Renewal of Overhead Catenary System (OCS) Inspection System, CATENARY EYE, for Hankyu Hanshin Electric System Co., Ltd.

Hidekazu Shimada

Keywords Non-contact measurement, Separation measurement, Line sensor camera, Laser range scanner, Laser Doppler system, Flat design

Abstract

Our product called "CATENARY EYE", an overhead contact wire inspection system indispensable for safe operation of electric railways, has been supplied to many railway operators. This equipment is designed based on the non-contact measuring system to which multiple cameras and our image analysis processing technology are applied.

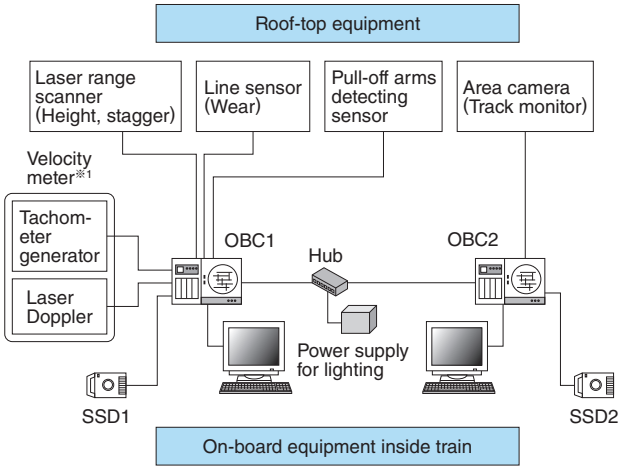
Since 2008, Hankyu Hanshin Electric System Co., Ltd. has been conducting inspection work by using our Overhead Catenary System (OCS) inspection system, CATENARY EYE. More than 10 years has passed since its delivery, and the inspection system was recently renewed due to aging equipment. During this decade, our CATENARY EYE has continually developed and improved its functions based on the experience gained from many years of track records and the demands from railway operators.

1 Preface

Hankyu Hanshin Electric System Co., Ltd. oversees the maintenance and management of railway facilities owned by railway operators, such as, Hankyu Corporation or HANSHIN ELECTRIC RAILWAY CO., LTD., etc. In 2008, our Overhead Catenary System (OCS) inspection system called "CATENARY EYE" was introduced for the maintenance and inspection of contact wires. More than ten years later since its introduction, this equipment was renewed in 2020. This paper introduces the major features of the latest CATENARY EYE system with a practical example of the inspection work by Hankyu Hanshin Electric System Co., Ltd.

2 System Configuration

Fig. 1 shows an outline diagram of the system configuration. The installed system in the train car is classified into roof-top equipment, on-board equipment inside the train, and a speed meter. Image data gathered on the roof top is recorded in the removable Solid-State Drive (SSD) and transferred to the ground system for the analysis processing.



Note: ※1. Used by changeover according to the applicable railroad vehicle.

Fig. 1 Outline Diagram of System Configuration

An outline diagram of system configuration is shown.

(1) Roof-top equipment (Fig. 2)

This equipment is installed on the roof top of a railway train car. The line sensor camera for contract wire wear measurement uses a Complementary Metal Oxide Semiconductor (CMOS) sensor and all lighting is supported by Light Emitting Diodes (LEDs). The laser range scanner is used for the

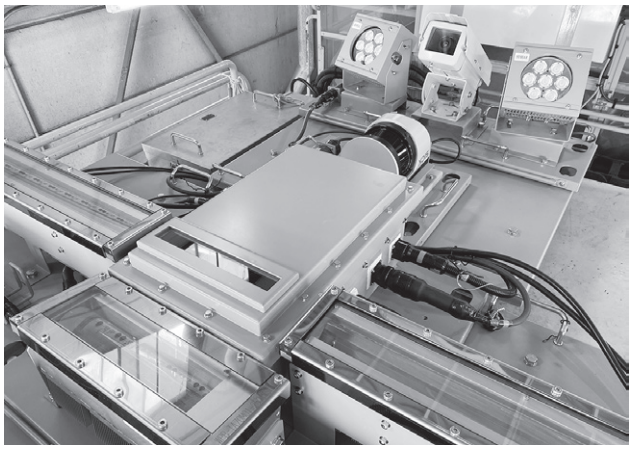


Fig. 2 Roof-Top Equipment

An overall view of the roof-top equipment mounted on the railroad vehicle roof is shown.

