International Journal of Engineering Research and Development
e-ISSN: 2278-067X, **p**-ISSN : 2278-800X, www.ijerd.com
Volume 4, Issue 10 (November 2012), PP. 08-12

Performance and emission parameters analysis of gasoline engine with EGR

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Abstract:- This paper presents an experimental investigation of various exhaust gas recirculation (EGR) rates on the engine performance like brake thermal efficiency, brake specific fuel consumption and brake power and engine exhaust gas emission parameters like nitrogen oxides(NOx), carbon monoxide (CO), hydrocarbon(HC) and particulate matter (PM) for the fuel used in the engine. Four observations are made for exhaust emission gas analysis 0% EGR, 10% EGR, 20% EGR and 30% EGR. The rotational speed of the engine is taken as constant at 1500 rpm. The experiment was performed on a four cylinder four stroke water cooled spark ignition engine fuelled with commercial grade gasoline of octane number 92 and a hydraulic dynamometer. Exhaust gas emissions were measured by using a Indus exhaust gas analyzer. Lower heating value of the fuel was 43700/kJ/kg and average molecular weight was 93.454. The effect of EGR addition to the fresh air on performance and exhaust gas analysis of the engine is investigated. The substantial reductions in NOx concentration are achieved with 10-30% EGR.

Keywords:- EGR, spark ignition, gasoline, NOx, emission.

I. INTRODUCTION

Due to the world-wide air pollution and strict upcoming regulations, it is urgently required the reduction of NOx and PM from the internal combustion engines exhaust emission. Exhaust gas emissions from internal engines have significant effects on human, animal, plant, and environmental health and welfare. This leads us to use different advanced technology to control the exhaust gas emission from internal combustion engines. The methods and techniques which are used to decrease exhaust emissions from spark ignition engines have some influences on engine performance. Many researchers are directed their research to reduce emission and to increase the efficiency of the spark ignition engine. For spark ignition engine an effective solution for reducing emissions by regulating some combustion parameters such that engine performance is kept unaltered. EGR technique is well proven method to decrease NOx and to increase thermal efficiency in internal combustion engines. Choongsik and Junemo et al have conducted an experiment to find out the effect of EGR on combustion phenomena of spark ignition engine. They observed that reducing EGR temperature by 180°C resulted the decrease of exhaust gas temperature by 15°C using cool EGR at 1600 rpm that also reduce thermal load at exhaust.[1]. Recirculation of exhaust gases into the engine enhances the intake temperature. This also decrease the level of smoke because unburned of previous cycle may re-burn in the forth coming cycles [2]. Zheng et al. (2004), reviewed the advanced and novel concepts in diesel engine exhaust gas recirculation. They observed that EGR process is effective way to reduce nitrogen oxides from diesel engines while increasing particulate matter. They also observed that power losses are significant when EGR is further increased. [3]. Abd-Alla (2002), have done a review on exhaust gas recirculation to internal combustion engines. The aim of the review work was to the potential of EGR to reduce exhaust emissions, mostly NOx, and to delimit the application range of the EGR process. [4]. Deepak Agarwal et al performed a test on a single cylinder DI diesel engine and measured the performance and emission characteristics with rice bran methyl ester (RBME) and its blends as fuel with EGR system. They optimized and observed that 20% biodiesel blends with 15% EGR produce the less NOx, CO and HC emissions and also improved thermal efficiency and reduced BSFC. [5] C.Sayin et al studied energy and energy analysis in a four cylinder, four stroke spark ignition engine using fuel of different research octane number and observed that the engine operates less energy efficiency when the fuel have octane rating is higher than the design rating.[6]. Among the many authors, Sato et al (1997), Sousa (2000), Kohketsu (1997), Han, S., and Cheng, W.K. (1998), have discussed the merits and demerits of the EGR technology. They have, also, proposed ways to minimize the drawbacks when applying EGR process in various types of diesel and gas engines. [7-10] Heffel has done experiment to study the NOx emission from internal combustion engine. [11]. Abu-Jrai et al, Zheng et al have analysed the effect of exhaust gas recirculation (EGR) on pollutant emission in diesel engine. [12] Pradeep and Sharma et al have studied performance of a single cylinder DI diesel engine with Jatropha oil methyl ester biodiesel (JBD) with hot EGR .They optimized 15 %EGR gave the adequate reduction of NOx emission with minimum possible smoke, CO,UBHC emissions. And further increased EGR rates produced more NOx emissions. [13]. The aim of the present study is to analyse the influence of using EGR on engine performance and the emission parameters at different EGR rates. Performance analysis and pollutant emission is studied using different percentage of EGR. It was found by analysing that adding EGR to the air flow rate is more beneficial way of utilizing EGR rather than displacing some of the inlet air.

