Ultra Sonic Sprayer Controlling Dust in Experimental Poultry Houses

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Abstract

Dust control tests of experimental enclosed layer and floor feeding broiler houses were performed with ultra sonic sprayer units which have some advantages such as 1) low cost, 2) low electric power consumption, 3) forcing the charge and 4) unnecessary to lay pipes to spray. With spraying 2 % solution of emulsified canola oil in layer house, the concentration of dust with aerodynamic diameter (d) of above 0.5 and less than 2 μm and that of $10 \leq d < 30$ μm significantly decreased 42 % and 49 %, respectively. The dosage was 14 g day^{-1} head^{-1}.

In an enclosed floor feeding broiler house spraying 2 % solution of emulsified canola oil reduced the concentration of dust with $0.3 \leq d < 5$ μm significantly. Dust concentration was reduced to 40 %. However, the concentration was too high at the order of 10^9 particles m^{-3}. For the floor feeding broiler house, spraying is not suitable method to reduce dust concentration.

Keywords: Ultra sonic sprayer, Dust control, Poultry house

Introduction

Some methods of dust control in enclosed livestock houses, such as ventilation system, oil spraying, ionization system, feeding control and etc. have been found. Dust control by ventilation system has been observed to be an achievable and effective method (Ikeguchi, 1997). However, if polluted air inside the house is simply exhausted to outside house, this approach is a failure, because it only generates pollutant emissions to the environment. The best way is to reduce emission at the same time to trap aerosol inside house. This leaves the inside air clean and prevents dusts from diffusing to outside house. It requires a function of not only ventilation system but also a combination of the above methods (Wathes, 1998). However, individual technique should be completed to ensure the use in livestock houses before they are combined.

One of the most successful methods of reducing airborne dust concentration is by spraying or sprinkling oil. Takai et al. (1995) reported that respirable dust in fattening pig houses at commercial farm was reduced to 52 % by spraying a mixture of water and rapeseed oil at 5 to 64 ml pig^{-1} d^{-1}. Zhang et al. (1996) investigated the relationship between the application of canola oil sprinkling on the floor and dust concentrations in swine buildings. The study reported that a higher oil application frequency was more effective than the lower application frequency and dust concentration was reduced from 37 to 89 % depending on the oil application rate. These studies performed on pig houses suggested that oil spraying was effective in reducing dust concentrations. On the other hand, they also showed the requirements on how to spray.

The objective of the present study was to reduce dust concentration in an enclosed experimental layer and floor feeding broiler house by using ultra sonic sprayers. This has some advantages such as 1) low cost, 2) low electric power consumption, 3) forcing the charge and 4) unnecessary to lay pipes to spray.

Procedures and Method

Ultra Sonic Sprayer Unit (USSU)

A supplied ultra sonic sprayer is (Eroica Co.: special model) shown in figure 1. The characteristics of this sprayer are: (1) it is small, (2) it has 12 W electric drive (including turbo fan) and (3) it dose not need pipes to spray. The spray performance were 2.78 X 10^{-7} m^3 s^{-1} and the diameter of sprayed particles was ranged from 7 to 150 µm. This sprayer were mounted to a tank and turbo fan unit, which was called ultra sonic sprayer unit (figure 1). Eight ultra sonic sprayer units were mounted on the automatic feeders which carried the units for a layer house and two units were set on rotating discs for a broiler house.

