A Numerical Investigation about the EGR Effect under the condition of Intake-Boost Pressure on HCCI Autoignition

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Abstract : This study investigates the EGR effect under the condition of intake boost pressure on homogeneous charge compression ignition (HCCI) combustion engine using numerical methods. The calculations were carried out using a single-zone model included in CHEMIKN-PRO. The detailed chemical-kinetic mechanisms and thermodynamic parameters for n-heptane and iso-octane from Lawrence Livermore National Laboratory (LLNL) were used for this study. Because changes in combustion phasing can significantly affect thermal efficiency, CA50 was maintained at 365oCA (5 ^{O}CA aTDC). The results show that the EGR increase, the heat release was reduced. So the maximum pressure rise rate and IMEP were reduced. The EGR addition under the condition of intake boost pressure was maintain the IMEP higher than only add EGR.

Key words : HCCI(Homogeneous Charge Compression Ignition), EGR(Exhaust Gas Recirculation), CA50(Crank Angle of 50% burn point, IMEP(Indicated Mean Effective Pressure), LTHR(Low Temperature Heat Release), HTHR(High Temperature Heat Release), PRR(Pressure Rise Rate), HRR(Heat Release Rate)

1. INTRODUCTION

The homogeneous charge compression ignition (HCCI) combustion process offers good fuel economy and very low nitrogen-oxide (NOx) and Particular emissions. Therefore, HCCI combustion consider one option for improving the effifiency of the spark-ignited gasoline engine, and also to reduce NOx aftertreatment requirement for diesel eingines. However, several technical difficulties need to be overcome before HCCI can be broadly applied in commercial engines. For example, controlling the combustion phasing and increasing the power output while maintaining acceptable pressure rise rate (PRR) are two important research areas. [1] Several method to increase the load range is to increase the intake boost pressure and EGR. One way to increase the load range is use EGR. The use of EGR reduces the oxygen concentration so that combustion duration was extended and heat release rate (HRR) was slow down. As a results, EGR addition lead to reducing PRR. However power output is decrease. [2] Other way to increase the load range is to increase the intake boost pressure. But the increase pressure enhances the autoignition reactivity of the fuel. Since overly advanced combustion phasing can substantially increase the PRR and lead to engine knock. [3] The main objective of this study is to numerical investigates about the EGR Effect under the condition of intake-boost pressure on HCCI autoignition.

2. NUMERICAL MODELING METHODS

The Numerical investigations have been conducted using single-zone model included in CHEMKIN-PRO. Heat-transfer and blow-by effects were not considered. The compressed and expanded were modeled using the standard slider-crank relationship. [4] This study has used the detailed chemical-kinetic mechanism and thermodynamic

Table. 1: Fuel Properties

Fuel	iso-octane	PRF50	n-heptane
iso-octane % vol	100	50	0
n-heptane % vol	0	50	100
RON	100	50	0
C-atoms	8	7.47	7
H-atoms	18	16.94	106
Molecular weight	114.23	106.797	100.205

Table. 2: Engine Specification

Displacement (cc)	**981**
Stroke (mm)	**120**
Bore (mm)	**102**
Connecting Rod (mm)	**192**
Compression Ratio (-)	**14:1**
IVC (°CA aTDC)	**202**
EVC (°CA aTDC)	**482**

parameters for n-heptane (species : 654, reaction : 2827) [5] and iso-octane (species : 874, reaction : 3796) [6] from Lawrence Livermore National Laboratory (LLNL).Table 1. shows the fuel properties. Calculation was carried out between intake valve close (IVC) of -158oCA to exhaust valve close (EVC) of 122 ^{O}CA. Engine specifications are listed in Table 2. After a complete combustion of fuel, complete stoichiometric products (CSP) was generated such as CO_2, H_2O, N_2 and Ar. So EGR properties were composed of CO_2, H_2O, N_2 and Ar. EGR ratio (r) is defined as shown in Eq. (1). The amount of fuel significantly influences on a power output and efficiency. To exclude this affect, the amount of fuel was kept constant regardless of increases EGR. The equivalence ratio (Ø) increases gradually with amount of EGR increase. Because the amount of fuel was kept constant, however the amount of air decreases.

$$r = \frac{n_{EGR}}{n_{EGR} + n_{air}} \quad (1)$$

n_{EGR} : Mole fraction of EGR of in-cylinder charge

$n_{EGR} + n_{air} = Mole\ fraction\ of\ sum\ of\ EGR\ and\ air$

3. RESULTS

Figure 1 showed the contribution matrix about n-heptane. EGR addition affected the HTHR, HTHR was weaker and short due to low oxygen mole concentration and high Cv.

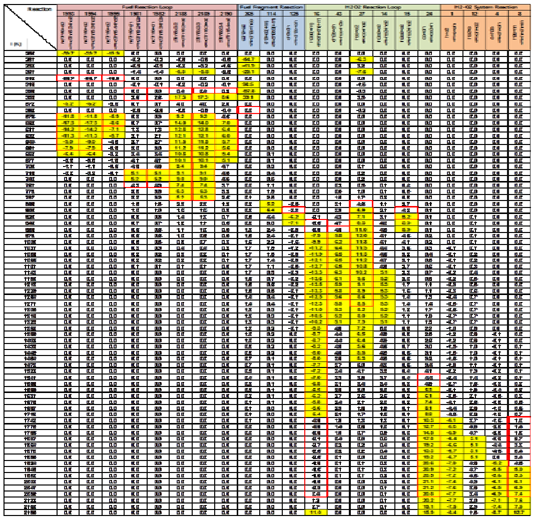

Figure 1. Comparison of contribution matrix between yellow part (r=0/P_0=1bar/T_0=290.3K) and red part (r=0.5/P_0=1bar/T_0=311.9K) for n-heptane.

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