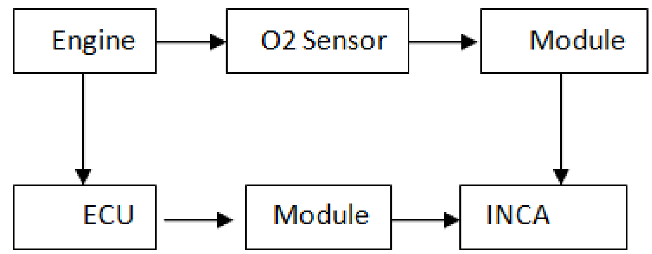


Fig. 2.Circuit diagram of experimental setup.

2.1 Methodology

The experiment was performed to know the percentage reduction in oxygen with increasing altitude and decreasing atmospheric pressure. It was performed at Narkanda, situated in Himanchal Pradesh, India.

A drill is made on the muffler of the vehicle to fit the external oxygen sensor. The oxygen sensor is then fixed at this drill and connected with a lambda module. An external battery is used to give required power to the lambda module. This lambda module then connected with a Calibration, diagnosis and validation Tool.

For taking vehicle parameters such as rpm, atmospheric pressure etc. another module is used. This module is connected to the vehicle by CAN High & CAN low and other end of the module is connected with Calibration, diagnosis and validation Tool.After completing all the connections data has been noted at different altitude and at different atmospheric pressure.

For taking the data three different altitude has been chosen according to the atmospheric pressure. The atmospheric pressure were 650 mbar, 700 mbar and 750 mbar. The data has been taken at idle condition as well as running condition.

3 Result and Discussion

It was found that a strong effect of altitude was there on air fuel ratio. The mixture becomes 30% rich on the altitude where atmospheric pressure was 650mbar. Graph 1 is showing the richness of air fuel mixture at different atmospheric pressure. At the altitude of 11154 feet, temperature 8-10ºC. It is found that the oxygen reduced up to 30% than the normal condition. The atmospheric pressure was found 650 mbar. It is very difficult to get proper idling at higher altitudes with a vehicle which is designed to run at plane areas. A self tuning in the throttle body is required to meet up the proper quantity of air for combustion of the fuel. In most of the cases, the drivers are used to tune the throttle body by themselves which leads to create more emissions from the exhaust of the vehicle in form of either Hydrocarbons or Nitrogen Oxides. Access hydrocarbons are formed when the air fuel mixture of the vehicle becomes too rich and access Nitrogen Oxides are formed when the air fuel ratio becomes too lean. It is very much necessary to maintain these two emission by products. Fig.3 represents the graph of emission vs air fuel ratio.

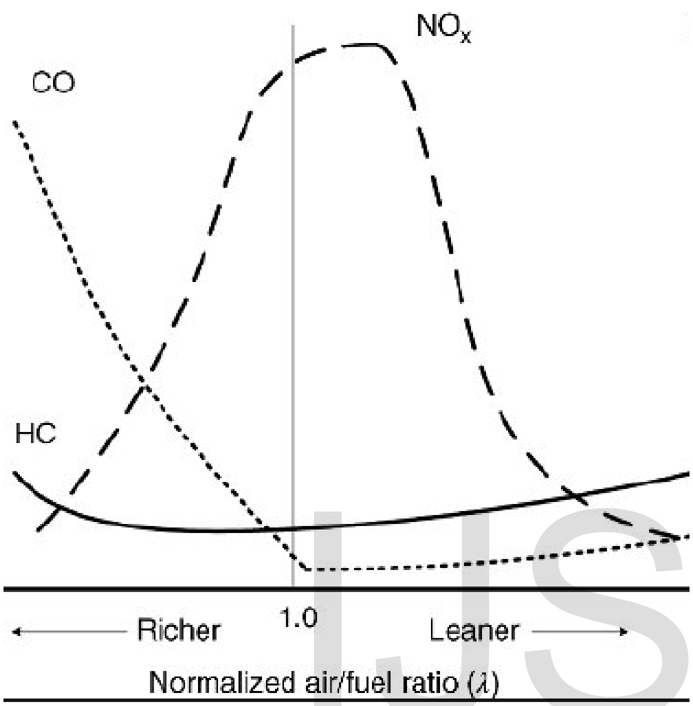
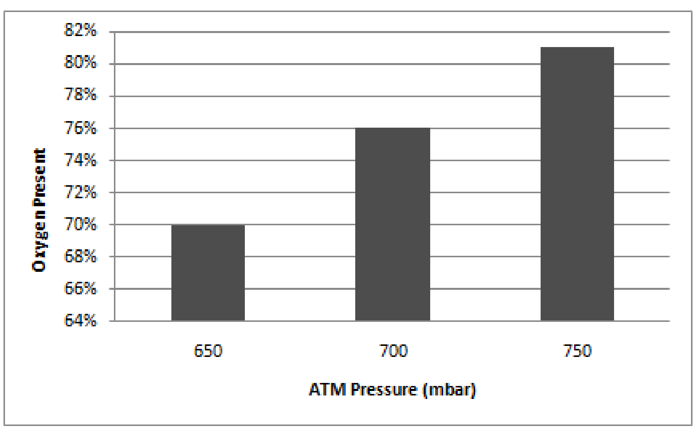