Fig. 3 On-Board Equipment inside Train

An overall view of the on-board equipment installed inside the railroad vehicle is shown.

measurement of contact wire height and stagger. We built this system by effectively using sensors as well as cameras.

(2) On-board equipment inside the train (Fig. 3)

This equipment is installed inside the train car. In the portable control box, an On-Board Computer (OBC) and power unit are installed. This computer is used to control the camera and record the camera images and sensor data. In addition, a retractable and foldable touch-panel type LCD monitor is mounted on top of the box.

(3) Speed meter attached to the front of the train car (Fig. 4)

A high-precision laser Doppler velocity meter is adopted.

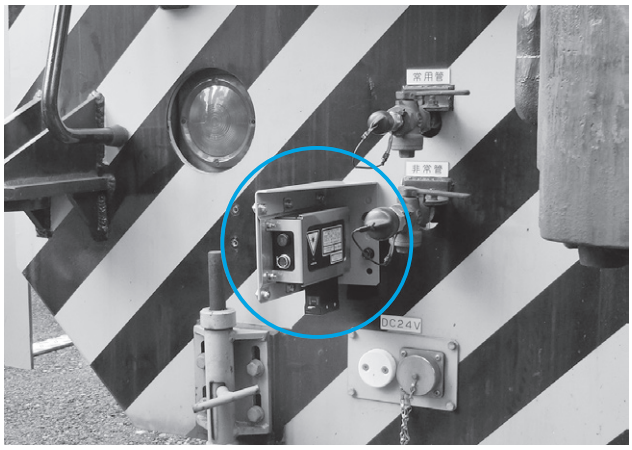


Fig. 4 Speed Meter Attached to Front of Train Car

The laser Doppler velocity meter attached to the front of the train car is shown.

3 Features of Equipment

3.1 Non-Contact Measurement System

The height and stagger of the contact wire are measured with a laser range scanner. The wear of the contact wire is measured with a line sensor camera, carried out by the non-contact system. In this manner, it can achieve a state (static measurement) in which the height and stagger are not affected by a contact force of the pantograph against the contact wire.

3.2 Added Function

A new function is added to measure a separation in vertical distance in the air section. We are currently working on the improvement of this function to increase the efficiency of measuring work that was formerly carried out manually.

3.3 Changes in Inspection Operation Method

Hankyu Hanshin Electric System Co., Ltd. oversees the contact wire measurement inspection service. It covers various lines of railway operators. Conventional equipment was regularly installed in a dedicated road-rail vehicle (running on both tracks and roads and used for railway maintenance) owned by this company. When inspecting the contact wire conditions, this vehicle moves to the other line of the railway operator for measurement.

As new equipment, a detachable system is adopted and necessary equipment only can be loaded into various train cars belonging to each railway operator. Thanks to this feature, measurements

on multiple routes can be realized by using the same system to be installed in a train car. Table 1 shows system-applied railway operator names and type of various train cars. Any of such a car is not a dedicated maintenance vehicle. In cases other than measurements, it is used either as a commercial train car or for conventional maintenance routines. Since the dedicated maintenance vehicle can be omitted, costs for both the introduction and running can be substantially reduced.

3.4 Adoption of High-Precision Velocity Meter

Information about train speed carries an important role for contact wire inspection. The running distance is computed based on train speed data gathered from the measurement starting point. As such, accuracy of the velocity meter greatly influences the identification of the measuring spot.

For this time, a high-precision laser Doppler type velocity meter has been adopted. The velocity meter measures ground speed, so it is not affected by wheel spin or wheel slippage. The accuracy is within ±0.05% (repetition accuracy).

For vehicles that are difficult to install the laser Doppler velocity meter, such as commercial train cars, we can use the input data of a conventional rate generator (tachometer) in the inspection system.

