International Journal of Modern Research in Electrical and Electronic Engineering
Vol. 1, No. 1, 42-46, 2017
http://www.asianonlinejournals.com/index.php/IJMREER

# Effect of Exhaust Gas Recirculation on Performance of Petrol Engine

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**Abstract**

Exhaust gas recirculation is a method of reducing the emission of internal combustion engine. The principle is based on the thermodynamic properties of the exhaust gas, reduction in combustion temperature and hence reduces the emission of the oxides of nitrogen. The technical involves the recirculation of high heat capacity of the exhaust gas to dilute the charges 2.6% of the total exhaust gas from the engine was recycled from the exhaust gas discharge manifold to the intake manifold. The changes on the parameters of the engine were observed. The resulting data were analyzed graphically. It was found out that the exhaust gas recirculation increased the Brake specific fuel consumption, reduced the flame temperature and the speed of the engine.

**Keywords:** Exhaust, Recirculation, Temperature, Specific, fuel.

## Contents



**Citation** | Tairu, Onawale O; Tairu O. Temitope (2017). Effect of Exhaust Gas Recirculation on Performance of Petrol Engine. International Journal of Modern Research in Electrical and Electronic Engineering, 1(1): 42-46.
**DOI:** 10.20448/journal.526.2017.11.42.46

**Contribution/Acknowledgement:** All authors contributed to the conception and design of the study.
**Funding:** This study received no specific financial support.
**Competing Interests:** The authors declare that they have no conflict of interests.
**Transparency:** The authors confirm that the manuscript is an honest, accurate, and transparent account of the study was reported; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained.
**History:** **Received:** 23 November 2016/ **Revised:** 15 March 2017/ **Accepted:** 29 March 2017/ **Published:** 5 April 2017
**Ethical:** This study follows all ethical practices during writing.
**Publisher:** Asian Online Journal Publishing Group

# 1. Introduction

Oxides of nitrogen ($NO_x$) are formed when temperatures in the combustion chamber get too hot [1, 2]. At high temperature, the nitrogen in the combustion chamber chemically combine to from nitrous oxides, which, when combine with hydrocarbons (HCs) and in the presence of sunlight, produce an ugly hazard in our skies know commonly as smog [3, 4]. Nitrogen and oxygen will unite to from oxides of nitrogen at rich fuel/air ratio mixture and high temperature while weak fuel/air ratio is needed to the control of the hydrocarbon and carbon monoxide. Since the fuel/air ratio cannot control the production of pollutants simultaneously in the engine. It is necessary to reduce the oxides of nitrogen and other unwanted particulates in the emissions from internal combustion engine. The introduction of exhaust gas recirculation is used to reduce the formation of the oxides of nitrogen. The exhaust gas recycled through the intake manifold back to the engine cylinders. Inter mixing the incoming air with recycled exhaust gas diluted the mix with inert gas, lowering the peak combustion temperatures and reduced the amount of excess oxygen as well as reduced the flame speed thus gave a useful reduction in formation of nitrogen without compromising the fuel economy. Exhaust gas recirculation (EGR) system were introduced in the early '70s to reduce an exhaust emission that not being cleaned by the other smog controls. The research and implementation of Exhaust gas recirculation started when the catalyst technology was not sufficient to reduce the formation of $NO_X$ [5, 6]. The approach reduces the combustion temperature and increase engine efficiency. The fuel mixture diluted with air [7] or exhaust gas recirculation (EGR) [8]. EGR has high potential to reduce exhaust gas emission, particular $NO_X$ emission [9] and the amount of oxides of nitrogen formed could be reduced better with Exhaust gas than air [10]. It reduced $NO_X$ formation from 25.4% up to 89.6% [11].

The initial concentration of $NO_x$ when the engine was cooler at startup was higher than the concentration of $NO_x$ when the engine was warmer [12]. The reduction NOx concentration substantial claimed be achieved from 10% of EGR [13, 14] and increased the brake specific fuel consumption .The effect of 1.6% of exhaust gas recirculation are on the flame temperature, the speed and fuel consumption were consider in this paper.

