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Engine Noise Contribution Analysis by Operational TPA for Improvement Examination

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In the development of diesel engines, economic efficiency and durability reliability are pursued, including compliance with regulations such as noise and exhaust gas. Major specifications of the engine are decided at the planning stage, and then if a problem occurs in a series of engine development flows, multiply-stacked reconsideration is occurred. In order to reduce the number of test man-hours required for engine development while maintaining the accuracy of the analysis, and to enable the study of improvement guidelines through detailed separation of mechanical noise, we applied the Operational Transfer Path Analysis(OTPA), a contribution analysis method using operational data, to a diesel engine and analyzed the noise contribution of the engine's main noise sources.

As shown in Fig. 1, diesel engine noise is generated as a result of vibrations generated by a number of noise sources propagating through the engine block and radiated from the engine surface. For the analysis of the mechanical noise contribution of the diesel engine, the in-cylinder pressure, the vibration at each point of the engine, and the microphone sound pressure around the engine were measured simultaneously. In addition, OTPA was applied to the in-cylinder pressure and bearing vibration to separate the bearing vibration into combustion and mechanical components. The OTPA contribution separation was then performed to obtain detailed contribution analysis results for combustion and mechanical noise.

Figure 2 shows the results of OTPA contribution analysis, showing that combustion noise (cylinder pressure and bearing vibration) accounted for 54%, and mechanical noise (bearing vibration and gear shafts vibration) accounted for 46%. These results are comparable to the contribution of the conventional method, which separates combustion noise from mechanical noise. The verification by changing the weight of moving parts and taking countermeasures against gear rattles showed the high accuracy of the contribution analysis results and the effectiveness of this method for noise reduction.

OTPA was applied to a high-efficiency diesel engine for a commercial vehicle, and it was shown that the noise contribution of the main noise source can be analyzed by identifying the transmission coefficient and recomposing the engine noise using the vibration near the main noise source and the in-cylinder pressure as reference signals. The novelty of this paper is that the crank bearing vibration was separated into a mechanical component mainly caused by crank impact and a combustion component caused by cylinder pressure, and then an operational TPA was applied to separate the mechanical noise in detail, enabling the consideration of improvement guidelines. As a result, it is clear that the mechanical component of crank bearing vibration and the noise contribution of gear shaft vibration are significant in the mechanical noise of the diesel engine to which the operational TPA is applied in this paper. The validation results show the validity of the noise contribution ratio and the effectiveness of the improvement guideline study using this method.

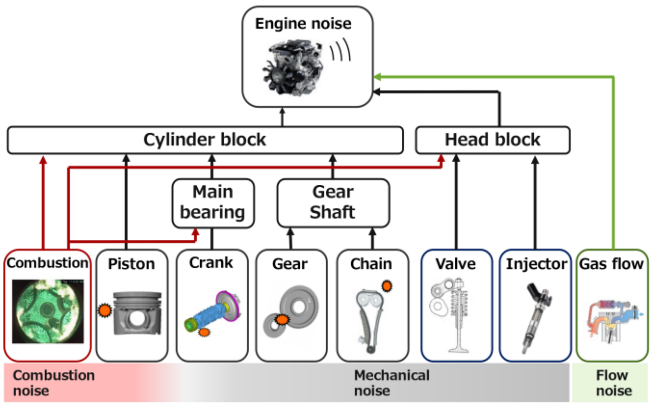

Fig. 1 Major engine noise sources and transmission routes

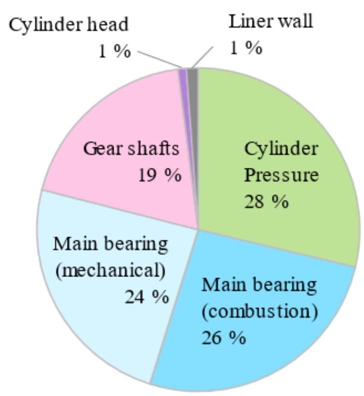

Fig.2 Engine noise power contribution of OTPA result with divided main bearing vibration