

RESEARCH ARTICLE

Effect of Exhaust Gas Recirculation on the Performance and Emission of Two-Stroke Spark Ignition Engine

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Abstract

Oxides of nitrogen (NO_x) which are formed during the combustion of charge in the internal combustion engine are the main cause of major respiratory issues in individuals. NO_x additionally adds to boost global warming and formation of acid rain. The impact of Exhaust Gas Recirculation (EGR) can successfully decrease the Nitrogen Oxides (NO_x) emissions by diminishing the ignition temperatures, since NO_x formation is a temperature dependent phenomenon. EGR is being utilized broadly to lessen and control the oxides of nitrogen (NO_x) discharge from both petrol and diesel engines. However, the utilization of EGR results in emission of more unburned hydrocarbons (20-30%) when contrasted with conventional engine. The present work is to study the effect of EGR on the performance and emissions of a self-made EGR setup on a single cylinder two stroke spark ignition engine. The EGR rate varied between 0-20%. Experiments were carried out for mass flow measuring of EGR with simplifying adjustment (manual designed EGR system) on the engine. The performance was measured on the basis of brake thermal efficiency (BTE) and brake specific fuel consumption (BSFC). The emission species measured were NO_x, unburnt hydrocarbons (UHC) and carbonmonoxide (CO). The tests were conducted at 2600, 3200 and 4000 rpm on no load condition. The findings showed that EGR would be one option to increase thermal efficiency and reduce BSFC and NO_x concentrations in the engine exhaust, but with a rise in EGR rate, the CO and UHC concentrations in the engine exhaust increased.

Keywords: Internal combustion engine, Oxides of nitrogen, exhaust gas recirculation, carbonmonoxide.

Introduction

Due to overall air contamination and strict forthcoming regulations, it is necessary to decrease NO_x and unwanted particulates from the internal combustion engines exhaust emission (Ghosh and Dutta, 2012). Emissions from internal combustion engines have serious impacts on human, creature, plant and ecological wellbeing and welfare which lead us to utilize distinctive propelled innovation to control the emissions from internal combustion engines (Sapre and Bhagat, 2014). The strategies and systems which are utilized to reduce emissions from internal combustion engines have a few undesirable impacts on performance of the engine (Singh and Rehman, 2013). Numerous analysts have tried to lessen emissions and build the efficiency of the petrol engine. For spark ignition engine, an answer for regulating emissions is by varying some burning parameters such that engine performance is kept unaltered (Douville, 1994). EGR procedure is a well demonstrated strategy to diminish NO_x 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_x 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). 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 study was aimed to find out the effect of EGR on the performance and emissions of a self-made EGR setup on a single cylinder two stroke spark ignition engine.

Materials and methods

Experimental setup: A single cylinder two stroke S.I engine building up 7.7 hp was suitably changed to work on petrol with and without EGR. A small amount of the exhaust gases is to be recycled back to the engine combustion chamber alongside intake air. The amount of EGR is to be measured and controlled. Limited facilities accessible in the lab did not permit programming the EGR framework and engine control unit, a by-pass for the exhaust gases was furnished alongside the handle (physically), EGR valve to control the amount of EGR mass stream. The independent EGR setup is outlined in Fig. 1. The trials were directed at 0, 5, 10, 15 and 20% of EGR stream rates. The experiment was conducted with different EGR rates at 2600, 3200 and 4000 rpm. Fuel consumption estimation was done utilizing a gravitational manometer. CO and HC concentrations were measured by manual Orsat apparatus. To accomplish the study's targets, engine was kept running under normal working condition and at distinctive EGR rates. The readings for HC, CO and fuel consumption were recorded. At that point, engine performance and emission patterns were plotted. Ideal EGR rate was found on the basis of engine performance and emissions of the engine. Specifications are as given in Table 1.

Fig. 1. Self-made EGR setup on two stroke engine.



Results and discussion

The engine was run on no load condition at 2400, 3200 and 4000 rpm with different EGR rates (from 0% to 20%) to investigate the effect of EGR on engine performance and emissions. The performance and emission data was analyzed and presented graphically for fuel consumption, HC and CO concentrations.

Table 1. Specification of the engine.