II. EXPERIMENTAL DETAILS

The experiment was performed on a four cylinder four stroke fiat water cooled spark ignition engine. The specifications of the engine are listed in table 1. In this experiment the load was varied but rpm remained constant in each observation. The engine load was adjusted by a hydraulic dynamometer. The engine torque was measured with a hydraulic dynamometer.

The intake air flow rate was measured by using a conic edge orifice meter. The fuel consumption of the engine was determined by monitoring the fuel level in a measurement container. The exhaust emissions gas like carbon monoxide (CO), nitrogen oxides (NOx) and unburned hydrocarbon (HC) emissions were measured using a Indus 5 gas exhaust analyser. Data were collected to analyse the performance and emission parameters of the engine after achieving the steady state operating condition. Schematic layout of the experimental setup is shown below.

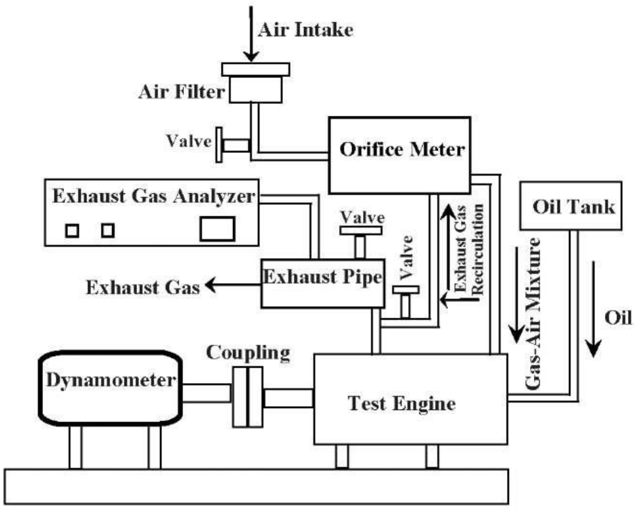

Fig.1: Schematic layout of the experimental setup

Table-1: Specification of the engine.

Engine	**Fiat**
Number of stroke	4
Number of cylinder	4
Cylinder bore	68mm
Stroke	75mm
Maximum torque	74N-m @4300rpm
Maximum Power	53hp@5400rpm.
Compression ratio	8:1
Break mean effective pressure	842.4 kpa
Cooling System	Water cooled
Displacement volume	1.09dm^3.

III. RESULTS AND DISCUSSION

A four cylinder four stroke water cooled spark ignition engine was used to evaluate the performance and emission parameters of gasoline fuel with different rates of EGR. The output obtained from the experiment is plotted to determine the performance analysis and exhaust emission gas analysis. Brake thermal efficiency and brake specific fuel consumption is plotted against brake power. Carbon dioxide (CO2) and Carbon monoxide (CO) are measured in percentage. Nitrogen oxides (NOx) and hydrocarbon (HC) are in ppm in measuring devices connected with engine.

A. Brake thermal efficiency v/s brake power

In Figure 2 brake thermal efficiency v/s brake power is plotted. It indicates the variation of thermal efficiency with increasing EGR rate. Thermal efficiency gets increased with the amount of exhaust gas re-circulated as the exhaust gas increases temperature of the fuel and air mixture is increased in the cylinder. Hence the amount of heat required is less which ultimately increases the thermal efficiency of the engine. In the engine, with hot EGR the thermal efficiency is improved due to increased intake charge temperatures and re-burning of the unburned fuel in the re-circulated gas simultaneously.

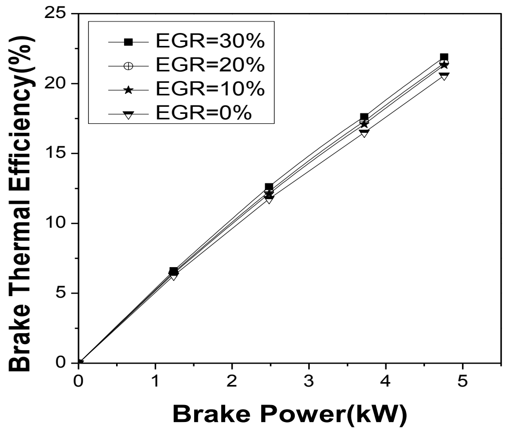

Fig. 2: Brake thermal efficiency v/s brake power

B. BSFC v/s brake power

In Figure 3, BSFC v/s brake power is plotted. It indicates the variation of brake specific fuel consumption with increasing EGR rate. There is a remarkable improvement in fuel consumption with increasing EGR. One of the main reasons for that effect is due to the reduction of pumping work. As the amount of EGR is increased (with fuel and air flow rate remaining constant), the pump work gets reduced and hence the entire inlet charge needing to come past the throttle. Again due to the reduction of heat loss to the wall of the cylinder the significant reduction in burnt gas temperature improves the fuel consumption trends. The reduction in the degree of dissociation in the high temperature burned gases also improves the brake specific fuel consumption.

