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# Utilization of Ultrasonic Atomization for Dust Control in Underground Mining

# 地下採掘空間における粉塵の飛散抑制を目的とした超音波霧化の利用

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## 1. Introduction

Environmental control to keep the air quality is necessary for underground mining. Ventilation is the important method to maintain a suitable environment in the space to work. However, ventilation is not enough to control dust which is generated by mining. Mineral dust influences workers health. The continuous exposure of fine dust, such as suspended particulate matter (<10 μm), increases the risk of disease.

Air conditioning process is also important for worker to work comfortably in underground. Air conditioning processes, heating and cooling, keep the suitable temperature and humidity in underground. Cooling coil and cool-water spray are used as methods to cool air. When spray is used, humidity of the space increases. In general, as humidity increases, the amount of suspended particulate matter decreases[1]. However, the water vapor capacity of the air, saturated absolute humidity, is dependent on the temperature. This is because that saturated vapor pressure changes with the temperature. As temperature becomes lower, saturated vapor pressure becomes lower. The temperature of the shallow underground quarry which is located in Akita is low about 10°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. We also considered that lower temperature is better for the ultrasonic atomization because the water vapor amount of saturated humidity at low temperature is lower than that at high temperature (**Fig.1** shows the comparison of the water vapor amount of saturated humidity). Therefore, fine water particle generated by ultrasonic atomization is difficult to be vapor. Fine water particles collect fine dust and precipitate it due to their heavier weight compared to air. This study examined the dust control at low temperature (10°C) using the water particles generated by ultrasonic atomization.

## 2. Experimental

An acrylic box (61 L) was used as the experimental field. Relative air humidity in this box was adjusted at 50% using dry air and water. The temperature in the box was maintained at 10°C 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). The top of the beaker was covered with a plastic lid and the side of flask had an outlet port for the water particles generated by the ultrasound. The experimental apparatus is shown in **Fig.2**. 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.

Dust suppression experiments were performed using an 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. Ultrasonic atomization was performed until the amount of atomization equaled that of water vapor, which raised relative air humidity incrementally 10-50% from 50%. Green tuff powder (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 the amount of dust particles was started using a low volume air dust sampler for 10 min.

## 3. Results and Discussion

At first, we performed the changes of the relative air humidity by the ultrasonic atomization at 10°C. The atomization was dropped to reach the targeted relative air humidity of 60-100% from an

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Table1 Change of relative humidity and absolute humidity at different additional amount of water particles.

| Targeted relative humidity | Temperature | Atomization amount | Attained relative humidity | Attained absolute humidity |
|---|---|---|---|---|
| % | ℃ | g | % | g/kgDA |
| 60 | 10.3 | 0.07 | 55 | 4.2 |
| 70 | 10.2 | 0.13 | 60 | 4.6 |
| 80 | 10.2 | 0.18 | 64 | 4.9 |
| 90 | 10.3 | 0.24 | 67 | 5.1 |
| 100 | 10.3 | 0.32 | 71 | 5.4 |

initial level of 50%. Table1 shows the results of additional amount of atomization, attained value of relative humidity, and attained value of absolute humidity. From these attained value of relative air humidity, fine water particles by atomization are difficult to be vapor under low temperature of 10°C. We also confirmed the presence of water particles in the box using a digital dust indicator. The intensity of the indicator was minimal after the end of increase of the relative humidity in the box. The water particles were stable over 10 min.

**Fig.3** shows results of dust control experiments using ultrasonic atomization at 10°C. Dust dispersion amount is suppressed when the amount of added fine water particles is increased. The reason is considered below two. One is the high relative air humidity. And the other is the presence of large amount of water particle. To cleat the effect of relative air humidity, we conducted dust suppression experiment without presence of water fine particles. Dust dispersion amount was 0.42g at 50%, 0.38g at 70% and 0.35g at 90%. Therefore, it was obvious that the contribution of relative air humidity (water vapor) is a little. The results of that dust dispersion amounts decreased significantly will relate to the amount of fine water particles. As the above results, fine water particle generated by ultrasound atomization is effective to suppress the dust at low temperature.

## 4. Conclusion

Dust control using the water particles generated by ultrasonic atomization was performed at low temperature of 10°C. Water vapor and water particles are worked to suppress the dust dispersion. Especially, the presence of large amount of water particles is necessary to suppress the dust drastically. This study has the possibility to be applied for dust suppression of the shallow underground mining.


**References**

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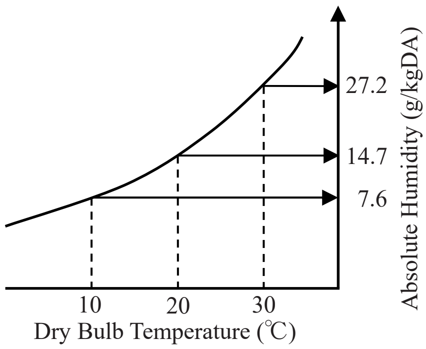


Fig.1 Comparison of the amount of absolute humidity by temperature shown on the psychrometric chart.

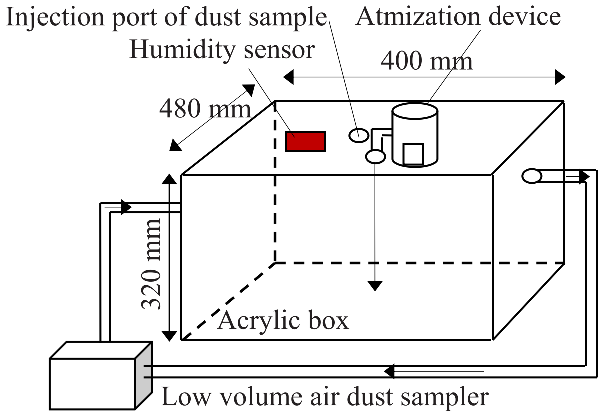


Fig.2 Schematic design of the experimental apparatus.

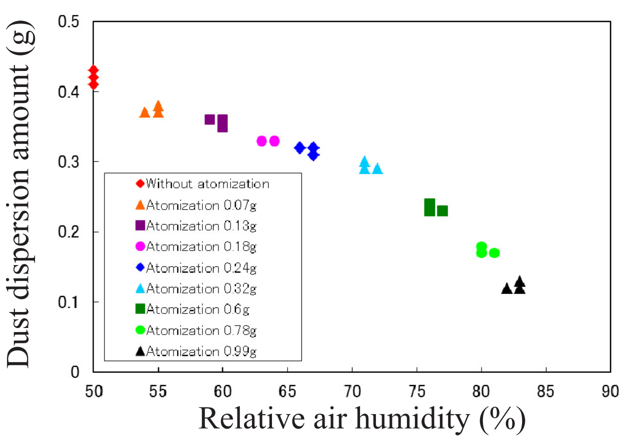


Fig.3 Effect of the amount of fine water particles generated by ultrasound atomization on dust dispersion at 10℃.