스파크 점화기관의 공회전 시 싸이클 변동에 영향을 주는 인자 고찰

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Study on Factors Influencing Cyclic Variations at Idle in Spark Ignition Engine

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ABSTRACT

To analyse the cyclic variations in a test engine, the burn parameters are determined on a cycle-to-cycle basis through the analysis of the engine pressure data. Combustion analysis based on cylinder-pressure provides a mechanism through which a combustion researcher can understand the combustion process. The objective of this paper is to identify the most significant sources of cycle-to-cycle combustion variability in a spark ignition engine at idle. The burn rate analysis program was used and the burn parameters were used to determine the variations in the input parameter. In this study, the author investigated the relationship of indicated mean effective pressure, coefficient of variation of indicated mean effective pressure and burn angles, and lowest normalized value in a spark ignition engine for the cyclic variations.

Keywords: Spark Ignition Engine(스파크 점화기관), Idle(아이들), COV of IMEP(압력변동계수), LNV(최저 표준값)

1. Introduction

Many researchers have dedicated to extend the limit of lean burn operation in order to improve fuel efficiency, as well as reducing exhaust gas emission from the spark ignition engine.The lean limit is imposed by increased cyclic variation of the combustion intensity which reduces the drive ability and the effect is usually quantified through the coefficient of variation of the indicated mean effective pressure. Although the causes of cyclic variations are able to be identified, there have been difficulties in analysing quantitative contribution phenomena. Detailed investigation on this problem by experiment is very difficult because of the controlling and measuring the changes of these factors.

Cyclic variations in the growth rate and location of the flame kernel at very early times were found to be the major cause of cycle-to-cycle pressure variations in spark ignition engines. They concluded that the most important parameters controlling the initial flame growth were the laminar flame speed at the spark plug and the size of the first eddy burnt.

Recently, Hoard and Rehagen proposed one other means of characterizing cycle-to-cycle variations, the lowest normalized value(LNV) . The purpose of this parameter is to assess the misfire tendency of an engine; test has shown that LNV correlates well with driver's subjective rating of engine smoothness.

In this study, the author investigated the relationship of indicated mean effective pressure, coefficient of variation of indicated mean effective pressure, burn angles, and lowest normalized value in a spark ignition engine for the cyclic variations in a spark ignition engine.

2. Experimental setup and procedure

The test engine had a pentroof head with a centrally- located spark plug and was modified to operate on a single cylinder to avoid multiple cylinder interactions. The engine was coupled to a dynamometer, which might be used to turn the engine while motoring or absorb when the engine was firing. The dynamometer was used to keep the engine at a constant speed of 800 RPM for all experiments. And fuel is injected and a spark is supplied to only one cylinder, and the intake and exhaust runners of the firing cylinder are isolated.

Cylinder pressure was recorded with a Kistler 6051B piezoelectric pressure transducer. The transducer was connected to a Kistler model 5004 dual mode charge amplifier. The voltage output of the amplifier was sampled by a PC-based digital data acquisition system using a Data Translation A/D converter DT2828. Pressure data were taken at a 1°interval using the pulse from a 360 pulse/revolution optical shaft encoder as an external trigger. The shaft encoder also provided a reference pulse at the bottom center.

For all experiments, the air/fuel ratio was monitored with a Horiba AFR Analyzer (Mexa-110λ) oxygen sensor. The inlet manifold pressure was adjusted to give an average gross IMEP of 1.55bar, which is a value typical of an idle condition.

3. Results and discussion

The only occurrence of misfire was in the 35° BTDC advanced case; there were partial burns in the 35°case as is shown in Fig.1. The misfired cycles and partial burns were eliminated for calculation of average. From Fig.5, MBT would appear to be at 35°BTDC or earlier; however, the presence of misfire prevents this spark timing from being practical. This is a common problem at low load: the low in-cylinder temperature hinder ignition. Since in-cylinder pressure, and therefore temperature, is lower for more advanced timing, the occurrence of misfire increases as spark is advanced. This figure shows that IMEP is quite.

sensitive to change of phase at idle timing, whereas close to MBT the curve becomes flat. Thus, relative changes in combustion phase have a larger influence on IMEP at idle because of this high sensitivity.

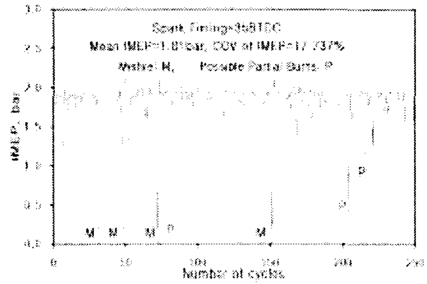

Fig.1 Indicated Mean Effective Pressure vs. number of cycles

Figure 2 show the number of cycles on the IMEP at idle. Here the relative air fuel ratio is 1.05 and spark timing is 15°BTDC. These figure show that the case of relative air fuel ratio 0.90 has better idle stability than relative air fuel ratio 1.05.

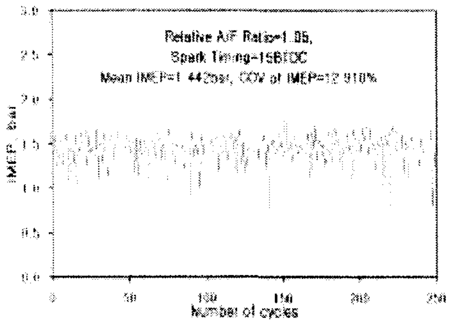

Fig.2 Indicated Mean Effective Pressure vs. number of cycles

Figure 3 shows the influence of spark timing and relative air/fuel ratio on the mean value of IMEP at idle. The plot is quite linear for the range about 1.05, indicating that this operating condition is suitable for the fuel perturbation experiment.