**Table-1.** Specification of the Engine

| **Engine Manufacturer** | **Toyota 4k** |
|---|---|
| Engine properties | 8 –valve OHV |
| Number of stroke | 4 |
| Number of cylinder | 4 |
| Cylinder bore | 75 mm |
| Stroke | 73 mm |
| Maximum Torque | 103 Nm@3600rpm |
| Maximum Power | 53 KW@5600rpm |
| Compression ratio | 9:1 |
| Cooling system | water |
| Brake mean effective pressure | 1003.4Kpa |

**Source:** https://en.wikipedia.org/wiki/Toyota_K_engine

**Table-2.** Nomenclature

| **Speed** | **N (rpm)** |
|---|---|
| Fuel consumption | Vf ($cm^3$/min) |
| Exhaust gas temperature | Te($^0$C) |
| Brake specific fuel consumption | BSFC (g/KWh) |

**Source:** https://en.wikipedia.org/wiki/Brake_specific_fuel_consumption

# 2. Description of Experimental Procedures

The engine of specification in Table 1was allowed running for thirty minute and pressure of the cooling water was reduced. The throttle control was used to change the speed. The exhaust gas was recycled with the aids of the hose connected the exhaust manifold to the intake manifold. The percentage of area of connected pipe to the area of the intake manifold pipe was 2.6%. The temperatures of the exhaust gas and the cooling water at the inlet and outlet, the fuel consumption and the flow rate of the cooling water were taken with the corresponding speed for overheated with and without exhaust gas recirculation at the particular throttle positions at ten minutes interval.

**Table-3.** The Readings Obtained for the Experiment

| **Throttle Position** | **Without EGR** | | | | **With EGR** | | | |
|---|---|---|---|---|---|---|---|---|
| | **N (rpm)** | **$V_f$ ($cm^3$/min)** | **$T_e$ ($^oC$)** | **BSFC (J/KWh)** | **N (rpm)** | **$V_f$ ($cm^3$/min)** | **$T_e$ ($^oC$)** | **BSFC (J/KWh)** |
| 1 | 1000 | 17.64 | 75 | 1.25 | 950 | 17.64 | 63 | 1.32 |
| 2 | 1200 | 21.17 | 85 | 1.25 | 1150 | 22.93 | 65 | 1.41 |
| 3 | 1400 | 28.22 | 95 | 1.43 | 1300 | 29.46 | 73 | 1.60 |
| 4 | 1600 | 35.28 | 105 | 1.56 | 1400 | 36.52 | 80 | 1.85 |
| 5 | 1800 | 40.57 | 124 | 1.60 | 1650 | 42.34 | 95 | 1.82 |
| 6 | 2000 | 42.34 | 139 | 1.50 | 1850 | 44.10 | 100 | 1.69 |
| 7 | 2200 | 45.86 | 159 | 1.48 | 2050 | 47.63 | 123 | 1.65 |
| 8 | 2400 | 52.92 | 180 | 1.56 | 2200 | 58.21 | 150 | 1.87 |

**Source:** Thermodynamic laboratory, Yaba college of Technology

## 3. Results and Discussion

The results obtained from the experiment shown in Table 3. The effect of EGR on the speed, fuel consumption, brake specific fuel consumption and the exhaust gas temperature were shown on the table and the graphs were plotted for analysis.

### 3.1. Effect EGR on the Speed of the Engine

As shown in the Fig. 1, the EGR reduced the speed of the engine. The speed minimum reduction is 5% and maximum reduction is 12.5%, the average reduction in speed is 7.5% as could be obtained in the Table 3. This due to the reduction in rate of combustion in the engine since the EGR diluted the concentration of air-fuel mixture of the combustion.