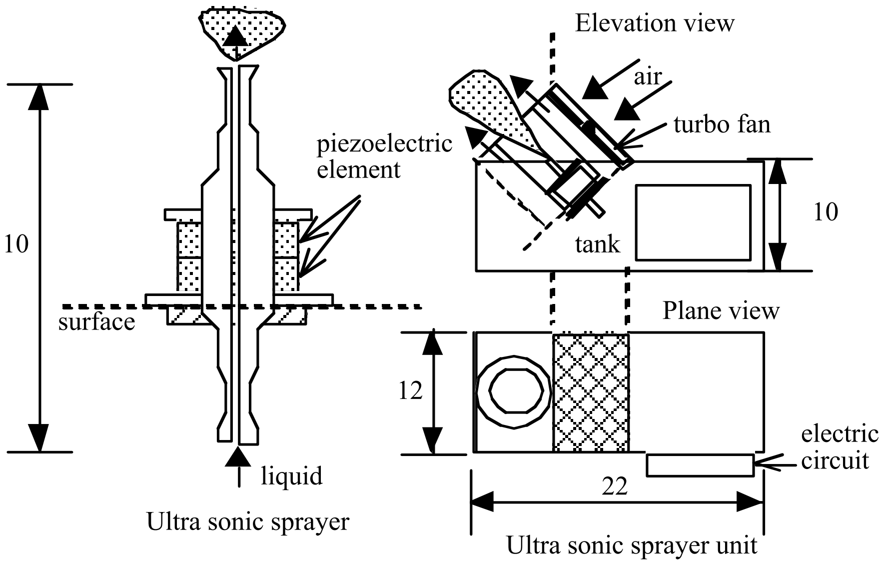

Figure 1- Ultra sonic sprayer unit. (All units in cm)

Layer House Test

Target house: An enclosed layer house in the National Institute of Animal Industry, Japan was used. Elevation and plane view of the experimental layer house are shown in figure 2. The room No.A and No.B were used as control and treatment room respectively. Each room measured 11.0 X 9.5 X 2.8 m and held 240 hens in two layers decks. There were 4 round inlets on the ceiling and outlets were located on the side wall near the floor. The bird ages were from 26 weeks to 27 weeks during experiments. Feeding was performed once a day by automatic feeders from 9:30 to 9:50 am. The house had air conditioning equipment and the air exchange rate was 2 times per hour during the experiments.

Treatment: 1 % and 2 % solutions of emulsified canola oil (weight base) were sprayed 14 g per bird once a day after feeding. Because the result was conducted such that dust concentration was the highest after feeding from preparatory experiment and the feeding was once a day in this management of the institute.

The oil treatments were conducted in treatment room B for 4 days for each test and the environment in the room was compared with that in control room A. The tests number and treatments are shown in table 1.

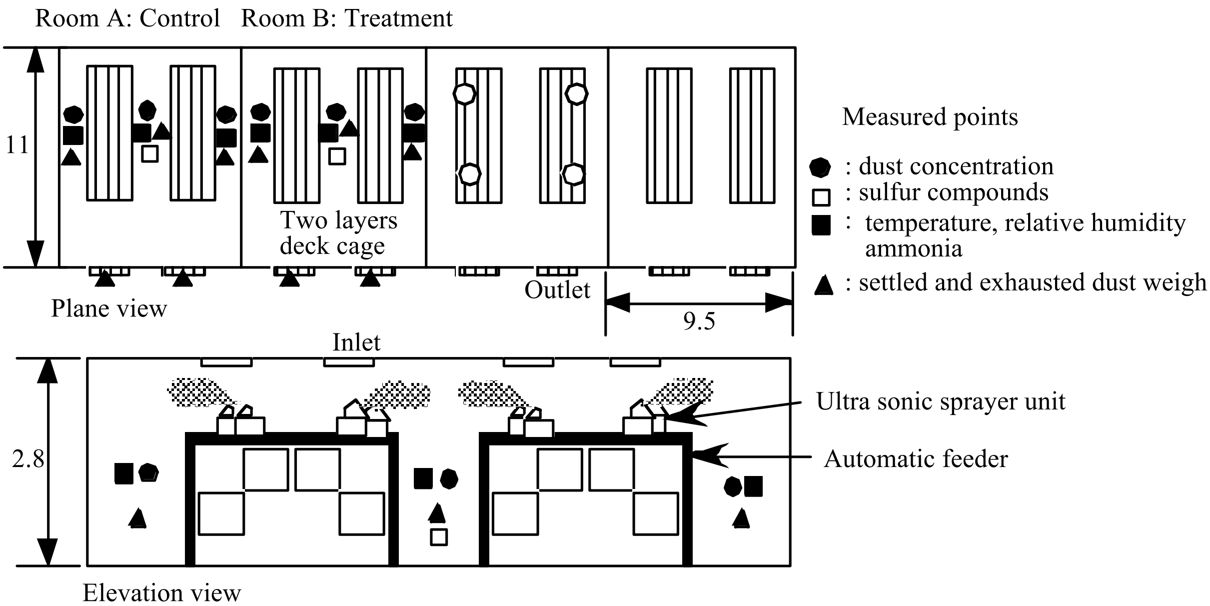

Figure 2 - An experimental layer house and measured points (All units in m).