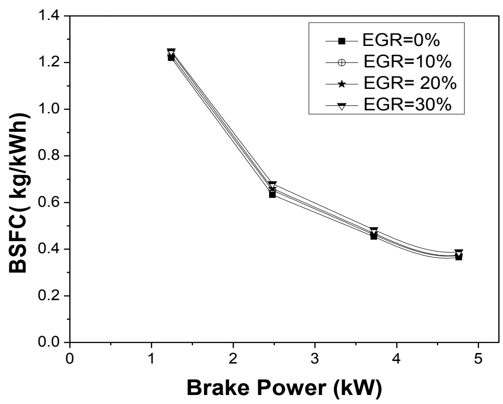

Fig. 3: BSFC v/s brake power

C. CO (%) Emission v/s brake power

In Figure 4, CO (%) v/s brake power is plotted. It indicates the variation of percentage of emission of carbon monoxide with increasing EGR rate. With increasing percentage of EGR, the CO emission is reduced. This is due to the better mixture preparation for combustion and the positive effects of the active radicals and thermal effect. It is observed that with 30% EGR the carbon monoxide emission is lowest.

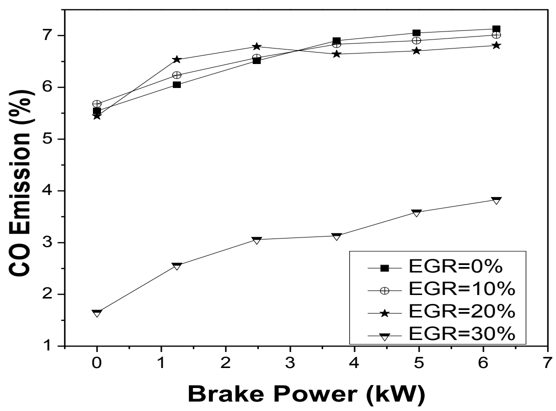

Fig. 4: CO (%) Emission v/s brake power

D. Carbon dioxide (%) v/s brake power

In Figure 5, CO2 (%) v/s brake power is plotted. It indicates the variation of carbon dioxide with increasing EGR rate. The use of CO2 to displace oxygen (O2) in the inlet air resulted in reduction in the O2 supplied to the combustion chamber of the engine (dilution effect), increased inlet charge thermal capacity (thermal effect), and, potentially, participation of the CO2 in the combustion process (chemical effect).

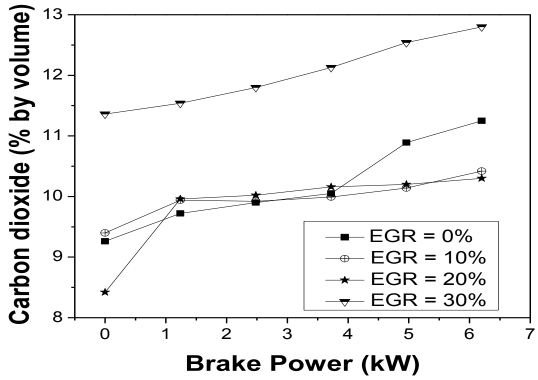

Fig. 5: Carbon dioxide (%) v/s brake power

E. Hydrocarbon (ppm) v/s brake power

In Figure 6, HC v/s brake power is plotted. It indicates the variation of hydrocarbon with increasing EGR rate. When the brake power is nearly zero the emission of hydrocarbon is maximum at constant EGR. It is also seen that when no exhaust gas recirculation is used, the hydrocarbon emission is maximum due to less availability of O2 results in poor air fuel ratio and tends to incomplete combustion. It is decreasing with increasing rate of EGR.

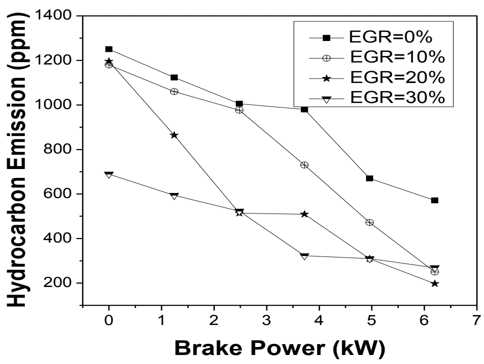

Fig. 6: Hydrocarbon (ppm) v/s brake power

F. NOx Emission (ppm) v/s brake power

Figure 7 indicates the variation of nitrogen oxides with increasing EGR rate. Formation of nitrogen oxides get reduced as the exhaust gas reduces the flame temperature by increasing the heat capacity of the cylinder charge. EGR functionally plays the role of additional diluents in the un-burnt mixture, as a result of which the peak burned gas temperature gets lowered and hence the nitric oxide formation rate is also decelerated. Thus, it is the total burned gas fraction in the un-burnt mixture in the cylinder (which consists of both residual gas from the previous cycle and the exhaust gas recycled to the intake) which acts as a diluents.

