



EFFECT OF EXHAUST GAS RECIRCULATION ON SI ENGINE PERFORMANCE AND EMISSIONS

Osama Ghazal

Department of Mechanical Engineering, Applied Science Private University, Amman, Jordan

E-Mail: o_ghazal@asu.edu.jo

ABSTRACT

One of the main challenges for the engine manufacturers is to reduce engine emissions to match Euro IV and Euro V standards. Many techniques have been adopted to improve the combustion process and reduce emissions. In this study, the effect of Exhaust Gas Recirculation (EGR) on performance and emissions of 4-cylinders Gasoline engine was investigated. A model was built using GT-Power professional software. The model was equipped with catalytic converter and EGR controller. The EGR were varied from 0.2 to 0.05 fractions. The engine speed was 4000 rpm and kept constant for all simulation runs. The engine torque, power, efficiency, fuel consumption, and emissions were calculated and discussed. The results showed that, the decrease of EGR ratio increase engine torque, power, and brake efficiency; while decrease fuel consumption. Moreover, the increase of EGR ratio resulting in decreased NO and HC and increased CO emissions.

Keywords: engine simulation, EGR, efficiency, emissions.

INTRODUCTION

The control of combustion process inside the IC engine was added various limitations, which should be considered by automobiles manufacturers. The reduction of engine emissions becomes a major constrain for IC engines imposed by the governments. Many solutions have been proposed by the researchers in the last decades. The low temperature combustion, the dual fuel engine, the water injection, and the EGR technique are some of the proposed solutions to reduce engine emissions and improve performance. Several researcher have investigated the effect of EGR on IC gasoline engine [1-6]. The researcher reported decreased in NO_x emissions with EGR system, due to reduction of oxygen amount introduced to the cylinder and in cylinder temperature. In addition, the EGR technique reduce the engine knock tendency due to the in cylinder mixture cooling. The effect of EGR on ignition delay of gasoline engine was studied by Cai *et al.* [7]. Sasaki *et al.* [8] concluded that, when EGR used in appropriate amount for gasoline engine, the fuel consumption and HC emission improved. Das *et al.* investigated the effect of EGR on NO_x reduction for H₂/gasoline engine [9]. The effect of EGR on the performance and emissions of diesel engine has been investigated by many researchers [10-15].

In this study, the effect of EGR on the performance and emissions of gasoline engine has been performed theoretically. A 4-cylinders gasoline engine with catalytic converter and EGR controller systems was built and investigated using GT-Power code. The gasoline has been injected to the engine port to create homogeneous air/fuel mixture which undergoes a compression process inside the cylinder. The EGR percentage was varied from (5%-20%). The engine speed along with the other engine operating parameters were kept constant for all engine runs. The final conclusions about the effect of adding EGR to gasoline fuel were fully discussed.

Simulation model

A four cylinder with catalytic converter and EGR system for gasoline engine has been built and simulated using professional code GT-power. The EGR percentage varied from (5-20%). The gasoline was injected to the intake port. Gasoline mixes with air and creates homogeneous charge. The physical and chemical properties of gasoline fuel are included in the software during the simulation. The engine speed was 4000 rpm and kept constant for all the runs. The tests were conducted taking into account the system behavior from intake valve closure (IVC) to exhaust valve opening (EVO). The in-cylinder pressure and temperature, heat release rate, CO, NO_x, and un-burnt hydrocarbon have calculated for different EGR percentages. Moreover, the engine power, thermal efficiency, and combustion efficiency were also estimated. The engine specifications are presented in Table-1. The simulation initial conditions are illustrated in Table-2 and were kept constant during all tests.

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**Table-1.** Engine geometry.