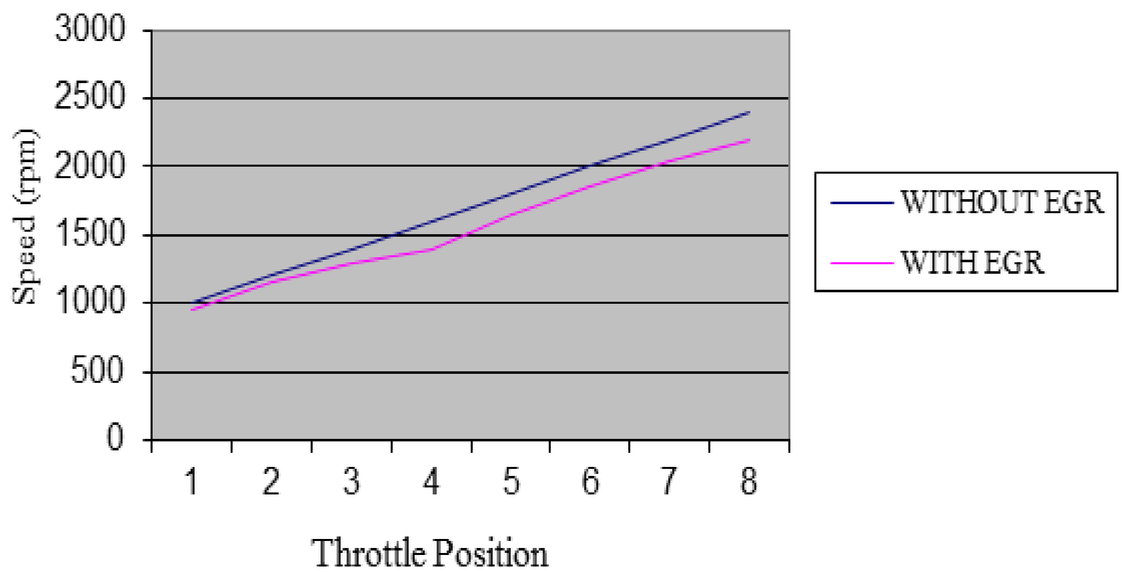


**Figure-1.** The Effect of EGR on the speed

**Source:** Thermodynamic laboratory, Yaba college of Technology

### 3.2. Effect of EGR on the Fuel Consumption

The fuel consumption increased as the load the engine with EGR. As shown on the Table 3 the minimum was 0% and the maximum was10%. The average fuel consumption increment was 4.8%. More fuel was consumed to compensate for EGR dilution as shown in the Fig.2.

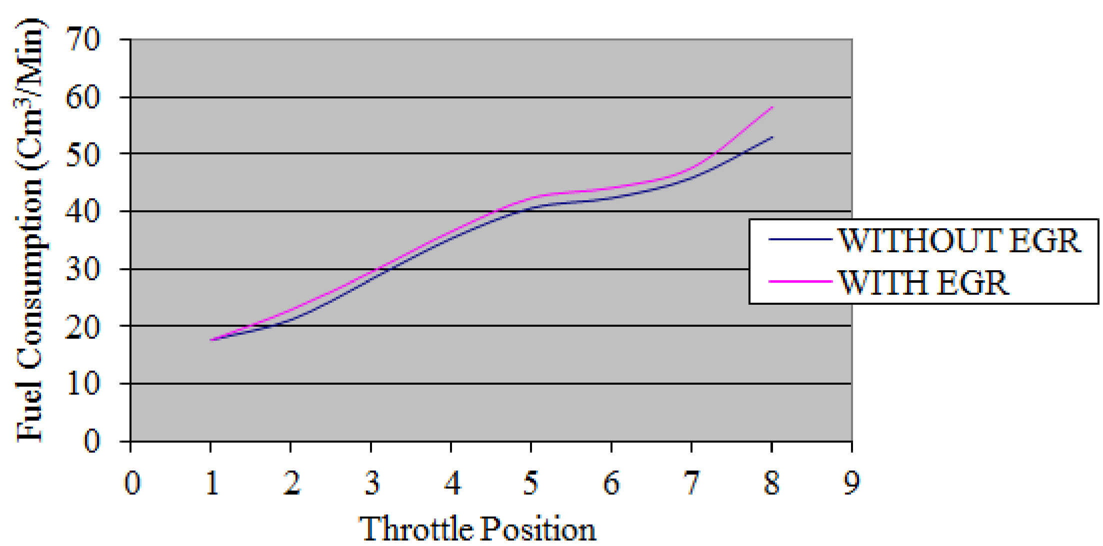


**Figure-2.** The effect of EGR on Fuel Consumption

**Source:** Thermodynamic laboratory, Yaba college of Technology

### 3.3. Effect of EGR on the Exhaust Gas Temperature

Table 3 above shows that for the exhaust gas temperature, the minimum reduction is 16% and maximum reduction is 28% while the average temperature reduction is 22%. Since the exhaust temperature reduced the $NO_X$ formation reduced as shown in Fig. 3. The ratio of reduction of exhaust gas temperature to reduction of speed and increment of the fuel consumption is 5:2:1.

