Combustion Parameter Estimation for ICE from Surface Vibration using Frequency Spectrum Analysis

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ABSTRACT: Surface vibration of internal combustion engine containing abundant combustion information could be analyzed using different signal processing methods, in which frequency-domain analysis is one of the common methods. In order to eliminate influence of adjacent excitation and enhance frequency resolution, S-Transform method was used to obtain frequency information of combustion pressure and surface vibration signal measured from a single-cylinder and 12-cylinder diesel engine. Based on the results of the single-cylinder diesel engine, the relationship between frequency information of vibration acceleration and characteristics parameters of combustion like peak combustion pressure and peak pressure rise rate was analyzed. It could be concluded that there existed a good linear relationship between the summation of frequency amplitude in the selected frequency range and the characteristics parameters under the same engine speed working condition. Frequency-domain analysis conducted with the 12-cylinder engine showed that characteristics parameters of combustion could be estimated from the summation of frequency amplitude when engine worked for power generation application, which was maintained the same engine speed normally.

Keywords: high power engine; combustion analysis; vibration acceleration signal; frequency spectrum analysis; time-frequency analysis

Abbreviations: ICE, internal combustion engine; SI, spark ignition; EMD, Empirical Mode Decomposition; IMF, intrinsic mode function; PIR , pressure rise rate; MSC, Morlet Scalogram; FFT, Fast Fourier Transform; GDI, gasoline Direct Injection; $T_{tq,}$ Torque; n, speed; θ, fuel injection advance angle; CA: crank angle; $C_{xy}(f)$, coherence coefficient; BTDC, before top dead center; θ_{ig}, start of combustion; TDC, Top dead center; ATDC,