Abstract:

In order to implement effective countermeasures to prevent dust scattering, it is important to analyze the existing condition before measures are taken and confirm the effects after measures are in place. In other words, it is important to analyze and measure dust, and to evaluate the types and amounts of dust for which measures should be taken. The dust that originates from a steel works consists of multiple types of particles, such as coke, coal, iron ore, sinter, slag, and lime. Furthermore, when actual measurements are carried out, dust also includes silica sand, and other types of dust which do not derive from iron and steel making. Dust is captured by exposing adhesive tape to the atmosphere or by placing open Petri dishes at observation points. After the adhesive tape or the Petri dishes are recovered from the observation points, the captured dust is measured or analyzed to i] Ş f usyz ssss } u " on f ave

1. Introduction

JFE Steel has made a commitment “To reduce the environmental impact of all business operations” in its environmental policy and is actively conducting technical development and capital investment for that purpose. Countermeasures to reduce dust scattering are one item in those efforts. JFE Steel is working to prevent dust scattering by carrying out various countermeasures, including sprinkling in raw material yards with water, constructing shielding fences around yards, installing dust collectors and increasing the capacity of dust collectors, cleaning the steel works grounds and sprinkling roads with water in its works, etc.[1)].

color of the adhesive tape was selected so that it appears darker than white particles and brighter than black and red particles.

Next, conversion of the color representation is performed. In this method, image process is basically performed in a YCrCb color space. In a YCrCb color space, colors are represented by luminance and chrominance and . Luminance represents the brightness of a color independent of its hue. The values of chrominance have hue information; expresses redness and expresses blueness. On the other hand, the colors of the pixels in an image taken by photography with a CCD camera are represented in an RGB color space. In an RGB color space, colors are represented by a mixture of the three m t mag f

2.3 Classification of Particle Color Types

After extraction of the particles from the input image, the particles are classified into the three color types, black particle, red particle, and white particle. First, before classification of the particle color type, the pixels contained in each particle area are classified into the three colors, black, red, and white. Next, the particle color is determined by the distribution of the colors of the pixels contained in the particle area. Basically, however, the color of a particle is determined by the dominant color of the pixels in that particle. **Figures 5** and **6** show the results of determination of pixel colors and determination of particle colors, respectively. White pixels are defined mainly as pixels that have a value which is larger than a certain threshold value. This threshold value is set to a value which is obtained by adding a certain offset value to the mean value of of the background color. Assuming this threshold value is , pixels which satisfy

Fig. 9 Raw images (Upper row) and result images (Lower row) of color type classification for eight directions[3)]

Fig. 10 Example of statistical data output by the analysis system[3)]

particle size distribution by approach direction for particles classified by designated colors. Here, the main sizes of the particles included in the dust can be understood. These results are also output simultaneously as numerical data.

The results obtained with this analysis system are used to identify the sources and scattering routes of dust. For example, estimation of the dust source, evaluation of the influence of each dust source on the amount of dust fall, evaluation of the influence of wind velocity on the particle size distribution, etc. are possible. These various types of evaluations are performed by comparison of the analysis results and weather conditions such as the wind velocity, etc. during the observation period, comparison with simulations of dust scattering under the same weather conditions, and so on. The analysis system is also used for validation after implementing countermeasures to prevent dust scattering.

5. Conclusion

The development of a technology and analysis system for automatic classification and quantification of dust particles originating from a steel works by analysis of color images and transmission images was described.

(1) Dust particles are extracted from color images acquired by photographing adhesive tape with adhering dust lighted from above, and are classified into the three colors, black, red, and white. Particle extraction and particle color classification are performed based on YCrCb values. Because the thresholds for color classification are regulated automatically based on the mean values of the YCrCb values, variations due to individual differences among operators are eliminated and analysis is possible within a short time.

(2) Focusing on the light transmission property (semi-transparency) of silica sand, silica sand which does not derive from steel manufacturing is excluded by using transmission images photographed by back-lighting the dust. This improves the accuracy of measurements of particles related to the steel manufacturing process.

(3) It is possible to obtain statistical data for the number