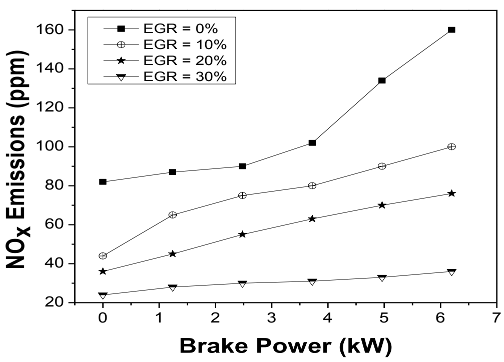

Fig. 7: NOx Emission (ppm) v/s brake power

IV. CONCLUSIONS

From the experimental analysis it can be concluded that EGR addition to the inlet air substantially reduce the NOx emission from petrol engine. In spark ignition engines, substantial reductions in NO concentration are achieved with 10-30% EGR. However, EGR also reduces the combustion rate, which made stable combustion more difficult to achieve. At constant burn duration and brake mean effective pressure, the brake specific fuel consumption decreases with increasing EGR.

REFERENCES

[1]. Choongsik Bae and Junemo Koo, *Exhaust Gas Recirculation in a Spark-Ignition LPG Engine*, the Third Asia-Pacific Conference on Combustion, Seoul, Korea, June 24-27, 2001

[2]. B. Sahoo, N. Sahoo and U.K. Saha, *Effect of engine parameters and type of gaseous fuel on the performance of dual fuel gas engines-A critical review*, Renewable and Sustainable Energy Reviews, vol. 13, no. 9, pp. 1151-1184, 2009.

[3]. Zheng, M., Reader, G.T. and Hawley, J.G., *Diesel engine exhaust gas recirculation – a review on advanced and novel concepts*, Energy Conversion Management, vol. 45, pp. 883-900, 2004.

[4]. Abd-Alla, G.H., *Using exhaust gas recirculation in internal combustion engines: a review*, Energy Conversion Management, 43, pp 1027-1042. 2002,

[5]. D. Agarwal, S. Sinha, A. K. Agarwal, *Experimental investigation of control of NOx emissions in biodiesel – fueled compression ignition engine*, Renewable Energy, vol. 31, pp. 2356-2369. 2006.

[6]. C.Sayin, M.Hosoz, M.Hosoz, M.Canakci, and I. Kilicaslan. *Energy and exergy analysis of a gasoline engine*, International Journal of Energy Research, vol.31, pp. 259-273 DOI: 10.1002/er.1246. 2007.

[7]. Sato, Y., Noda, A., Sakamoto T., *Combustion NOx Emission Characteristics in a DI Methanol Engine Using Supercharging with EGR*, SAE Paper 971647. 1997,

[8]. Sousa, M. T., *Controle da Formação de NOx por Meio da Recirculação dos Gases de Escapamento nos Motores do Ciclo Otto*.Dissertação de Mestradoem Engenharia Mecânica – Universidade de Brasília. 2000,

[9]. Han, S., and Cheng, W.K., 1998, *Design and Demonstration of a Spark-Ignition Engine Operating in a Stratified-EGR Mode*, SAE paper 980122.

[10]. Kohketsu, S., Mori, K., Sakai, K., Hakozaki, T., *EGR Technologies for a Turbocharged and Intercooled Heavy-Duty DieselEngine*, SAE Paper 970340. 1997.

[11]. Ladommatos N, Abdelhalim SM, Zhao H, Hu Z. *The effects of carbon dioxide in exhaust gas recirculation on diesel engine emission*.212, 1998.

[12]. A.Abu-Jrai, A. Tsolakis, A.Megaritis. *The influence of H2 and CO on diesel engine combustion characteristic, exhaust gas emissions, and after treatment selective catalytic NOx reduction*. International Journal of Hydrogen Energy. vol. 32: pp. 3565-3571. 2007.

[13]. V. Pradeep, R. P. Sharma, *Use of HOT EGR for NOx control in a compression ignition engine fuelled with bio diesel from Jatropha oil*, Renewable Energy, vol. 32, pp. 1136-1154, 2007.