Make	Kinetic Honda (moped)
Model	ZX
No. of cylinders	1
No. of strokes	2
Bore	31.75 mm
Displacement	100 cc
BHP/BP	7.7/5.736 KW
Type of cooling	Air cooled
Aspiration	Natural
Speed	2600, 3200 and 4000 rpm
Compression ratio	7.1:1

Fig. 2. Thermal efficiency for different EGR rates.

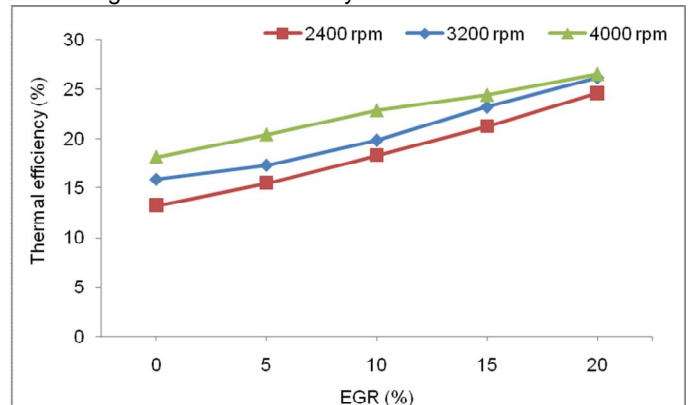
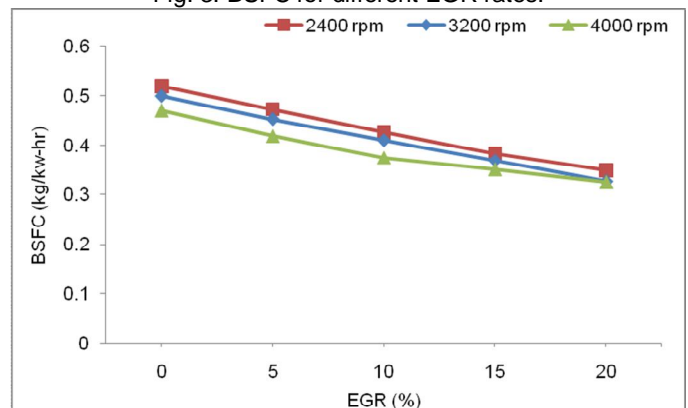


Fig. 3. BSFC for different EGR rates.



Engine performance analysis: The patterns of thermal efficiency are demonstrated in Fig. 2. Thermal efficiency is found to have somewhat increased with EGR at lower engine speed. The reason may be re-combustion of hydrocarbons that enter the ignition chamber with the re-circulated exhaust gas. At lower rates, exhaust gas has less CO₂ and genuinely high measure of O₂. Additionally, mostly cooled EGR acts like a pre-radiator of the intake blend, at the point when this exhaust gas is re-circulated to the chamber, the unburned HC in exhaust gas burn on account of adequate O₂ accessible in ignition chamber and sensibly high intake temperatures. At higher speeds, exhaust gas has higher measure of CO₂, which diminishes most extreme temperature in ignition chamber alongside oxygen accessibility therefore re-burning of HC is not significant.

Figure 3 shows the correlation of BSFC at distinctive EGR stream rates. BSFC is lower at higher speeds for engine on EGR when contrasted with engine without EGR. At higher speeds, measure of fuel supplied to the chamber is more at higher rate and oxygen accessible for ignition gets diminished. Along these lines, air fuel proportion is changed and this shifts the BSFC.

Engine emission analysis: Impact of EGR on unburned hydrocarbon (UHC), carbon monoxide (CO) and NOx are indicated in Figs. 4, 5 and 6 separately. These graphs demonstrate that HC and CO emissions increment 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. The findings demonstrate the primary advantage of EGR in decreasing NOx emissions from petrol engine. The level of lessening in NOx at higher speed is higher. The explanations behind lessening in NOx discharges utilizing EGR as a part of petrol engines are diminished O₂ concentration and diminished flame temperatures in the combustible blend. At lower rates, O₂ is accessible in adequate amount however at high speeds, O₂ lessens radically, in this manner, NOx is decreased more at higher rates contrasted with lower speeds.