Table 1. Test No. and treatment

Test No.	Treatment
test No.1	1 % solution of emulsified canola oil (weight base)
test No.2	2 % solution of emulsified canola oil

Measurement: Measurement items were dust concentration, NH_3, sulfur compounds (methylmercaptan (MM), dimethyl sulfide (DMS), dimethyl disulfide (DMDS)), temperature, relative humidity, the amount of dust which settled inside room and exhausted dust by ventilation. Each measured point is shown in figure 2.

Dust concentration was measured by aerodynamic particle sizer (TSI Inc., model 390041). The sampling period was 180 s and the measurement was performed twice a day at 9:00 and 14:30. At 9:00 layers were very active before feeding. Settled dust weight was measured for test No. 2 using weighing petri dish whose diameter and depth were 157 mm and 35 mm respectively in three points inside the room. Exhausted dust was collected using the same weighing petri dish under the each outlet hood. They were collected and weighed at 9:00 and 14:30.

Concentration of NH_3 was measured at 9:00 and 14:30 using detector tubes. Inside air was collected in one liter polyvinyl fluoride bag at 9:00 and the concentration of three sulfur compounds were measured using gas chromatography (Shimaz Co., model GC-8A).

Temperature and relative humidity were continuously measured using C-C thermocouples and relative humidity sensor (TDK Co., model XU1). These were recorded at 600 s intervals by a data logger (Campbell Scientific Inc., model 21X).

Measurements were performed from 1997 November 4 to 7 for 2 % oil spray test and from October 28 to 31 for 1 % oil spray test.

Floor Feeding Broiler House Test

Target house: The experimental floor feeding broiler room is illustrated in figure 3. The room size was 4.5(w) X 6.6 (l) X 2.5 (h) m and the density was about10 heads per m^2. Saw dust was spread on the floor at 5 cm depth. Birds age was 8 weeks and feeding was performed at 1:00, 4:00, 7:00, 10:00, 13:00, 16:00, 19:00 and 22:00. The air exchange rate was 28 times per hour.

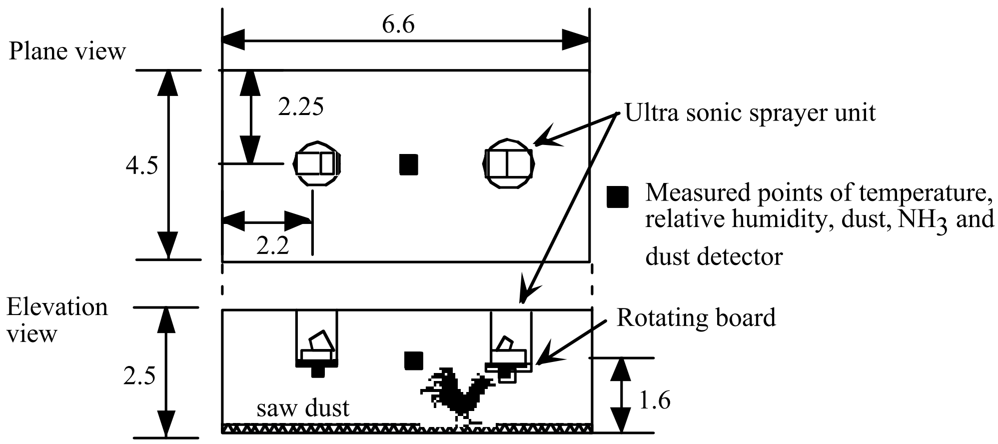

Figure 3 - The target floor feeding broiler house (all units in m).

Treatment: Two percent solutions of emulsified canola oil (weight base) were sprayed by two USSUs which were set on rotating boards at 1 RPM. Spraying was performed every one hour for 10 minutes (75 g was sprayed) or when a dust concentration detector detected a threshold concentration which was 5.0 X 10^8 particles m^{-3} less than 5 □m. in aerodynamic diameter. The detector was developed by the author and used transmitted laser (Ikeguchi, 1998).

