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## A Survey on EGR System in 2-Stroke SI Engine in Two Wheeler

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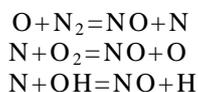
**ABSTRACT:** Many industrious cities face a serious air pollution problem from two wheelers that run on two-stroke engines. Since two-stroke engines burn an oil gasoline mixture, they emit more smoke, carbon monoxide, hydrocarbons, and particulate matter than the gas run four-stroke engines found in newer motorcycles. However, this problem can be reduced by fixing an ERG system to the two-stroke SI engines in two wheelers. This EGR system is already been executed in CI engines but an efficient system to control pollution in two stroke SI engines is yet to be designed. In Internal Combustion Engine when combustion chamber temperature reaches 2500°F or 1370°C, nitrogen and oxygen combine to form oxides of nitrogen (NO<sub>x</sub>).EGR works by recirculating a portion of (10 to 15%) exhaust gas to inlet manifold. The recycled exhaust gas lowers the oxygen concentration in the combustion chamber and increase the temperature of intake charge which lowers the flame temperature and leads to lower NO<sub>x</sub> formation. It also slightly increases the efficiency of the engine.

**KEYWORDS:** EGR (Exhaust Gas Recirculation), SI engine, NO<sub>x</sub>, Recirculation, Concentration.

### 1. INTRODUCTION

Nitrogen Oxide (NO<sub>x</sub>) emissions can be reduced using internal combustion engine by Exhaust gas recirculation system. In this process 10-15% of exhaust gas is recirculated into inlet valve where charged air is produced with increased temperature. This results in reduction of the combustion temperature and less Nitrogen Oxide is produced. This process is called Exhaust Gas Recirculation (EGR) and is one of the principal methods used to reduce NO<sub>x</sub> from Diesel engines .MTU has been developing this technology and the functions and components associated with it since the beginning of the 1900s.

The principal reactions at near stoichiometric fuel–air mixture governing the formation of NO from molecular nitrogen are:



The formation of NO<sub>x</sub> is a function of temperature. Since the exhaust gas transmitted inside the cylinder head is completely inert, it considerably reduces the peak combustion temperature by diluting the air-fuel mixture .So there is no sufficient temperature for nitrogen dissociation and hence there is high reduction in NO<sub>x</sub> evolution .On contrary hydro-carbon (HC) and carbon mono-oxide (CO) formation is inversely proportional to temperature due to higher incompleteness in combustion. Since NO<sub>x</sub> reduction cannot be done under such condition, only a critical range of 10 to 15% of exhaust gas can be re-circulated for maximum EGR efficiency. This limit is called “EGR Stability Limit”.

### II. RELATED WORK

EGR procedure is a well demonstrated strategy to diminish NO<sub>x</sub> and to increase thermal efficiency in internal combustion engines (Dangar and Rathod, 2013). Re-circulating emission gas on S.I engines is utilized basically to diminish throttling loss at part load range with a specific end goal to lessen fuel utilization and optionally, to decrease NO<sub>x</sub> discharge levels. EGR impacts the performance and emission on S.I engine. The exhaust gases mostly comprise of carbon dioxide, nitrogen and so forth and the blend has higher specific heat than atmospheric air (Wei *et al.*, 2012).

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Re-circulated exhaust gas displaces outside air from entering the combustion chamber with carbon dioxide present in the exhaust of the engine. In spark ignition engines, significant decreases in NO concentrations are accomplished with 10-20% EGR (Dangar and Rathod, 2013). Then again, EGR additionally diminishes the ignition rate, which makes stable combustion harder to accomplish. Petrol engines working at low loads for the most part endure a higher EGR proportion in light of the fact that re-circulating gases contain higher concentrations of oxygen and low concentrations of carbon dioxide and water vapors (Wasiu *et al.*, 2012). However at higher loads, the oxygen in exhaust gas turns out to be rare and the inactive constituents start increasing with increasing exhaust temperature. Therefore, as load increases, S.I engine have a tendency to produce more smoke in light of decreased accessibility of oxygen. EGR on direct injection S.I engine enhance mileage and HC discharge (Singh and Rehman, 2013). This phenomenon was probably because of the intake temperature increment by EGR, which enhanced the flame spread in the generally lean region of the air-fuel blend, which is non-consistently circulated (Wei *et al.*, 2012). Keeping the above facts in view, this survey on EGR in two stroke SI engine is obtained to reduce NO<sub>x</sub> and increase efficiency of the engine.

