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Application of Ultrasonic Atomization for improving dust control in underground mining
地下採掘における超音波霧化を用いた粉塵の飛散抑制

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1. Introduction

Dust control is an important factor which influences workers health in mining fields. The continuous exposure to fine dust, such as suspended particulate matter (<10 μm), increases the risk of disease. Especially, underground mining (closed pit mining) is necessary to control dust dispersion. In general, as humidity becomes higher, the amount of dust dispersion becomes lower[1]. Thus, we have been focused on ultrasonic atomization to suppress dust[2]. The water particles generated by the ultrasonic atomization are very fine, and they can raise the humidity quickly without wetting the space. However, the water vapor amount in air is changed by the temperature. As temperature becomes lower, water vapor amount in air becomes lower. The temperature of a shallow underground quarry (Akita) is low (< 12°C) through a whole year. Therefore, it is difficult to control dust using the regulation of humidity in the underground quarry. We focused on the water particles generated by the ultrasonic atomization. These particles are able to stay for a long time at high value of relative air humidity and absorb dust and precipitate due to their heavier weight compared to air. This study examined dust suppression using the water particles generated by ultrasonic atomization at low temperature.

2. Experimental

An acrylic box (61 L) was used as the contained space to adjust relative air humidity. Relative air humidity was adjusted using dry air and water. The temperature in the box was maintained using an air conditioner. The ultrasonic atomization was performed with a submersible transducer (2.4 MHz; Honda electro. Co.) and 300 ml of ion-exchanged water (500 ml flask, 30 °C). The top of the beaker was covered with a plastic lid and the side of flask has an outlet port for the water particle generated by the ultrasound. The experimental apparatus is shown in **Fig.1**. The change of the relative air humidity by ultrasonic atomization in the box was recorded using a humidity sensor. The ultrasonic atomization was performed until the amount of atomization reached the calculated amount of water vapor amount. After the ultrasonic atomization, the weight of the flask was measured by an electronic scale to calculate the amount of the atomization.

Dust suppression experiments were performed using the ultrasonic atomization device, a dust sampler, a digital dust sampler (scattered light detection method), an acrylic box (61 L) as the experimental field, and green tuff particle (average diameter 6 μm) as dust. The relative air humidity in the box was regulated at 50%. The temperature in the box was adjusted to 10°C. Ultrasonic atomization was performed until the amount of atomization equaled that of water vapor, which raised relative air humidity by 10-50%. Green tuff (1 g) was dropped from the top of the acrylic box to the floor of the box when these conditions were achieved. 10 min after the drop of green tuff, the measurement of dust particle numbers was started using a low volume air dust sampler for 10 min. The same experiment was conducted at 30°C to compare the result of the experiment at 10°C.

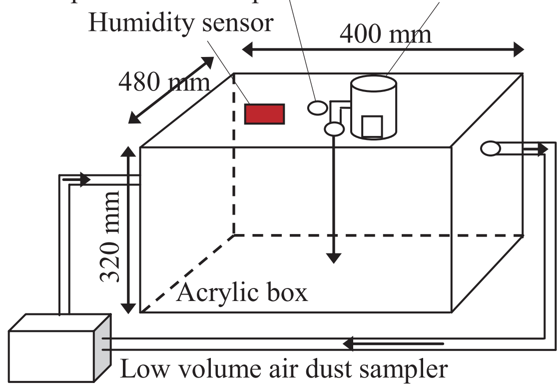

Fig.1 Schematic design of the experimental apparatus

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3. Results and Discussion

Fig.2 and **Fig.3** show the changes of the relative air humidity using the ultrasonic atomization at 10°C and 30°C respectively to reach the targeted relative air humidity (60-100%) from an initial level of 50%. Regardless of the same value of relative air humidity, water vapor amount in the acrylic box changed with the temperature. Thus, the additional amount of atomization was different between at 10°C and 30°C even though the same target level of relative air humidity. After the addition of ultrasonic atomization into the box, the relative air humidity was raised in both conditions. However, the reached level of relative air humidity at 10°C is lower than that at 30°C. These results suggest that the water particles are difficult to transform into water vapor at low temperature. We also confirmed the presence of water particles which did not change to water vapor from atomization in the box using a scattered light detection method. Therefore, we calculated water particles quantities in the box by the following formula: water particles quantity = additional amount of atomization – water vapor change from atomization.