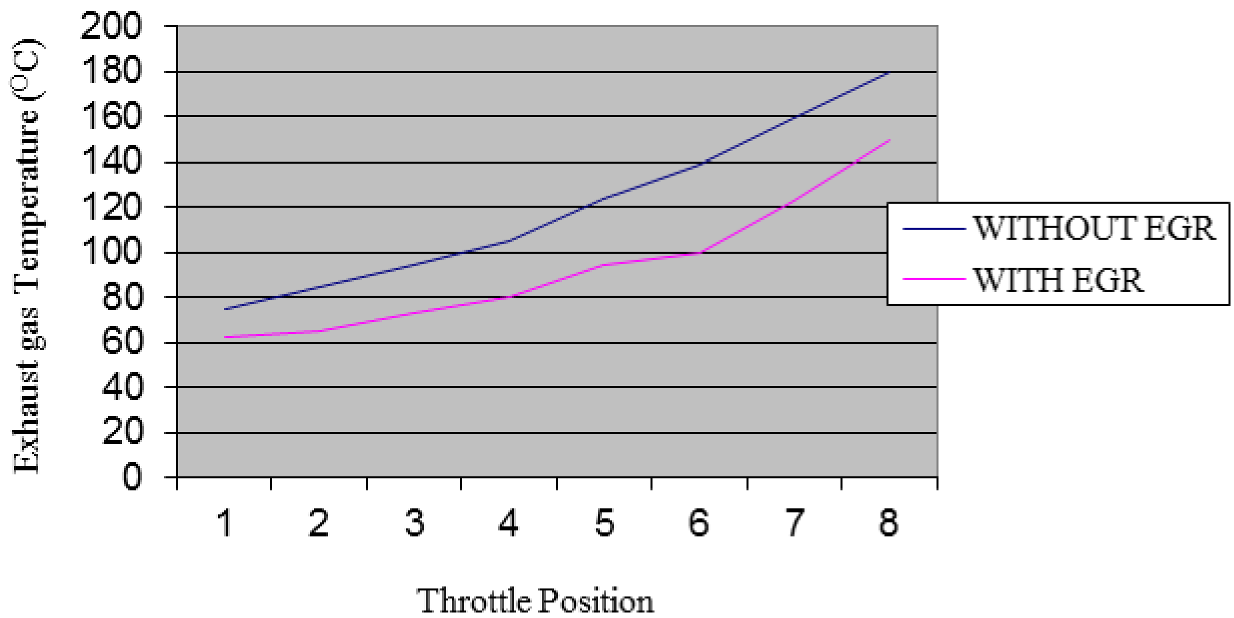


**Figure-3.** Effect of EGR on Exhaust gas Temperature

**Source:** Thermodynamic laboratory, Yaba college of Technology

### 3.4. Effect of EGR on the Brake Specific Fuel Consumption

When the speed reduced and fuel consumption increased, the brake specific fuel consumption increased. The increments range from 5.6% to 19.8% with average of 13.6%, as shown in Table 3. This was shown in the Fig 4.

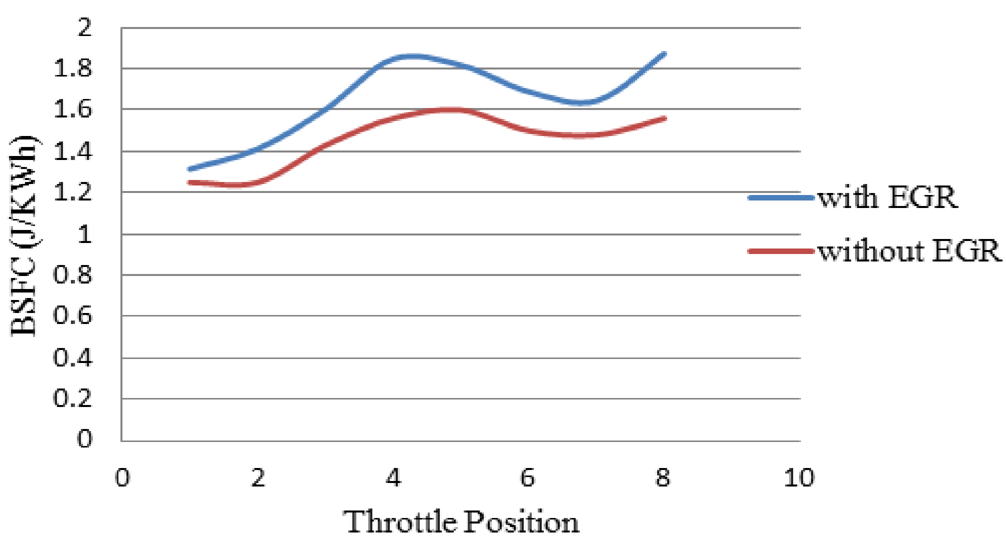


**Figure-4.** Effect of EGR on the Brake specific Fuel Consumption

**Source:** Thermodynamic laboratory, Yaba college of Technology

## 4. Conclusion

When 2.6% of the exhaust gas recycled into the engine there were following effect on the parameters of the engine:

(a) Significant reduction in the exhaust gas temperature i.e. the flame temperature of the engine reduced by 22%

(b) Increment in fuel consumption i.e. fuel consumption increased by 4.8%

(c) Decreased in the speed of the engine i.e. the brake power reduced by 7.5%

The percentage of the flame temperature reduced is more than the percentage of power reduced and fuel economy increased. EGR is the effective way to reduce the pollution of oxides of nitrogen without increase in the other pollutants in the internal combustion engine. There was significant reduction in the flame temperature below 10% EGR.

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