Fig. 4. Hydro carbons for different EGR rates.

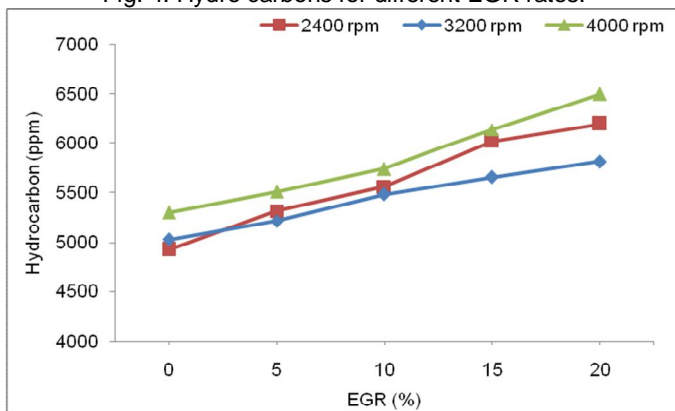


Fig. 5. Carbon monoxide for different EGR rates.

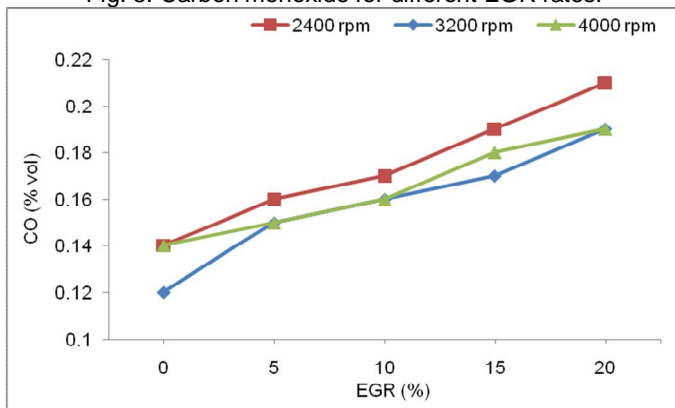
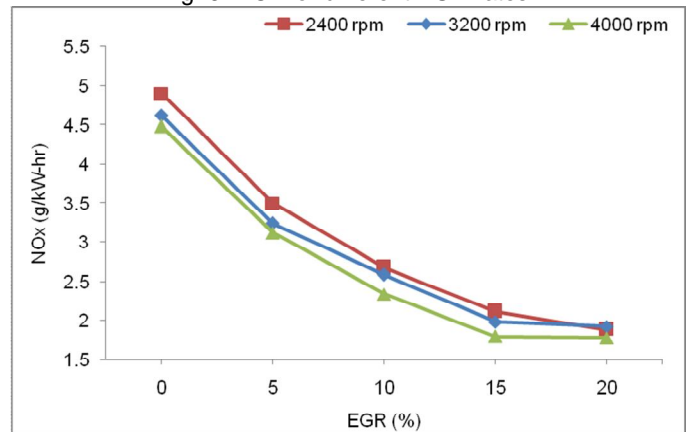


Fig. 6. NOx for different EGR rates.



Conclusion

EGR is an extremely helpful system for decreasing the NOx discharge. In the present exploration, experimental examinations were conducted to study the impact of EGR on performance and emission of a self-made EGR setup on a two stroke petrol engine. EGR displaces oxygen in the intake air by re-circulation of exhaust gas to the ignition chamber. Exhaust gasses bring down the oxygen concentration in combustion chamber and increase the specific temperature of the intake air blend, which brings about lower flame temperatures. Lessened oxygen and lower flame temperatures influence performance and emissions of petrol engine in diverse ways. Thermal efficiency is slightly increased and BSFC is diminished at higher speeds with EGR when contrasted with without EGR. NOx emission diminishes fundamentally. At lower rates, EGR lessens NOx without reducing performance and emissions. At higher speeds, increased rate of EGR decreases NOx however deteriorates performance and emissions. Subsequently, it can be presumed that higher rate of EGR can be applied at lower speeds. EGR can be connected to petrol engine without sacrificing its effectiveness, mileage and NOx reduction. The increment in CO and HC discharges can be lessened by utilizing exhaust after-treatment methods.

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