3.5 Data Transfer and Continuity of Maintenance Control Work

The measurement data acquired from the conventional system was transferred to the new system. As such, the past measurement results can be reviewed and it can be compared between new and past measuring data relating to contact wire wear, height, and stagger. As a result, we maintained the continuity of maintenance and control work.

Table 1 System-Applied Railway Operator Names and Type of Various Train Cars

Railway lines taking measurements by this equipment and the applicable type of train car are shown.

Applied line	Applied type of train car
Hankyu Corporation	Maintenance vehicle
HANSHIN ELECTRIC RAILWAY CO., LTD.	Maintenance vehicle
Nose Electric Railway Co., Ltd.	Maintenance vehicle
Kobe Electric Railway Co., Ltd.	Commercial Car
Hankai Tramway Co., Ltd.	Road-rail vehicle

3.6 Operability

The Graphical Use Interface (GUI) is improved for the inside train equipment and ground system.

Fig. 5 Display Screen of On-Board Equipment inside Train

A display screen design for on-board equipment is shown.

Table 2 Measuring Conditions

Measuring conditions for this equipment are shown.

Item	Conditions
Time zone for measurement	Nighttime
Carrier speed	45 km/h Max.

Table 3 Measurement Items and Accuracy

Measurement items possible for this equipment and accuracy are shown.

Measurement Items	Applicable sensors	Output	Static measuring accuracy/ Performance
Contact wire height	Laser range scanner	Contact wire height (mm) CH No.: 4	±10 mm Height measuring range: 1200 mm
Contact wire stagger	Laser range scanner	Contact wire stagger (mm) CH No.: 4	±10 mm Wire stagger range: ±300 mm
Contact wire wear	Line sensor camera	Remaining diameter of contact wire (mm) CH No.: 4	0.1 mm basis
Contact wire gradient	Laser range scanner	Contact wire gradient between poles (‰)	—
Positioning data	Laser Doppler velocity meter	Vehicle velocity (Running position)	Measuring accuracy: ±0.2% Min. Repetitive reproducibility: ±0.05% Min.
	Pull-off arms detecting sensor	Steady arm, pull-off arm position	—
Track monitor	Area camera	Track condition video (2.3 million pixels)	10 Hz

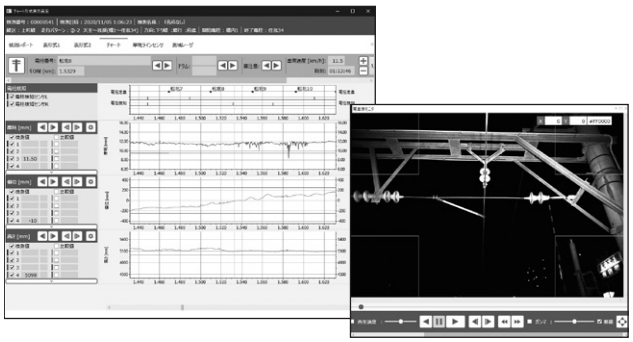


Fig. 6 Screen Display of Ground Equipment

A screen display of the ground equipment in multi-window mode is shown.

A flat design policy was adopted to improve the operability such as color scheme and effective icon arrangement. Multi-device support and multilingual support became possible. **Fig. 5** shows a display screen of on-board equipment inside the train.

4 Conditions for Application

Table 2 shows measuring conditions and **Table 3** shows measurement items and accuracy.

5 Display of Measurement Result

The result of analysis done by the ground equipment is displayed in the inspection report, table format, and chart format. Images from line sensor camera, laser range scanner, and track monitor can be displayed, interlinked with the results.

The ground equipment uses the multi-window system which allows charts and image data to be viewed at the same time. This improves the operability. **Fig. 6** shows a screen display of the ground equipment.

6 Postscript

The latest contact wire inspection system introduced in this paper was supplied to Hankyu Hanshin Electric System Co., Ltd. This equipment already finished its test run at each railway operator and is currently used for practical operation.

Lastly, we sincerely express our thanks to many related people at railway operators for your kind suggestions and cooperation. We would also like to express our gratitude to the related people at Hankyu Hanshin Electric System Co., Ltd. for your insights and kind advice since the introduction of the first inspection system.