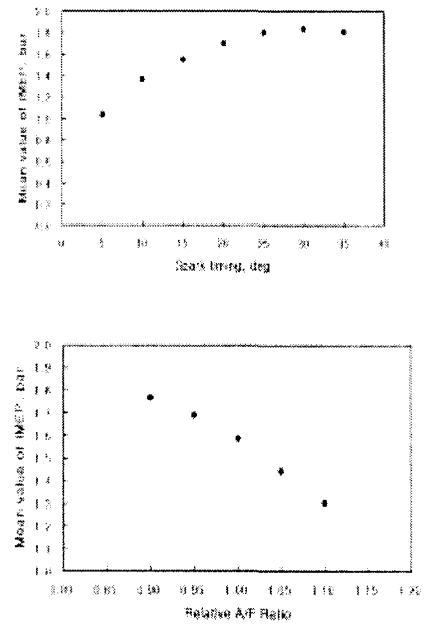

Fig.3 Influence of spark timing and relative air/fuel ratio on the mean value of IMEP at idle

Figure 4 shows the influence of spark timing on the COV of IMEP. It is the standard deviation in IMEP divided by the mean IMEP. As the spark is advanced, the COV goes down because relative changes in combustion phase have a smaller effect on the IMEP, as the spark timing indicated.

Figure 5 shows the influence relative air/fuel ratio on the COVimep. One important measure of cyclic variability, derived from pressure data, is the coefficient of variation in IMEP.

Heywood suggest that the vehicle drive ability problems usually result when COV of IMEP exceeds about 10%. However, for two most advanced cases, the COV of IMEP begins to increase again, probably because the lower temperature at the time of spark is adversely affecting the ignition. Note that the COV of IMEP at the idle spark timing is slightly under 10%, which is typically considered the limiting point above which combustion variability is unacceptably high.

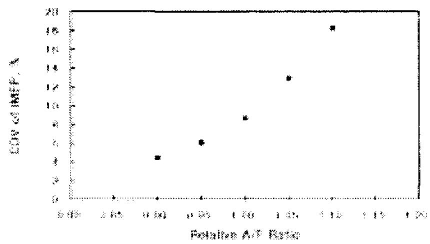

Fig.4 COV of IMEP vs. spark timing

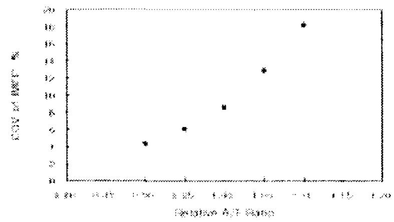

Fig.5 COV of IMEP vs. relative air/fuel ratio

Figure 6 shows the lowest normalized value

(LNV) for the spark timing and the relative air/fuel ratio. As the figure shows, the experimental engine only matches that criterion at the 25° BTDC spark timing. Extensive empirical experience with combustion parameters and vehicle development has confirmed the results of the earlier experiment.

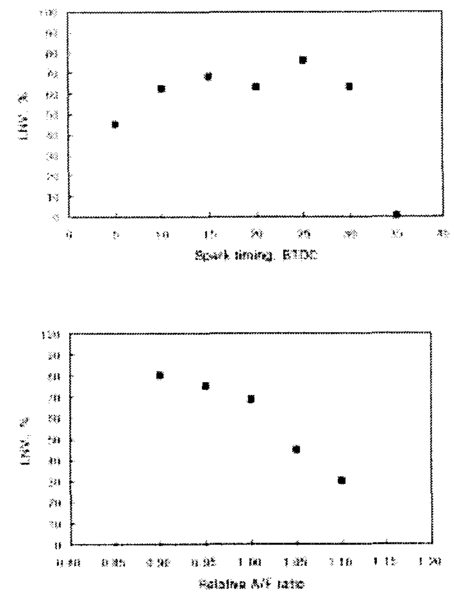

Fig.6 Lowest Normalized Value vs. spark timing and relative air/fuel ratio

Figure 7 shows the COV of burn angle as a function of relative air/fuel ratio with 0-2%, 0-10%, 0-50%, 0-90%, and 10-90% burn angles. The COV of burn angle shows minimum value at the relative air/fuel ratio 0.90 that minimum COV of IMEP appears, and the COV of burn angle increases according as relative air/fuel ratio is increased.

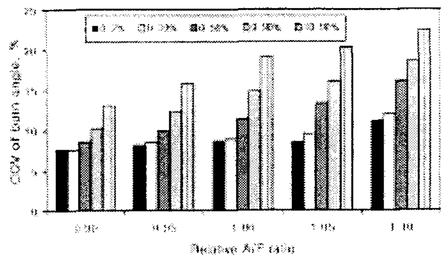

Fig.7 COV of burn angle vs. relative air/fuel ratio

4. Conclusions

The results obtained are as follows.

(1) As the spark timing is advanced, the COV of IMEP goes down because relative changes in combustion phasing have a smaller effect on the IMEP. However, for the most advanced case at the spark timing 35°BTDC, the COV of IMEP begins to increase again.

(2) Experimental and empirical data suggest that COV of IMEP and burn angles and LNV levels for acceptable idle quality are fairly similar for a wide range of test engine. The COV of burn angle shows minimum value at the spark timing 5°BTDC that maximum COV of IME appears, and the COV of burn angle increases according as spark timing is advanced.

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