Measurement: Dust concentration was measured for 5 minutes every 30 minutes by laser particle counter (KANOMAX Japan INC., model IF-500S) and, temperature and relative humidity were measured every one minutes using C-C thermocouples and relative humidity sensor (TDK Co., model XU1). The output from dust concentration detector was also recorded every one minutes by a data logger (Campbell scientific Inc., model 21X). Concentration of NH_3 was measured by using detector tubes. Measurements were performed from 1998 December 12 to 16 for treatment and from 16 to 17 for control.

Results and Discussion

Layer House Test

Effect of Oil Concentration on Dust Concentration

The mean dust concentrations for each test are shown in table 2 and 3. In test No.1, the dust concentration for any aerodynamic diameters (d) in treatment room was apt to reduce about 20 %, however, there was no significant difference between treatment and control.

On the other hand, dust concentration in treatment room was significantly reduced compared with that in control room when the 2 % solution was sprayed (test No. 2). However, the effect of treatment on dust concentration depended on aerodynamic diameter. In the case of $0.5 \leq d < 2.0$ μm there was significant difference ($F=7.82$ (1,26), $P=0.0096$) between treatment and control. The mean dust concentration was $1.06 \times 10^7 \pm 1.59 \times 10^6$ particles m^{-3} in the treatment room. The dust concentration was reduced 42 %. But the differences were not significant in the cases of $2 \leq d < 5$ and $5 \leq d < 10$ μm. When the aerodynamic diameter of dust was $10 \leq d < 30$ μm, there was significant difference ($F=8.46$ (1,26), $P=0.0073$). The reduction of dust concentration was 49 % compared with control. The mean dust concentration in the treatment room was $3.51 \times 10^3 \pm 5.87 \times 10^2$ particles m^{-3}.

Table 2. Dust concentrations in test No.1

Aerodynamic diameter of dust (μm)	Treatment Mean (particles m^{-3})	Treatment SE (particles m^{-3})	Reduction (%)	Control Mean (particles m^{-3})	Control SE (particles m^{-3})
$0.5 \leq d < 2$	1.72	0.171($\times 10^7$)	19	2.12	0.186($\times 10^7$)
$2 \leq d < 5$	8.52	0.541($\times 10^6$)	-	8.34	0.399($\times 10^6$)
$5 \leq d < 10$	10.5	0.980($\times 10^4$)	19	11.2	0.810($\times 10^4$)
$10 \leq d < 30$	8.00	1.10 ($\times 10^3$)	19	9.87	1.08 ($\times 10^3$)

Table 3. Dust concentrations in test No.2

Aerodynamic diameter of dust (μm)	Treatment Mean (particles m^{-3})	Treatment SE (particles m^{-3})	Reduction (%)	Control Mean (particles m^{-3})	Control SE (particles m^{-3})
$0.5 \leq d < 2$	1.06	0.159($\times 10^7$)	42	1.83	0.221($\times 10^7$)
$2 \leq d < 5$	6.23	0.745($\times 10^6$)	6	6.65	0.674($\times 10^6$)
$5 \leq d < 10$	7.41	1.19 ($\times 10^4$)	17	8.90	0.985($\times 10^4$)
$10 \leq d < 30$	3.51	0.587($\times 10^3$)	49	6.95	1.03 ($\times 10^3$)

These indicated that spraying the 2 % solution could reduce the dust concentration more effectively than spraying the 1 % solution for this layer house. The change of dust concentration with the passage time at $0.5 \leq d < 2.0$ μm in test No. 2 is shown in figure 4. It was found that dust concentration before feeding decreased daily due to oil spraying.

Effect on Settled Dust Weight

Settled dust weights were measured for test No. 2 and their change on standing is shown in figure 5. The mean settled dust weight in treatment room and control room were 9.8 ± 0.33 and 8.0 ± 0.24 g m^{-2}, respectively. There was significant difference between treatment and control (F=19.1 (1, 10) P=0.001). The exhausted dust weight of treatment and control were 5.5 ± 0.09 and 6.7 ± 0.04 g m^{-2}, respectively. They were significantly different (P=0). The settled weight inside treatment room was larger than that inside control and the exhausted dust weight of treatment was smaller than that of control and of treatment room. This indicates that dusts in the treatment were piled up by oil spraying and settled dust could not scattered.