### III. METHODOLOGY

EGR works by recirculating a portion of an engine's exhaust gas back to the engine cylinders. We have used YAMAHA RX100 engine for this experiment. The exhaust gas from the muffler is passed to a Heat exchanger (Coolant Box) and then to the inlet of the IC engine. The Heat exchanger contains coolant (Engine oil), a spiral coil arrangement (like economiser), Fins and carbon filter. Here the temperature is reduced more than 150° from exhaust gas since coolant and Fins absorbs heat while passing through the coil. The activated Carbon filters removes small quantity of carbon monoxide from exhaust gas. Then the low temperature exhaust gas is sent to EGR valve which sends 10 -15 % of exhaust to inlet manifold and remaining to the atmosphere. Inter mixing the incoming air with recirculated exhaust gas dilutes the mix with inert gas, thus lowers the adiabatic flame temperature and reduces the amount of excess oxygen. The exhaust gas also increases the specific heat capacity of the mix lowering the peak combustion temperature. Because NO<sub>x</sub> formation progresses much faster at high temperatures, EGR serves to limit the generation of NO<sub>x</sub>. NO<sub>x</sub> is primarily formed when a mix of nitrogen and oxygen is subjected to high temperatures. When the exhaust gas continues to recirculate at each stroke NO<sub>x</sub> emissions are reduced gradually. The activated Carbon Filters is used in the exhaust pipe which removes small quantity of carbon monoxide from exhaust gas

### ADJUSTMENTS TO BE MADE IN SI ENGINE

#### THROTTLE VALVE

- To continue exhaust gas recirculation at the time of idling and full throttle open position, the throttle valve must be linked with EGR valve with suitable mechanism in addition to the accelerometer.
- The addition of inert exhaust gas into the intake system means that for a given power output, the throttle plate must be opened further, resulting in increased inlet manifold pressure and reduced throttling losses

### IV. COMPONENTS

#### HEAT EXCHANGER

The heat exchanger is located in the engine exhaust pipe. It consists of rectangular tube in a spiral coil arrangement and a Carbon filter. The heat exchanger is made up of M.S. plate. The inner tube is inserted tightly on the muffler tube. A spiral coil tube arrangement is made in between the two concentric tubes (inlet and outlet) so as to make a spiral path to the incoming gas. So that the heat transfer to the oil can be increased. Moreover the air is flowing in the walls of the Fins so thereby effective heat transfer can be achieved. The heat exchanger outlet is fitted with a Carbon filter and then connected to an EGR valve.

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Fig.1



Fig.2

### COOLANT (ENGINE OIL):

Oil has a higher boiling point than water, so it can be used to cool items at a temperature of 100°C or higher. The temperature of the exhaust gas from engine will be around 400-500°C, the exhaust must be cooled before it has to be recirculated. So engine oil is used to cool the exhaust gas. The main function of these lubricants is to reduce wear on moving parts; they also clean, inhibit corrosion, improve sealing, and cool the engine by carrying heat away from moving parts. Motor oils are derived from petroleum-based and non-petroleum-synthesized chemical compounds. Motor oils today are mainly blended by using base oils composed of hydrocarbons, polyalphaolefins (PAO), and polyinternal olefins (PIO), thus organic compounds consisting entirely of carbon and hydrogen. The base oils of some high-performance motor oils however contain up to 20% by weight of esters. Engine oil is the used as a coolant, typically to remove surplus heat from the exhaust gas. Engine oil is filled inside Heat Exchanger to reduce temperature of exhaust gas.