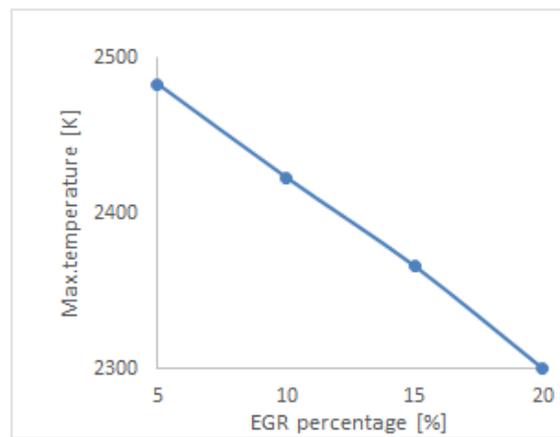
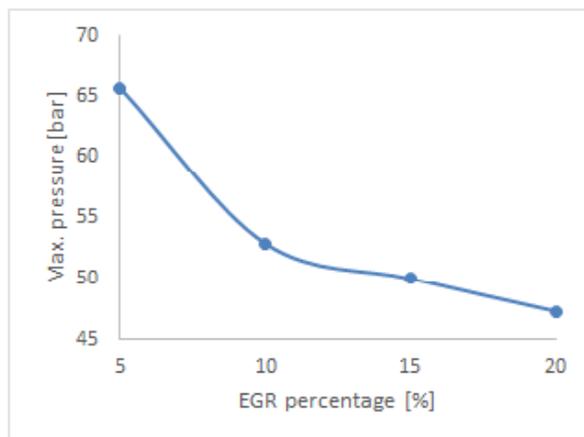
Bore	82 mm
Stroke	83 mm
Connecting rod length	165 mm
Compression ratio	9.5
Max. intake valve lift	9.5 mm
Max. exhaust valve lift	9.5 mm
IVO angle	331 CA
IVC	-127 CA
EVO	131 CA
EVC	384 CA

Table-2. Initial conditions.

Initial pressure	1 [bar]
Initial temperature	298 [K]
Speed	4000 [rpm]
Head temperature	575 [K]
Piston temperature	575 [K]
Cylinder temperature	400 [K]

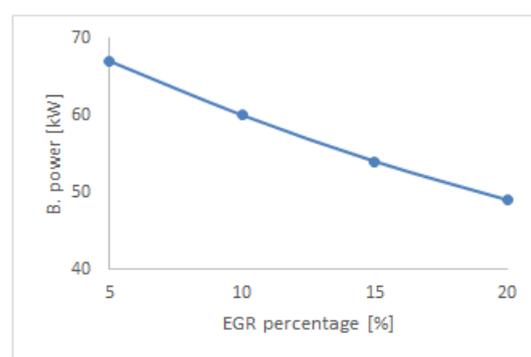
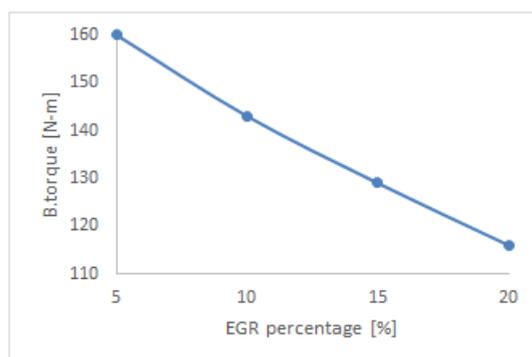
RESULTS AND DISCUSSIONS

The effect of EGR percentage on in cylinder maximum pressure and temperature is presented in Figure-1. As shown, the pressure and temperature decreased as the EGR percentages decreased. This is due to cooling effect of EGR introduced to the cylinder. Figure-2 presents the effect of EGR on engine torque and power. As seen, the increased of EGR percentage resulting in decreased engine brake power and torque.

**Figure-1.** The effect of EGR percentage on engine pressure and temperature.

The effect of EGR on engine efficiency is presented in Figure-3. The increased of EGR amount resulting in decreased the engine brake thermal efficiency and increased specific fuel consumption. The EGR addition to gasoline fuel has positive effect on engine

emissions. As shown in Figure-4, the increase of EGR percentage leads to reduction of overall engine emissions. The NO, HC and CO emissions decreased as the EGR percentage increased.