<u>Effect on Odor Gases</u>

Means concentration of odorous gases are shown in table 4. There were no significant difference between treatment and control. The oil spraying of this study did not affect reduction of odor gases.

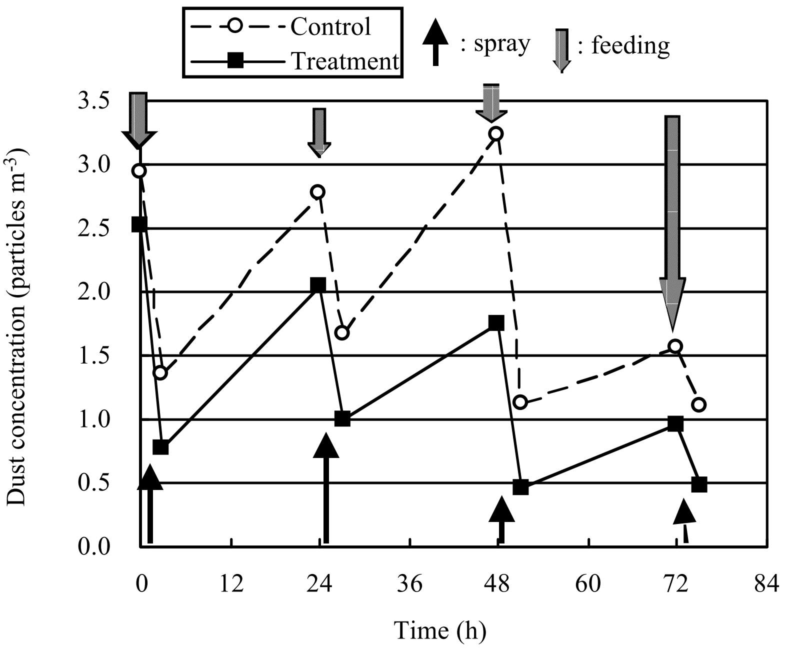

Figure 4 - Change of dust concentration with the passage time.

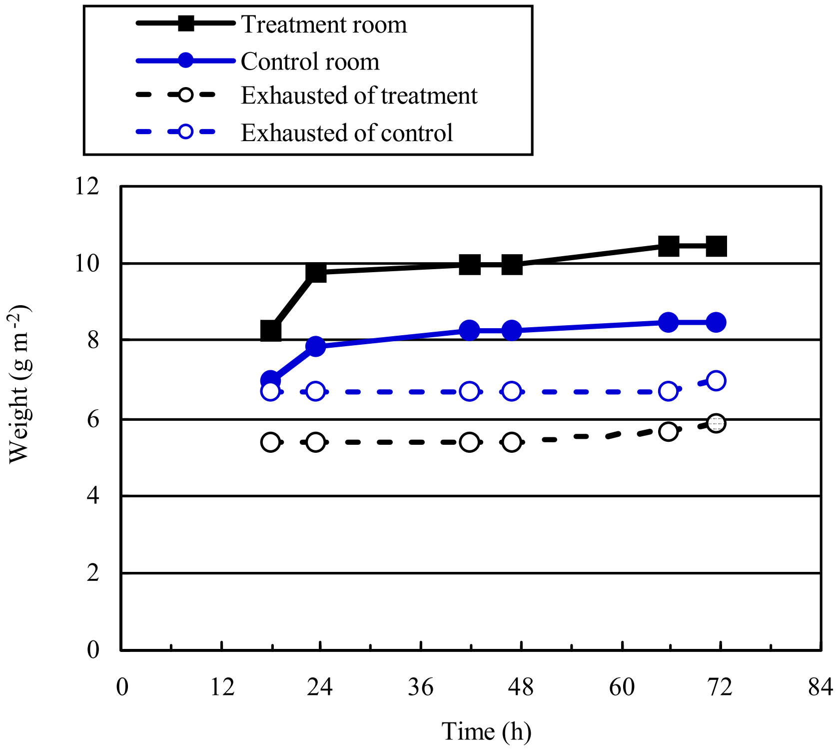

Figure 5- Change of weight of settled and exhausted dust in test No.2.

