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Thickness Measuring System for Brake Shoe of Traveling Rolling Stock*

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1 Introduction

The system introduced here is an automatic thickness measuring system for railway brake shoes, which measures the remaining thickness of the brake shoes (disc lining, brake shoe) of traveling rolling stock by means of image processing.

Inspections of the equipment and parts of railway rolling stock are performed either at set intervals decided in advance or after a certain distance of travel, and had conventionally relied on visual inspection by maintenance personnel at the site. Inspections of consumables, as represented by brake shoes, involved a heavy work load, because it was necessary to complete the inspections in a short period, considering the large number of parts to be inspected. By applying this system, the load of these jobs can be reduced substantially. This system was supplied to the Yamanote Electric Train District (located in Tokyo) of the East Japan Railway Company in 1993, and is contributing greatly to the improvement of the above-mentioned work.

In Tokyo area, there runs a railway of Yamanote Line, consisting of 29 stations on a loop line, taking about one-hour ride in one round, extending to 34.5 km (22 miles), and is, so to speak, the main artery, having the world's largest proficiency in passenger transportation, capable of carrying a maximum of over 180 thousand passengers per hour and electric trains of 205 series are afford to the line. The electric trains there total to 550 passenger cars and their maintenance work is performed solely at the Yamanote Electric Train District, which is located adjacent to Ohi Plant, in Shinagawa Ward, of the East Japan Railway Company. At Ohi plant, in which over one hundred work force of various types, such as, office workers, train drivers and technical employees are involved, daily checking and repair and maintenance works, including, the inventory control of consumables, washing of the outside and the inside of railway rolling stock, inspections of the functions of controlling devices, are performed.

2 Outline of System

The configuration of the system is shown in **Fig. 1**, and comprises an image input section, which photographs the brake shoe being measured with CCD cameras and stores the image data, and an image processing and data management section, which processes the obtained image data and measures and displays the remaining thickness. The brake shoes of trains traveling at low speed are photographed by a noncontact method, and all the processes from detection of the passage of the train to thickness measurements and output of the results are performed automatically.

3 Basic Functions of System

3.1 Image Input Section

The image input section, which comprises the CCD

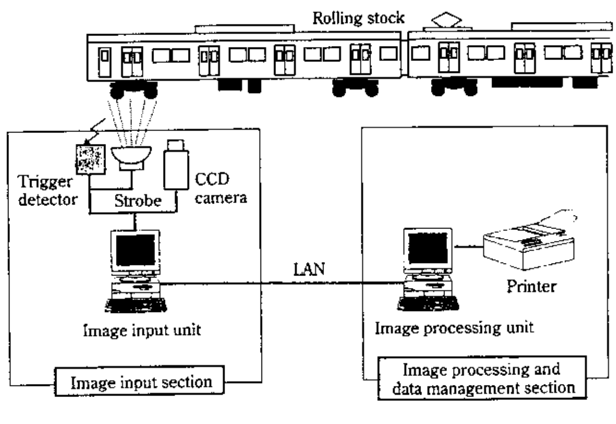

Fig. 1 Configuration of hardware

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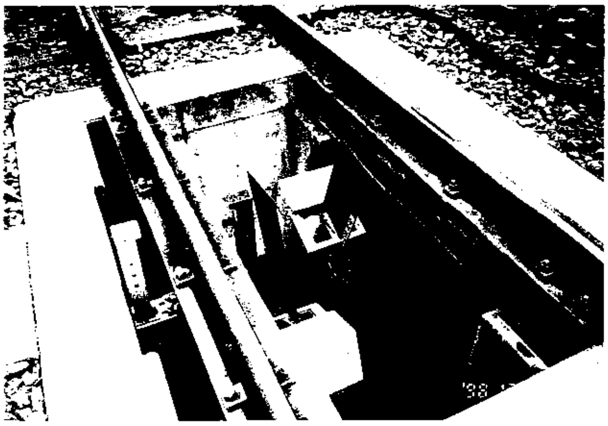

Photo 1 External view of image input equipment

Photo 2 Sample of view image processed

cameras, image input unit, and other hardware, is installed on the operating line which all trains use to enter the electirc car shed from the commercial service lines. A general view of the image input section equipment is shown in **Photo 1**.