### CARBON FILTER:

Carbon filter is placed in the outlet of Heat Exchanger. Carbon filter uses a bed of activated carbon to remove contaminants and impurities, using chemical absorption. Each particle/granule of carbon provides a large surface area/pore structure, allowing contaminants the maximum possible exposure to the active sites within the filter media. activated carbon works via a process called adsorption, whereby pollutant molecules in the fluid to be treated are trapped inside the pore structure of the carbon substrate. The most advanced activated carbon filters, like those found in Blueair air purifiers, are infused with other compounds like magnesium dioxide and copper oxide to remove even more hazardous pollutants from the air, such as carbon monoxide, ethylene oxide, and ozone. The main scope of carbon filter in the experiment is to reduce certain amount of carbon monoxide from exhaust gas

### FINS:

A fin is a surface that extends from an object to increase the rate of heat transfer to or from the environment by increasing convection. The amount of conduction, convection, or radiation of an object determines the amount of heat it transfers. Increasing the temperature difference between the object and the environment, increasing the convection heat transfer coefficient, or increasing the surface area of the object increases the heat transfer. Fins are provided at the bottom and walls of heat exchanger which helps to reduce temperature in exhaust gas.

### EGR VALVE:

It reroutes some of the exhaust gases which are emitted by the engine into the combustion chambers. This effectively reduces temperatures in the combustion chambers. The EGR valve is an important component in exhaust gas recirculation process as it helps to prevent exhaust valves from overheating, which can accelerate their wear and tear .The EGR valve therefore helps to maintain the exhaust system at full capacity and increases the longevity of the internal combustion process .The EGR valve is fitted to outlet of heat exchanger which bypass 10-15% of exhaust to inlet an remaining to the atmosphere. While taking NO<sub>x</sub> test, various percentage of exhaust is recirculated (0-30%), which is properly recirculated with desired proportion by using EGR valve.

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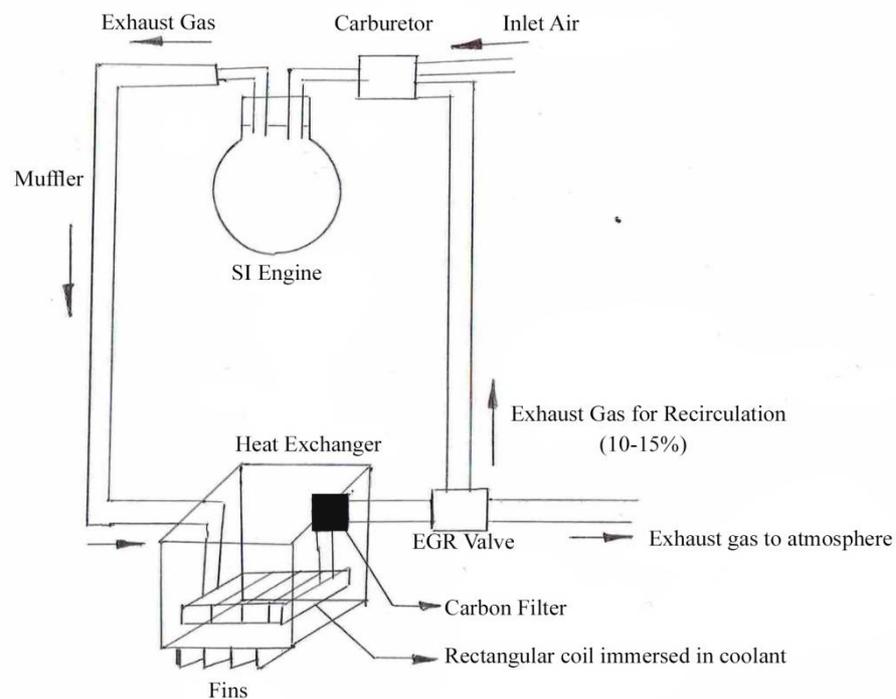
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Fig.3

## V. SCHEMATIC DIAGRAM OF EGR IN TWO STROKE SI ENGINE



### FUEL EFFICIENCY TEST: (WITHOUT LOAD)

Initially the engine is made to run with 10ml of petrol and a speed of 2500 rpm is maintained without EGR by adjusting the throttle.