Table 4. Summary of odor gases

gases	Treatment		Control	
	Mean	SE	Mean	SE
NH_3 (ppm)	1.8	0.3	2.0	0.3
MM *(ppb)	2.0	0.41	2.0	0.29
DMS** (ppb)	0.55	0.13	0.88	0.30
DMDS*** (ppb)	0.06	0.03	0.05	0.03

*: methylmercaptan
**: dimethyl sulfide
***: dimethyl disulfide

Effect on Temperature and Relative Humidity

It seems that spraying affects relative humidity and temperature in the room. After spraying, relative humidity in the treatment became 10 % larger than that in control. However the period was about 2 hours after spraying. With respect to room temperature no difference between treatment and control was found. The present manner of spraying did not affect thermal environment much.

Floor Feeding Broiler House Test

Effect on Dust Concentration

The mean dust concentrations for $0.3 \leq d < 5$ μm in aerodynamic diameter of treatment and control were 6.81 X $10^8 \pm$ 2.96 X 10^8 and 1.29 X $10^9 \pm$ 4.26 X 10^8, respectively. There was significant difference [F=6.92 (1, 90) P=0] and average reduction was 47 %. The change of concentration with time is shown in figure 6. Both of concentrations were lower in the day time rather than at night. Dust concentration tended to increase after feeding. Dust reduction of treatment in the day time and at night was about 60% and 40 %, respectively.

However, the value itself was higher compared to that of layer house. Because the floor of broiler house consisted of saw dust and waste and spraying. And spraying was performed every 30 minutes for the setting of the dust detector. Considering these, it is impossible for floor housing to reduce dust concentration to the concentration level of layer house with spraying. For floor housing, it is essential to separate waste from broilers from the view point of not only dust reduction but also hygienic environment. Consequently, net floor seems to be better for floor feeding broiler house.

Effect on NH_3 Concentration

It was seen significant difference for NH_3 concentration between treatment and control [F=34.5 (1, 16) P=0]. However, the average NH_3 concentrations of treatment and control were 50 and 55 PPM, respectively. Though the reduction was 10 %, both values were more than 50 PPM.

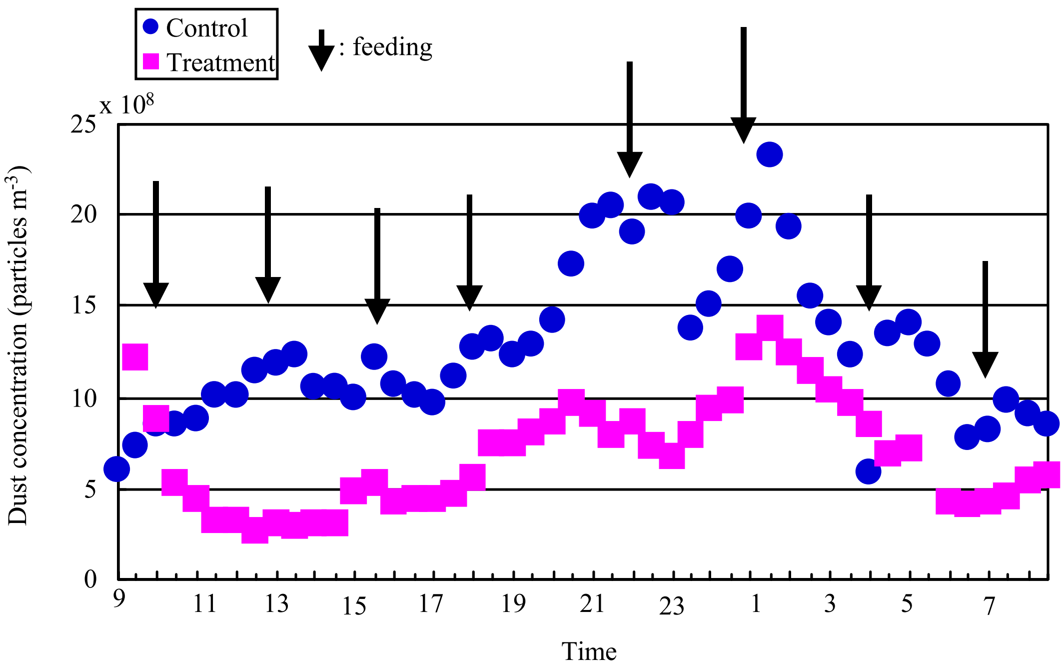

Figure 6- Change of dust concentration in floor feeding broiler room.