Fig.4 shows results of dust control experiments without ultrasonic atomization at 10°C and 30°C respectively. For both conditions, dust dispersion amount decreased linearly with increase in relative air humidity. And dust dispersion amount at 10°C was larger than that at 30°C at same level of relative air humidity. The results of dust suppression experiments with ultrasonic atomization were plotted in Fig.4. These results show that dust dispersion amounts decreased significantly compared to those without ultrasonic atomization at same relative air humidity. The water particles contributed to dust suppression even though the low temperature condition which is difficult to suppress dust dispersion with relative air condition.

4. Conclusion

Low temperature and high relative air humidity are good condition to keep the water particles generated by ultrasonic atomization. It was clear that the water particles are effective to suppress the dust dispersion.

References

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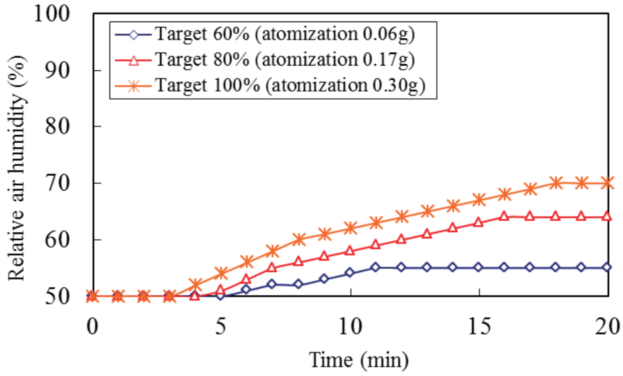

Fig.2 Change in relative air humidity by atomization at 10°C.

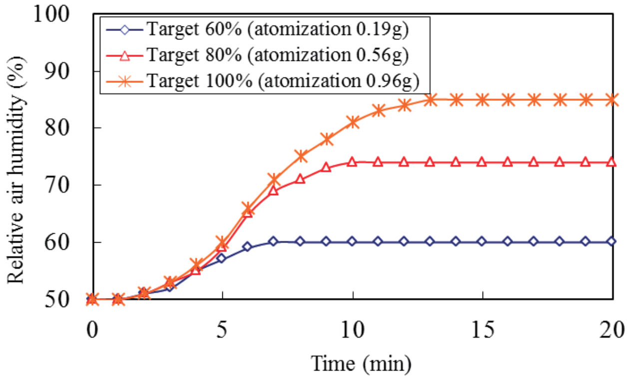

Fig.3 Change in relative air humidity by atomization at 30°C.

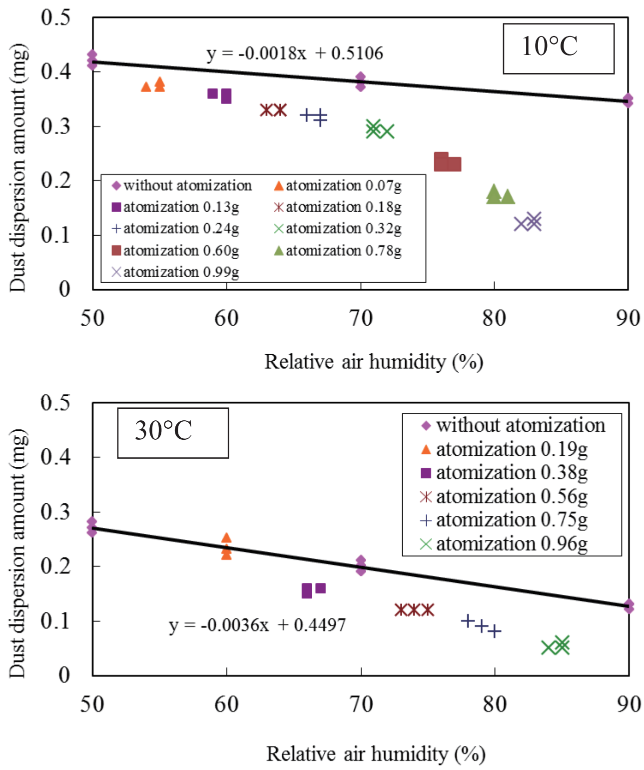

Fig.4 Relationships between the dust dispersion amount and the relative air humidity with and without water particles.