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Analysis of Factors Causing Combustion Pressure Vibration in Gasoline Engines

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Vibration and noise in automobiles are important factors in automobile development from the viewpoints of cabin quietness and environmental friendliness, and there is a need to improve the prediction accuracy of vibration and noise for more efficient development. Among these, the vibration generated by the engine is one of the sources of vibration due to changes in the cylinder pressure caused by combustion, requiring accurate prediction of the cylinder pressure. However, even with sufficient prediction accuracy in the time domain, there is a problem of insufficient prediction accuracy in the frequency domain, which is critical for vibration. In order to reduce vibration and noise and improve the accuracy of model predictions, it is necessary to clarify the factors that cause vibration in each frequency band in the cylinder pressure. In this study, we focus on the vibration component in the frequency band of 1 to 2 kHz and the heat release rate from the combustion point of view. Using tests on actual production engines and simulations, we investigated the factors that affect the vibration components in the frequency band in the cylinder pressure waveform. In addition, we attempted to elucidate the factors that cause these factors by using an engine with in-cylinder visualization. Here, we discuss the first half of this section.

First, we used cycle simulation to focus on the heat release rate pattern, particularly with regard to factors that affect the frequency domain. The results of the study showed that the prediction accuracy of the rising edge of heat release is important. We then investigated this influence in our experiments. The maximum value of the slope of the heat release rate (dROHR/dθmax), the maximum value of the rate of change of the heat release rate (d^2ROHR/dθ^2max), and the vibration intensity of 1 to 2 kHz in the experiment were confirmed as parameters to organize the rise of heat release, and a correlation was confirmed. The same correlation was also observed when the maximum value of the rate of pressure increase (dP/dθmax) was sorted out as shown in Figure 1, suggesting that the rise in heat release affects the rate of pressure increase in the cylinder, which in turn affects the frequency range. The results of each cycle and the ensemble average show a divergence in the vibration intensity, and it can be confirmed that the divergence is larger for the delayed conditions. In the condition of ignition timing 13deg.BTDC (Figure 2), it can be confirmed that the heat release rate itself has an oscillatory component, with two maxima. It is thought that an increase in the heat release rate for some reason causes the heat release rate to include an oscillatory component, which in turn causes the cylinder pressure to include an oscillatory component, thereby increasing the intensity of the oscillation. It was found that the heat release rate using ensemble averaging does not correspond to actual vibration in terms of vibration, and that a combustion model including cycle fluctuation elements is required for noise and vibration prediction.

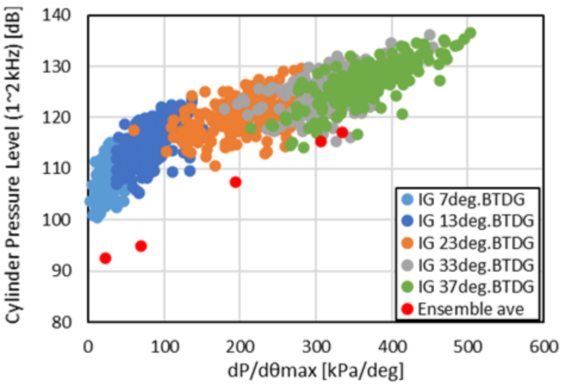

Fig1 Relationship between dP/dθmax and vibration

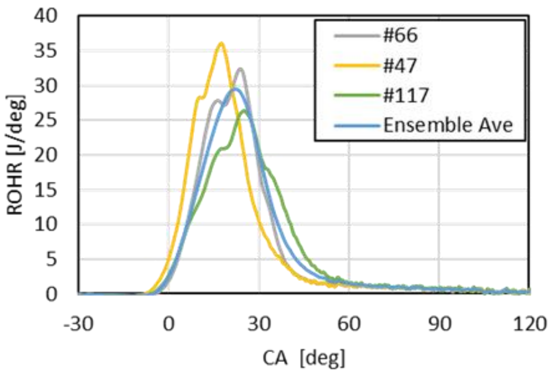

Fig2 Ensemble average and each cycle Rate of heat release