Conclusions

The following conclusions were drawn:

1. Spraying 2 % solution of emulsified canola oil with ultra sonic sprayer unit (USSU) for the enclosed layer house significantly reduced the concentration of dust with 0.5 ≤ aerodynamic diameter (d) < 2 µm and with 10 ≤ d < 30 µm to 58 % and 51 %, respectively. The dust reduction depended on aerodynamic diameter. The dosage of 2 % solution was 14g day^{-1} $head^{-1}$.
2. One % oil spraying for the layer house did not reduce the dust concentration significantly. However, it reduced dust concentration to about 20 %.
3. Since settled dust weight in the treatment room was larger than that in the control room for broiler house, it was shown that piled dusts resulted from 2 % oil spraying.
4. The present manner of spraying did not affect thermal environment and the concentration of odor gases.
5. This spraying way could reduce dust concentration at 47 % daily average in floor feeding broiler room but concentration itself was 100 times as high as that in layer house.

Future Work

It was validated that an ultra sonic sprayer unit was useful to reduce dust concentration in an enclosed layer house. Furthermore, practical spraying manner making the most of advantages of the ultra sonic sprayer should be considered for layer house. Presently a spraying system with autonomous traveling robot to carry the ultra sonic sprayer units is developing as showing in figure 7. This system takes aim at not only dust control but also odor locally or supporting manage.

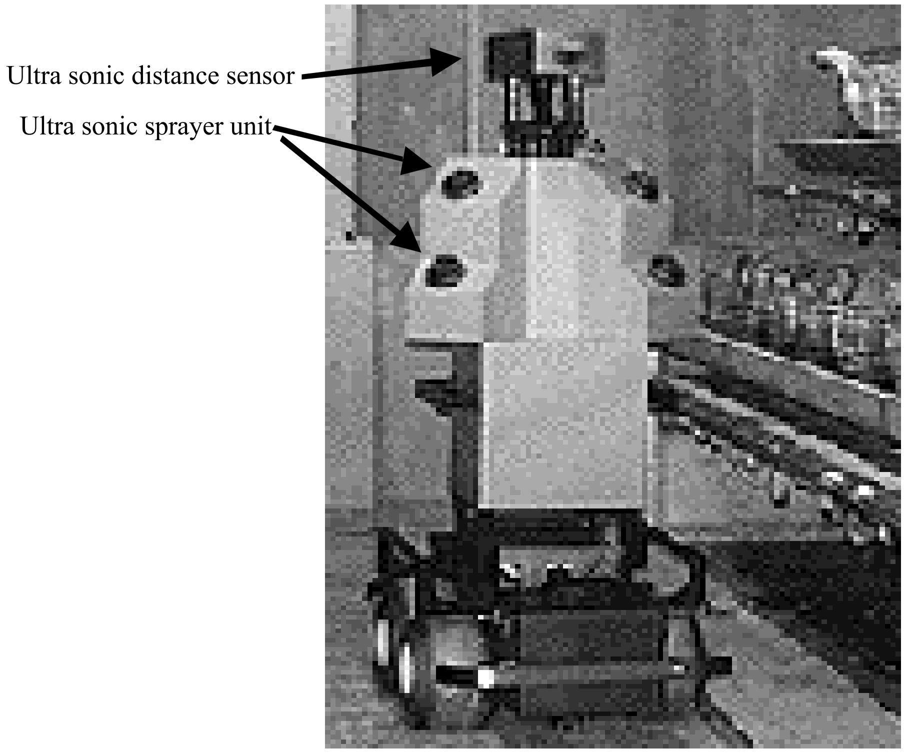

Figure 7 - Autonomous traveling robot for control local environment.

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