- The time of the engine running with the 10 ml of petrol is noted down
- Several readings are taken for same rpm and the mean value is taken

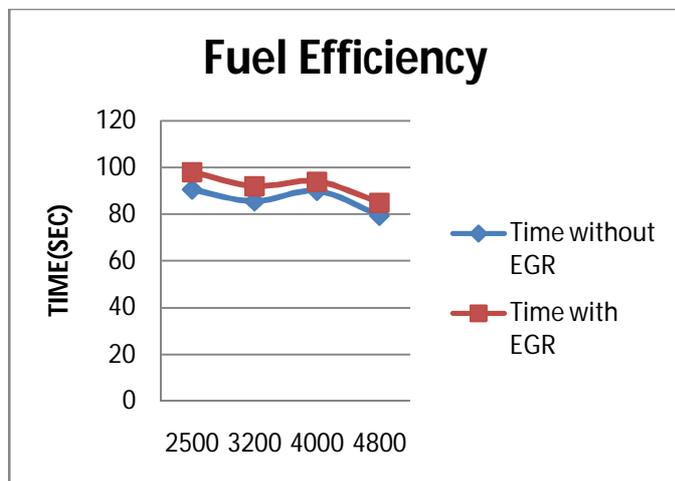
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- Similarly for the same amount of petrol at different rpm (2500, 3200, 4000,4800 ) are taken and the time is noted down
- The same process is repeated now for various rpm with exhaust gas recirculation (EGR).
- The readings are plotted on a graph to see the performance difference. The graph shows slight increase in efficiency.

SPEED (RPM) WITHOUT LOAD	RUNNING TIME OF ENGINE WITHOUT EGR (Sec)	RUNNING TIME OF ENGINE WITH EGR (Sec)
2500	90.6	98
3200	85.6	92
4000	90	94
4800	79.5	85



RPM  
Fig.5

### NO<sub>x</sub> TEST:

NO<sub>x</sub> test is done by allowing the gas into a exhaust gas analyser and the various percentage of CO, NO<sub>x</sub>, HC emission is noted down at Exhaust gas recirculation.

**EXHAUST GAS ANALYZER:** Gas analyzers may be hand operated or automatic. The most common analyzers of the former type are based on the absorption principle: the components of a gas mixture are absorbed one after another by different reagents. Automatic gas analyzers continuously measure some physical or physicochemical property of a gas mixture as a whole or of its separate components. The emission readings are taken with various percentage of EGR at various rpm.

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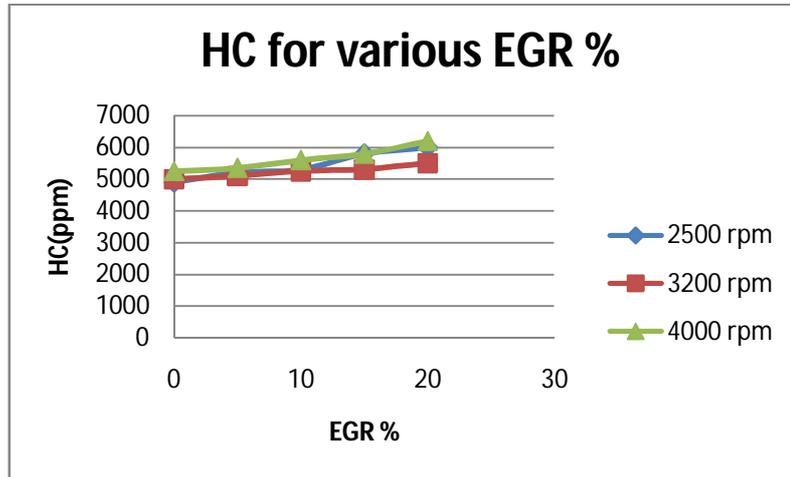