**Figure-2.** The effect of EGR percentage on engine torque and power.

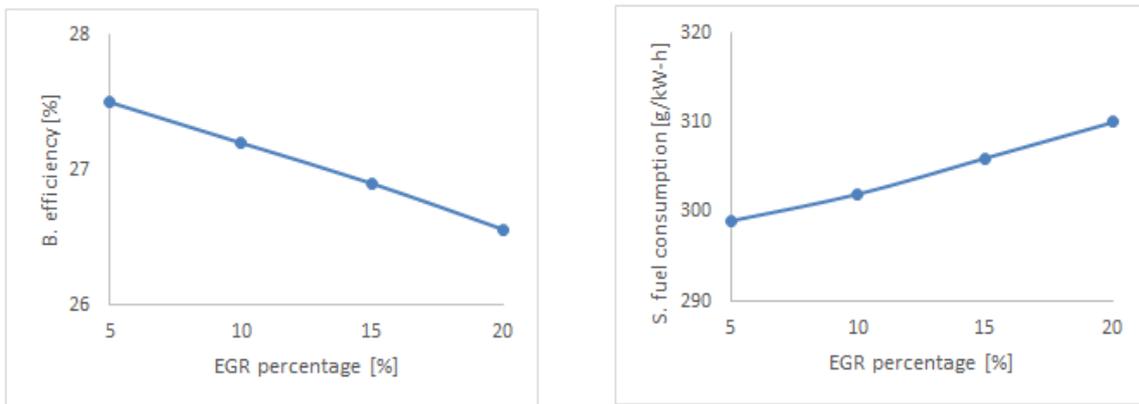


Figure-3. The effect of EGR percentage on engine efficiency.

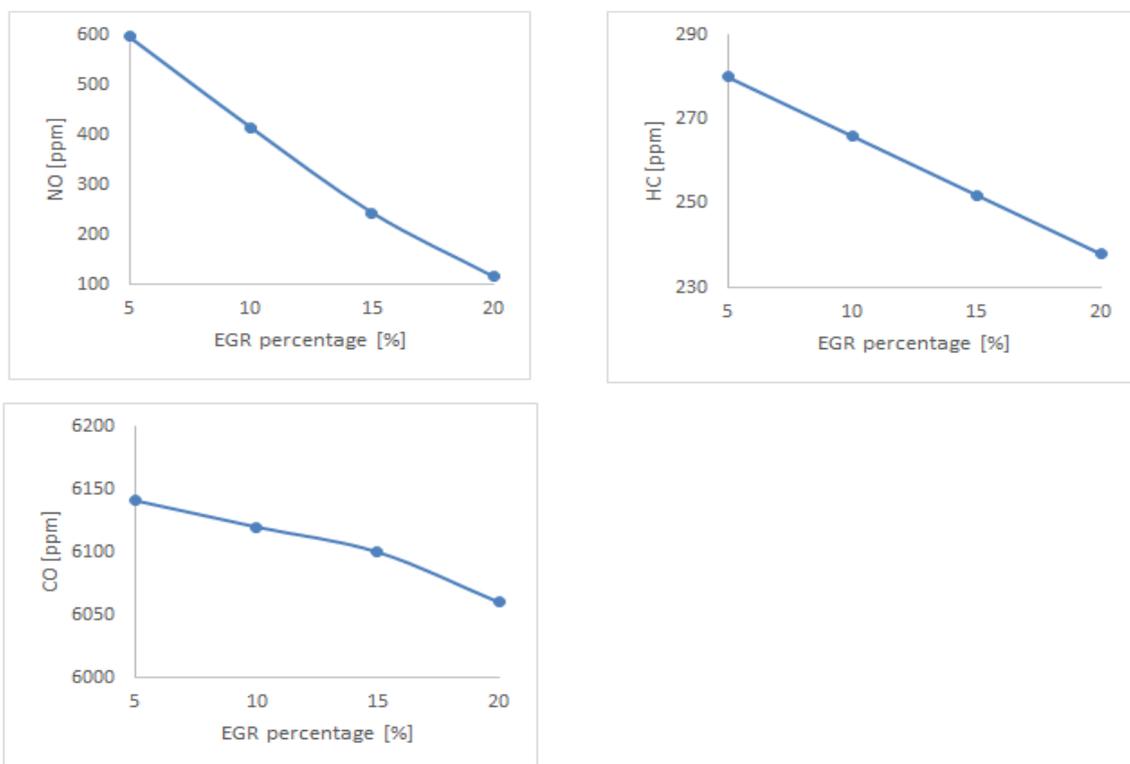


Figure-4. The effect of EGR percentage on engine emissions.

CONCLUSIONS

In this study, the effect of EGR addition to gasoline fuel was investigated. The results showed that, the increased of EGR ratio resulting in decreased the engine efficiency and emissions; while increased engine specific fuel consumption.

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