When a train passes, the position of the wheels is detected by a trigger sensor, and at that timing, the brake shoes are photographed. Because all wheels are photographed, the right and left wheels are each photographed using a total of two cameras. A strobe is triggered each time a photograph is taken, making it possible to obtain images with uniform image quality at all times.

The photographed image data are stored in an image recording device, and are then transmitted to the image processing and data management section (normally installed in the office building), which is connected to the input section by the network (LAN) of the same segment.

3.2 Image Processing and Data Management Section

This section processes the image data which have been transmitted from the image input section. The image processing section extracts the data for the brake shoe part from the obtained image data and measures the remaining thickness of the brake shoe at all specified locations. A sample of a processed view image is shown in **Photo 2**.

Based on the results of image processing the systems judges whether the remaining thickness is within the allowable wear limits or not, and when the shoe has reached the wear limit, gives a warning by indication on the computer screen, printout, or other means. It is possible to set the position of parts which are to be measured and the wear limit values as desired. Further, by combining the wear measuring system with a car number reading device (option), it is also possible to designate the rolling stock to be measured, enabling data control by train composition, by car, and by part. In image processing, there are cases in which processing cannot be performed due to adhering trash or similar conditions. In such cases, direct confirmation is possible by displaying the screen concerned separately.

4 Features of System

The most important feature of this system is that it is possible to ensure safety in a consistent and reliable manner. In the railway industry, not only the safe and correct transportation of passengers, but also the safety of all personnel, take priority over every other consideration. In this sense, the application of this system to transportation work is of great significance from the following viewpoint.

4.1 Improvement of Working Environment —Securing the Safety of Personnel

When brake shoes are inspected visually, it is necessary for the maintenance personnel to crawl under the bogies. Safety can be ensured by freeing personnel from work in such dangerous place.

4.2 Improvement of Measurement Accuracy

In inspections which depend on the conventional visual method, deviations in the results of judgments occur due to individual differences. In contrast, with this system, deviations are minimized and reproducibility is good due to systematization, and high accuracy measurement becomes possible. Although measurement accuracy varies depending on the measurement environment and the object of measurement, the measurement performance of this system is 0.5 mm. In other word, it is possible to make measurements in this unit.

Moreover, in exceptional processing, the strong points of the human and mechanical systems are skillfully utilized by clearly defining the division of functions, such as items which are left to the operator, and overall control accuracy is improved by establishing a well-balanced complementary relationship between the two.

4.3 Improvement of Working Ratio

With this system, the time required for measurements is greatly shortened, as measurements are performed while trains are traveling. As mentioned above, because it is possible to perform safe and stable measurements in a very short time, improvement in the working ratio of operating rolling stock can be expected. Taking the Yamanote Electric Train District of the East Japan Railway Company as an example, inspectons of all the wheels of the rolling stock in one composed train required approximately 30 min by the conventional visual method, but can be completed in about 10 min following the introduction of this system, shortening the inspection time by 1/3.

4.4 Improved Efficiency in Maintenance Control

By incorporating the results of measurements in a data base, brake shoe wear prediction (life prediction) is possible. Because this in turn enables a quantitative grasp of the replacement cycle of parts, further improvement in the efficiency of maintenance control can be expected.

5 Conclusion

This system was developed as part of a maintenance improvement project at the East Japan Railway Company. The results of operation of the system over a number of years have been highly evaluated, and horizontal development to include other routes within the same company is planned for the future. Similarly, these results have also received a high evaluation overseas, and a formal order for the same system was received from the Deutsche Bahn AG in 1998. At present, a project is in progress in Hamburg, and application at other rolling stock bases, including Munich, Berlin, etc., after the completion of this project is being studied.

As to the potential market scale, there is considerable latent demand for maintenance automation for the purposes of ensuring stable safety and saving labor, against the background of a shrinking working population. In addition to the orders mentioned above, an increasing number of inquiries have been received from railway companies in Japan and other countries.

In the future, the authors will endeavor to develop a line of products capable of responding flexibly to the needs of customers, and hope to contribute to the improvement of maintenance work in the railway industry.

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