Track Inspection Technologies

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Higher speeds of revenue service trains require track inspection cars that run at the same speed. The Railway Technical Research Institute has developed a two-truck inspection technique to use the asymmetric chord offset method and is now bringing out a new track inspection device to apply the inertia measuring method as a means of high-speed inspection at comparatively low costs as outlined below.

TRACK INSPECTION CARS TO PRACTICE THE ASYMMETRIC CHORD OFFSET TECHNOLOGY

Most of the conventional track inspection cars are based on the mid-chord offset method to use three trucks, front, center, and rear, to obtain measurements simultaneously at these three points. However, the center truck cannot run at 210 km h^{-1} for structural reasons. To increase the speed of the inspection car, therefore, we removed the center truck and adopted the asymmetric chord offset method to calculate track irregularities by taking three measurements carried out with the sensors at the ends of the trucks. See Fig. 1. For each of the left and right rails, the sensors are placed at four points, or on the inner and outer sides of each truck. One of the sensors on the inner sides is installed for measurement when the car runs in one direction, and the other in the other direction. The waveforms obtained through the asymmetric chord offset method are digitally converted into those of the mid-chord offset method on the car and recorded for management and maintenance purposes. To use it as a reference line, the car body of conventional inspection cars is extremely rigid and heavy to make a constraint for high-speed operation. If a car body of the normal type is introduced, however, its deflection would be 20 times as large as that of the conventional inspection car to adversely affect measurement precision. So as to set a reference line at a place other than on the car body, we developed a reference device that emits a laser beam from the projector equipped on the end of the car, detects the displacement of the car body with a light sensor or a position sensitive device (PSD), and corrects the measurements of track irregularity. The asymmetric chord offset method cannot accommodate the large and heavy optical rail displacement sensor that monopolizes the center of the car body of conventional inspection cars, since the measuring frame is not so strong to support the sensor. We, therefore, newly developed a rail displacement sensor that has a self-contained light detector of PSD and a projector of a semiconductor laser oscillator. See Fig. 2. Although it uses the conventional principle of measurement, it is far more compact and lightweight than sensors for conventional rail displacement measurement. Based on these new technologies, regular track inspection at 275 km h^{-1} has been realized for Shinkansen in Japan.

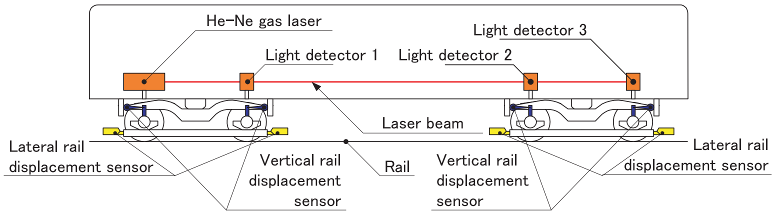

Figure 1. Composition of two-bogie asymmetrical chord offset track inspection car.

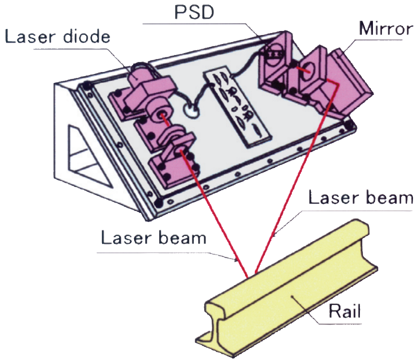

Figure 2. PSD-type lateral rail displacement sensor.

DEVELOPMENT OF NEW INERTIAL MEASUREMENT METHOD

In contrast to the aforementioned mid-chord offset and asymmetric chord offset methods for three-point measurement, the inertia method that integrates acceleration twice enables a one-point measurement of track irregularities. It may also introduce the manufacture of measuring devices at low costs. There were drawbacks in this method, however, in that waveforms were distorted due to the characteristics of electronic circuits to make measurements difficult to process. Thus, we contrived an inertial measuring method to obtain waveforms equivalent to those by the mid-chord offset method, which we call the inertial mid-chord offset measuring method. It features an on-board analog integrator that incorporates the measurement characteristics in the long waveform range of a mid-chord offset method in filter characteristics and calculations for correction with a general-purpose personal computer on the ground. We aim at a compact measuring unit that can be installed directly on a truck. Figure 3 shows an image of system composition, and Fig. 4 the construction of a prototype sensor unit. The newly developed element is the two-axle rail displacement sensor. This sensor tracks the rail with a servo-driven reflector and calculates the lateral and longitudinal rail displacements including those of large scales by the principle of triangulation. Figure 5 shows the irregularities of longitudinal level measured with the prototype device, which are similar to those available by the mid-chord offset method inspection car.

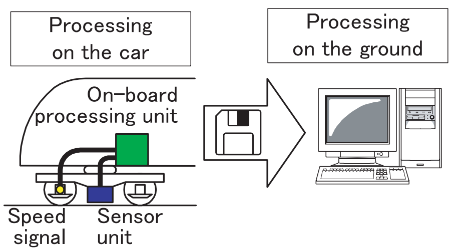

Figure 3. Composition of the inertial mid-chord offset measuring device.

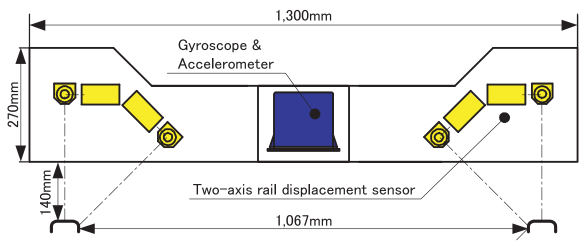

Figure 4. Composition of the sensor unit.

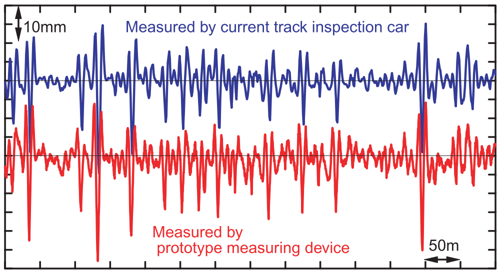

Figure 5. Results of track inspection by inertial mid-chord offset method.