Fig.6

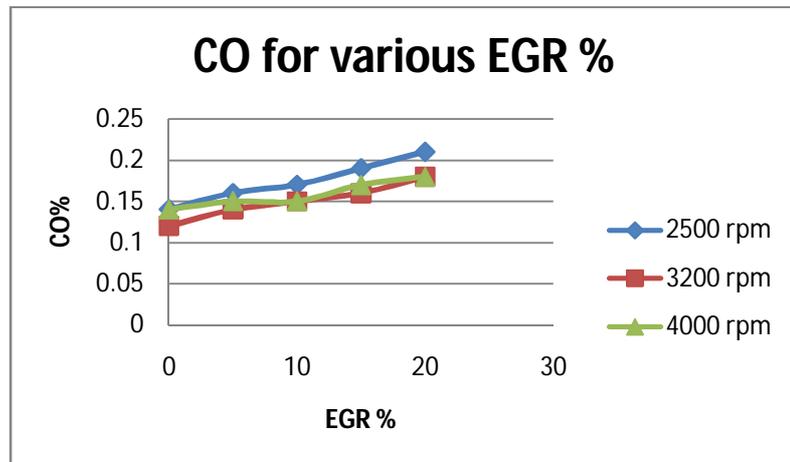


Fig.7

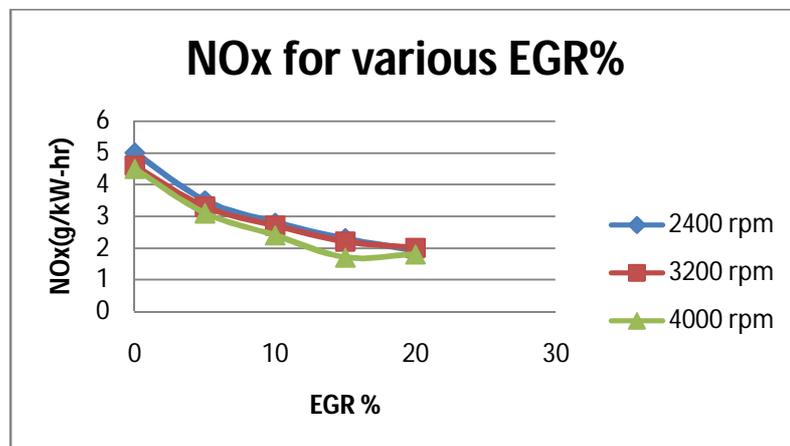


Fig.8

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From the fig.6,7 and 8 the impact of EGR on SI engine is shown. The graphs show HC and CO emission increases with increasing EGR rates. Lower oxygen concentration results in rich air-fuel blends at diverse areas inside the combustion chamber. This heterogeneous blend does not combust totally and results in higher hydrocarbons, and carbon monoxide discharges. However, NO<sub>x</sub> emission decreases as the percentage of EGR increases. The reason behind low NO<sub>x</sub> emission utilizing EGR in SI engines are diminished O<sub>2</sub> concentration and diminished flame temperatures in the combustible blend. At lower rates, O<sub>2</sub> is accessible in adequate amount however at high speeds, O<sub>2</sub> lessens radically, in this manner, NO<sub>x</sub> is decreased more at higher rates contrasted with lower speeds.

## VI. RESULTS

As seen, Exhaust Gas Recirculation is a very simple method. It can be very useful and it is being modified further to attain better standards. It can be easily fitted to two wheelers to eliminate Nitrous Oxides gas from IC Engine. From emission tests we conclude that emissions of NO<sub>x</sub> decreases with increase in % of EGR due to diminished flame temperature and oxygen concentration. At the same time CO and HC emission raises as the EMF % increases. It is also found that fuel efficiency of engine is slightly increased.

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