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Analysis of Stick-slip Phenomenon during Brake Creep Groan Using AE Technique

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Creep groan is a phenomenon that stick-slip occurs at a friction interface and vibration sound of 10-300Hz is generated when a brake is released while a vehicle is stopped. Improving this phenomenon is an important issue for the quietness and comfort of automobiles. Numerous studies have been conducted on the mechanism of creep groan generation, and it has been reported that an oscillation force is stick-slip phenomenon at the friction interface. However, it was rare to directly measure the friction phenomenon during creep groan and evaluate the relationship between creep groan and vibration. On the other hand, acoustic emission (AE) is a phenomenon in which strain energy stored inside a material is released as elastic stress waves (AE waves). An AE technique can be used to elucidate the friction phenomenon. In this study, AE waves generated from the brake pads at the time when creep groan is occurring under the condition that the brake is released ~~on the slope~~ were measured and examined.

The experiments were performed using a chassis dynamometer with an environmental chamber. A small car weighing 1,440 kg and a NAO brake pad were used in this study. An AE sensor was mounted to the centre of the brake pad.

Fig.1 shows the changes in oil pressure, torque, and creep groan sound captured by an in-vehicle microphone in the creep groan reproduction experiment. An initial torque of 12~~23~~0 Nm~~, which corresponds to a slope,~~ was applied to the brakes, and the creep groan sound generated was measured. Fig.2 shows the changes in the vibration acceleration of the pads and rotor, and the AE signals. From a detailed analysis of these results, it was confirmed that brake parts are shaken every time a slip was caught as an AE signal change. And it was found that there is a good correlation between the AE signal intensity and the acceleration vibration of each brake parts. Although it was conventionally thought that the only low-frequency stick-slip was occurring, stick-slip has several frequencies, and it was clarified that the stick-slip is a combination of slip after long-period stick and short-period (about 100 Hz) stick-slip.

Next, frequency analysis of the AE signal waveforms was performed. The main frequency component was found to be from 20 to 300 kHz. Based on the results of previous studies, it is said that the frequency peaks appeared in this region relate to cracks and deformation on the sliding surfaces. During slip after long-period stick, an increase in the AE signal intensity was observed at around 200 kHz, indicating that the friction phenomenon was different from that of short-period stick-slip.

Finally, relationships between the AE signal intensity and the phenomena under the various experimental conditions were examined. The AE signal intensity tended to increase under high humidity. Also, the results of frequency analysis of the AE signal waveforms suggested that similar friction phenomenon occurred even if humidity changes. Furtheromore, it was found that the AE signal intensity tended to increase in proportion to the initial torque. When the initial torque is higher, a higher AE signal intensity is observed than when the initial torque is low, even if at the same point of torque and pressure. However, the AE signal intensity did not relate to the depressurization speed. As the depressurization speed increased, the time of long-period stick decreased and the number of short-period stick-slip increased.

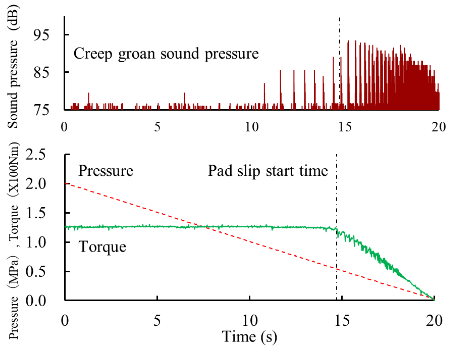

Fig.1 Changes in torque, brake pressure and creep groan noise

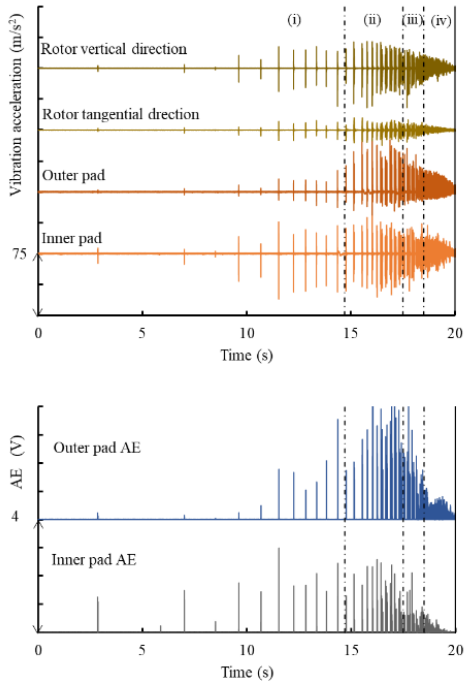

Fig.2 Changes in vibration and AE signal for each brake parts