A Method to Measure the Contact Force of Pantographs through Image Processing

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The contact force between pantograph and contact wire (hereinafter referred to as the "contact force") is used as a criteria to evaluate contact performance (in the standard IEC 60913, for example), while research and development is being conducted to diagnose overhead catenary system conditions by utilizing contact force measurements. To improve the current collecting performance and reduce the aeroacoustic noise of pantographs, smooth-shaped panheads with complicated inner structure are increasingly used for high-speed pantographs. In the conventional contact force measuring method, panheads have built-in accelerometers and other sensors. But, the installation of sensors and wiring in the smooth-shaped panhead is difficult due to the spatial limits. To eliminate these drawbacks, RTRI has developed a contact force measuring technique which can replace the whole or part of the built-in sensors with some image processing sensors.

This technique uses line sensor cameras with high-level time and spatial resolution. These are placed on the rooftop of the train near the pantograph. The system determines the contact force by evaluating the inertia force and supporting spring forces of the panhead using the image information obtained from the line sensor cameras. However, some pantographs requires built-in sensors in the panhead to measure non-linear forces such as stopper touching forces or friction forces working at the vertical guide of the panhead. These cannot be measured through image processing due to their non-linear characteristics. In that case, the new system needs far fewer built-in sensors only to measure such non-linear forces as compared with the conventional contact force measuring system.

To verify the measurement precision of the new system, RTRI performed a calibration test for a pantograph which is free from effect of non-linear forces. In this case, measurement of the contact force can be done with only three line cameras. See Fig. 1 for the configuration of the test apparatus. Figure 2 (a) shows the frequency characteristics of the contact force measurement accuracy of this technique, where the X-axis indicates frequency and the Y-axis the ratio of the measurement value to the true value. Figure 2 (b) illustrates the time history waveforms of the estimated and true values of the contact force when the panhead is subjected to 10 Hz excitation. Figures 2 (a) and 2 (b) demonstrate that the image processing technique measures the contact force between pantographs and contact wires at high precision.

This technique has been developed through a joint study with Meidensha Corporation. Meidensha has a project to supply a contact force measuring system based on this technique to Taiwan High Speed Rail.

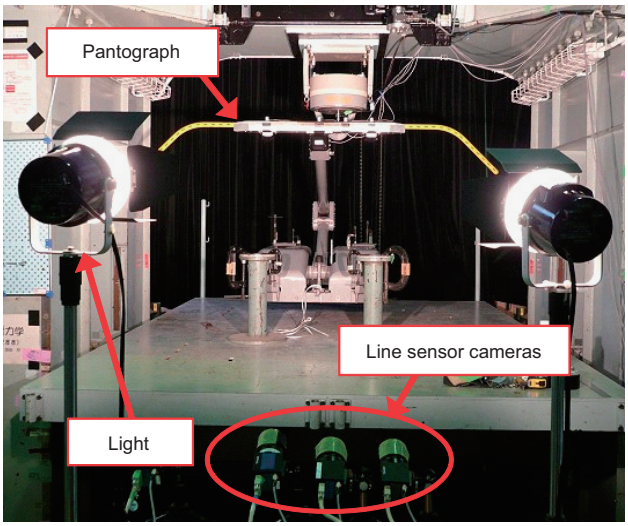

Fig. 1 Composition of the contact force measuring system using image processing

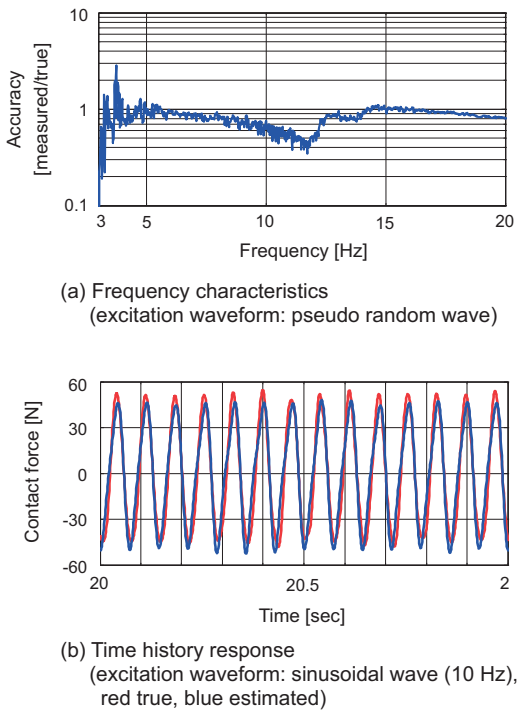

Fig. 2 Results of a excitation test