Fig. 3.Emission vs Air-Fuel ratio



Graph. 1.Pressure change vs oxygen present

The change in Air fuel ratio also leads to low fuel efficiency. In India, fuel efficiency is the major criteria for selecting (buying) a vehicle. So, it is very much important to maintain better air fuel ratio at higher altitude as well.

During the test it was found that the vehicle was hunting sometimes at idle condition also powerlessness was observed during the driving of the vehicle when going uphill. In fig. 4 idle hunting is shown in which on X axis time is placed and on Y axis Stechiometric coeficient.

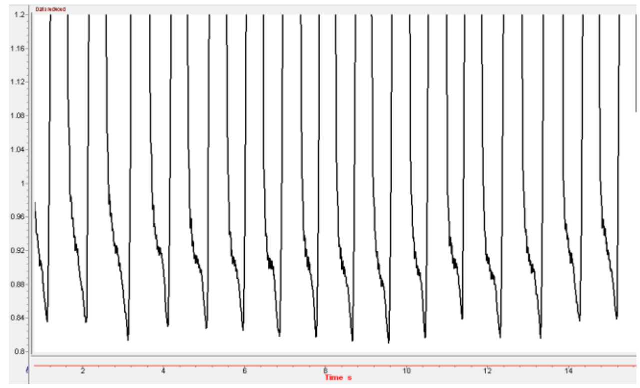


Fig. 4.INCA recording of lambda for idle hunting

3.1 Power output

Power output is one of the key factor when designing a vehicle which can run as smooth as it runs on lower altitudes.The power output of the vehicle decreased with the increase in altitude. There are many factors due to which the power output of the engine decreses on higher altitude. Reduced octane number and the availability og less oxygen are some maine reason behind this loss.Because of the less oxygen present in the atmospheric air improper combustion of the air fuel mixture takes place which ultimately leads to the power loss of the engine.

3.2 Low Fuel Efficiency

Fuel efficiency can be defined as the distance travel by the vehicle divided by the quantity of fuel used in liters.

Because of the rich mixture of air and the fuel in the vehicle, the vehicle starts taking more fuel for covering any short of distances. In this trial it was found that the fuel economy decrease upto 40% on higher altitudes as compare to the flat areas. The impact of altitude on fuel economy could be minimized by using a close-loop fuel management system in the engine. For activating close loop management system , fuel injection system is required instead of carburator system.

3.3 Less Engine Life

If the vehicle keep running with very rich mixture of air and fuel for long time then the chances of failure of the engine increases.Knowking is the main factor bihend this failure. In this trial knocking was there for alost 45% of time when the vehicle was running without any fuel correction. Fuel correction is only possible in the vehicles with Electronic Control Units before the launch of the vehicle in the market or only on the particular companies service sentres.Along with engine the chances of damaging catalists are also very high.If the air fuel mixture becomes too rich then very large amount of unburnt fuel goes into the catalytic converter due to which they get deposited on the converter and makes it less effective.

3.2 Emissions

Because of the rich air fuel ratio the engine starts releasing more Hydrocarbon pollutants which is very harmful all the living animals on the planet.

Hydrocarbons are organic compound, made up of one molecule of Hydrogen and one molecule of Carbon. They can be found at many places like natural gases and crude oils.As per the newly BSVI norms in India the emission of CO is reduced by 30%,nox by 80% also sets some limits for emission of Hydro Carbons.To fulfil these norms the correction in the air fuel mixture is even more required now on high altitudes.

4 Conclusion

Experimental investigation were carried out to study the reduction of oxygen present in the air at different altitudes.A drastic fall in the engine performance was observed due to the enrichment of air fuel mixture.Engine started loosing its power when going to uphill and HC emission increased.Knocking was also observed in the vehicle for almost 45% of the time when the vehicle was running without any fuel correction.Upto 30% enrichment in the air fuel ratio was observed which can harm engine,emits more emissions,lower down the output power and decrease the fuel efficiency of the vehicle.

Acknowledgment

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