Component Analysis of Extraneous Stuffs Attached on Measurement Target of Track Irregularity

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The rail track is one of the most important structures for maintenance among railway structures. The rail track is subjected to repeated loads by the wheels directly, causing track deviation. Track irregularity causes unsafety and uncomfortable running of train. There is a method of measuring orbital deviation. By installing a recursive target for image measurement on the rail of the train, the coordinates of the center of gravity are measured with a digital camera. Track distortion caused by repeated train running is measured. However, since the train repeatedly travels, deposits are attached due to external environmental factors, and the target becomes black. In this study, the attached matter was analyzed and the kind of attached matter was confirmed. By analyzing the attached matter, various materials are found, and it is possible to infer a blackened state. Knowing the actual condition of the adhering matter enables countermeasures and prevention, leading to a reduction in maintenance work.

Keywords: Infrastructure technology, Image measurement, Contamination, Railway track, Polymer surface, Evaluation criteria, Antifouling technology

1. Introduction

The control of the track irregularity is important from the viewpoints of railway maintenance. The track irregularity becomes large caused by cyclic train loading from train wheels. Track irregularity causes unsafety and uncomfortable running of train. Thus, railway track is controlled to offer a safe and comfortable service. Especially, in case of an excavation work having a risk of subgrade depression, track control for 24 hours is needed (Fig. 1) [1-4].

In recent years, the measurement technology of the track irregularity has been developed. In this technology, the displacement of recursive target which is attached on the railroad track is measured by the digital camera (Fig. 1) [1-4]. The recursive target follows a movement of railway track. However, by cyclic train loading, the extraneous stuffs are attached on the measurement target, and the target becomes black. In the black target, the centroid displacement cannot be measured exactly, the measurement target must be cleaned twice a month.

From these backgrounds, we have been developing the antifouling technology of the measurement target used by metamaterial effect [5-10]. There have been many studies on polymer surfaces and water droplets [11-24]. However, the behavior of deposits and the composition of elements on the polymer surface. In this study, in preparation of the antifouling technology development, the extraneous stuffs attached on the measurement target of the track irregularity is analyzed.
2. Measurement target of track irregularity

The targets measuring the track irregularity are collected from sites A and B, as shown in Table 1.

In the site A, not only passenger trains but also heavy freight trains are passing.

In the site A, the exposure period of the target was 45 days. In this site, a target is installed facing travel direction of a train.

In the site B, only passenger trains are passing.

In the site B, the exposure period of the target was 28 days.

In addition, targets are installed inside and outside a rail, in each site, as shown in Fig. 2(b).

The targets collected from the site A and B show

Figs. 3-5. The target between rails is fouler than that outside a rail (Figs. 3-5).

The target collected from the site B (cant = 100 mm) is tend to be fouler than that collected from the site B (cant = 0 mm), as shown in Figs. 4 and 5.
3. Component analysis

3.1. X-ray fluorescence mapping

X-ray fluorescence analysis microscope (Horiba, XGT-5200W) was used to measure the constituent elements of the deposit. The measurement conditions were an X-ray irradiation diameter of 1.2 m, a tube voltage of 50 kV, and three integrations.

3.2. Low vacuum scanning electron microscope

The surface condition was observed with a low vacuum scanning microscope (HITACHI, TM3030Plus). The accelerating voltage was 15 kV, and the measurement was performed without vapor deposition. For elemental analysis, BRUCKER Quantax70 was used.

3.3. Particle size distribution analysis

The particle size distribution test was performed to clarify the size of the deposit. The laser diffraction scattering particle size distribution analyzer (Beckman Coulter KK, model number LS13 320XR) was used. Deposits were collected by washing the target with ethanol.

4. Results and discussion

4.1. X-ray fluorescence mapping results

4.1.1. Target (site A)

Figure 6 (a) shows the results of point analysis of the site A by fluorescent X-ray analysis. As can be seen from the figure, the element of the deposit was Fe. Fe is considered to be iron oxide generated by friction between rails and wheels.

Next, Fig. 7 (a) shows the results of X-ray fluorescence mapping. In addition to Fe detected by X-ray analysis, Si and Ca were also detected.

![Figure 6: X-ray fluorescence analysis results. (a) Site A (standard product, inside gauge and outside gauge). (b) Site B (standard product, train running side and train running opposite side).]

![Figure 7: X-ray fluorescence mapping results of targets. (a) Site A. (b) Site B.]

Fig. 6. X-ray fluorescence analysis results. (a) Site A (standard product, inside gauge and outside gauge). (b) Site B (standard product, train running side and train running opposite side).

Fig. 7. X-ray fluorescence mapping results of targets. (a) Site A. (b) Site B.
Figure 8 shows the results of observing the sediment collected on site with a low vacuum SEM-EDX. The constituent elements of the soil particles were Si, Al and Ca. Fe is also attached.

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Figure 9 shows the result of observing the state of deposits on the target using a low vacuum SEM-EDX. As can be seen from the figure, Fe, Si and Al were detected. In addition, Si is attached in layers and Fe is attached in particles. This tendency is the same as the pattern of soil particles shown in Fig. 8. Therefore, it is considered that sediment is also attached to the target.

From the above, it is considered that most of the deposits on the target are iron oxides, and some of the deposits also adhere to the soil.

4.1.2. Target (site B)

Figure 6 (b) shows the results of point analysis of the site B by X-ray fluorescence analysis. As can be seen from this figure, the element detected for both targets was Fe, which was the same as the result for site A.

Figure 7 (b) shows the result of X-ray fluorescence mapping at site B. Unlike Site A, Si and Ca were not significantly detected. This may be due to the difference in the exposure period and the difference in the weather during the exposure period.

4.2. Particle size distribution analysis

Figure 10 and Table 2 show the results of particle size distribution analysis. In Fig. 10, the vertical axis represents the particle size (unit: μm), and the horizontal axis represents the particle size distribution according to the number. As shown in Fig. 10, a 90% cumulative diameter of the extraneous stuffs is from 0.2 μm to 1 μm.

Figure 10 shows an example of the results of the particle size distribution test. The vertical axis is the grain shape (unit: μm), and the horizontal axis is the number-based frequency distribution. As can
be seen from Fig. 10, most of the particles had a particle size of 0.2 μm to 1 μm. This was the same for all other samples. Table 2 shows a list of the test results of the particle size distribution. Regardless of the weather or the position of the target, the average diameter of the deposit was about 0.55 μm and the mode diameter was about 0.65 μm. It can be inferred that the particle size of the deposit is almost the same because the deposit is caused by friction fatigue between the train and the rail.

5. Conclusion

In this study, we analyzed the deposits that flew to the measurement target and identified the types of deposits. As a result, it was found that most of the deposits were iron oxides generated by the friction between the rails and the wheels, and the soil was partially clumped. Knowing the actual condition of the adhering matter enables countermeasures and prevention, leading to a reduction in maintenance work. In the near future, we will work on the development of a target for image measurement incorporating antifouling technology and aim for free maintenance.

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Table 2. Particle size distribution result on target.

| Site | Cant [mm] | Target installed inside a rail | Target installed outside a rail |
|------|----------|-------------------------------|-------------------------------|
|      |          | Average diameter | Mode diameter | Average diameter | Mode diameter |
| A    | 0        | 0.66             | 0.55            | 0.74             | 0.55          |
|      | 100      | 0.65             | 0.55            | 0.64             | 0.55          |
| B    | 0        | 0.63             | 0.55            | 0.63             | 0.55          |

Unit: μm
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