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Controlling Insects by Ozone in a Wheat Storehouse

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Abstract: The test of controlling insects with ozone in 900t of high moisture wheat was conducted through mobile modular ventilation system and ozone generators. Recirculation fumigation in the grain bulk through mobile ventilation ducts with four to six ozone generator was tested on 4 species of stored grain insect pests: *Sitophilus oryzae* (Linnaeus), *Cryptolestes ferrugineus* (Stephens), *Rhyzopertha dominica* (Fabricius), *Tribolium castaneum* (Herbst). The stored grain insect density was 10 to 30 insects per kilogram grain. Stored grain insets were completely killed by ozone at 15 ppm concentration and 290 hours exposure.

Key words: ozone, stored grain insects control, mobile ventilation system

1 Preface

As an allotrope of oxygen and a strong oxidizing agent, ozone with a half-life in the atmosphere of 20 – 30 minutes was extensively applied in the medicine and the food professions. It was mainly used to destroy germs on surfaces, and in water and for space disinfections. Ozone as a fumigant could be also used for destroying stored grain insects. As it changes into oxygen, there is no pollution to the food and also no harm to the environment.

Many domestic and international experts have researched ozone's effects on insects. Erdman (1979) reported that *Tribolium. castaneum* (Herbst) and *T. confusum Jacquelin du Val* were all dead after exposure to 450 ppm ozone for 7 hours at 30℃. Li Changguo et. al. reported that ozone from an ozone generator at 3 – 30ppm applied intermittently for a long time in the storehouse space could effectively control the development of grain insects inside the wheat. Linda J. M used ozone of 10 – 50 ppm to fumigate adults of *Sitophilus. zeamais* Motschulsky, *T. castaneum* (Herbst), *T. confusum Jacquelin du Val* and larvae of *Sitotroga cerealella* (Olivier) in the laboratory. Cao Zhanggui used ozone at 15 – 120ppm to fumigate adults of *S. zeamais* Motschulsky, *Rhyzopertha dominica* (Fabricius) and *T. castaneum* (Herbst). The work established the lethal CT value of adults. Fan Shengliang concluded that greater than 10 ppm ozone could kill insects when it was introduced through an air duct into part of a warehouse that was sealed.

In the reports on ozone to control insects, Fan Shengliang's partial experiment was the only experiment in warehouses. In the experiments reported here, high concentration ozone produced by many ozone generators was introduced into the grain through ventilation pipes. It was evenly distributed in the whole grain storehouse, which had previously been sealed. The lethal time and CT value, as well as the moisture, were calculated by periodically measuring ozone concentrations and moisture content.

2 Materials and Methods

2.1 Experiment Storehouse and Time

The experiment was carried on in the Yaonan Heishui State Grain Reserves. The storehouse was 60 meter long, 24 meter wide and 6 meter high.

The wheat for experiment came from Henan province and the moisture content was 12.1%, while the height of wheat was 4.1 meter.

The storehouse had groups of three 4 – 72A type centrifugal blowers with 7.5kW power. The experiment started on 5 June 2007 and ended on 20 June.

2.2 Ozone

2.2.1 ozone generator and supporting facilities

a. 6 YLHD – LJC type ozone generators.

b. 5 BLZ – 11 – 3A type circulation fumigation machines.

c. 6 YBT – 1.1 type anti – explosion centrifugal fan

d. 6 sets of QG · JC · 12 type partial vent-

1. *Jilin Branch, State Grain Reserves* 130033
2. *State Grain Reserves Yaonan Heishui Depot*

ilators and 55 sets of ventilation ducts (two punched ventilation ducts and two porous ones)

e. 2 LDQ – 1400WI multi – function samplers

The equipment was provided from Qinpeng green equipment limited liability warehouse protection company.

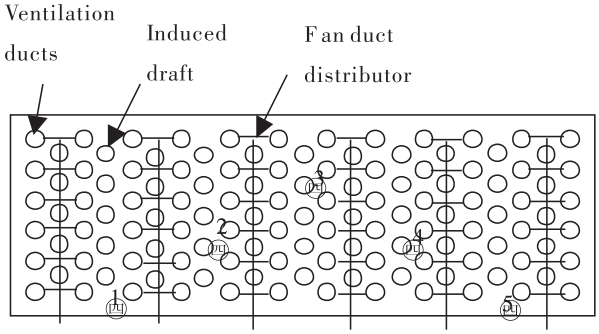

Fig. 1 **The plane arrangement of the ventilation ducts**

2.2.2 The connection of ozone generator and its supporting facilities

The ventilation ducts were put into bulk grain, each group of them consisted of alternate groups of two punched ventilation ducts and two porous ones(see chart 1). The branch ventilation duct of the distributor was connected with ventilation ducts, and then the anti – explosion centrifugal fan was connected with the distributor. The ozone generator was placed on the surface of the bulk grain. The ozone was sucked out by the circulation fumigation machines, then pressed into the bulk grain by the anti – explosion centrifugal fan and entered into the inside space of the storehouse through the guide ventilation ducts. The ozone flowed in a closed circulation system. When the ozone and produce had been bought into balance, the ozone concentration was determined. The connection of single distributor is shown in the chart 2.

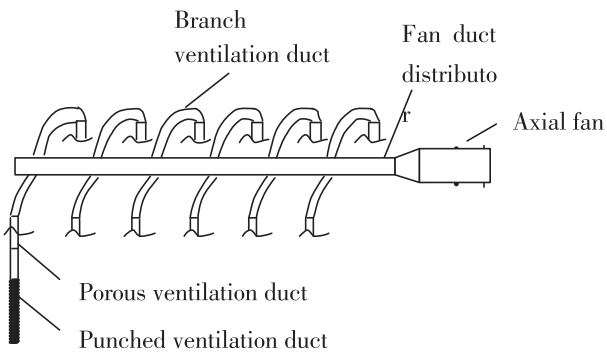

Fig. 2 **The connection of single ventilation duct**

2.2.3 measurement of the ozone concentration

2.2.3.1 detecting tube

The ozone density was measured by the detecting tube made by the labor department occupational safety bureau Beijing labor insurance. The detection range was 2 – 50ppm. The ozone concentration was calculated by the colour change after sucking 100mL through the tube.

2.2.3.2 Distribution of sampling points

Because the storehouse was enclosed, the ozone concentration in the grain surface and inside the grain became consistent after the ozone concentration had been brought into balance.

2.3 Stored Grain Insects

2.3.1 detection of stored grain insects

Five places inside the storehouse were chosen to detect insects.

2.3.2 Detecting the live or dead insects

The stored grain insects were assessed as live as long as their body could move even if their legs stretched. If the insects didn't move for a long time, they were determined to be dead.

2.4 Laboratory Apparatus and Equipments

2.4.1 grain statement detection system

Temperature measurement cables were made by State Grain Reserves Yaonan Heishui Depot and distributed uniformly in the whole grain bulk. Pocket thermodetector was made by Taizhou.

2.4.2 Detecting the moisture and quality

The measurement of moisture was standardized according to the Chinese Standard method. The measurement instrument of rapid moisture measurement was used to measure moisture. Some storage indicators such as Fatty acid, germination rate, viscosity and quality indicators such as percentage of flour and quality of flour were measured according to the Chinese Standard method.

2.4.3 microbioassay

Microorganism fast measurement instrument

2.5 Other Instruments LDQ – 1400W

2.6 Type Multi – function Samplers

1 LDS – ID type computer moisture measurement instrument

Some ozone detecting tubes

150mL volume suction tube

3 Results and Discussions

3.1 Ozone Concentration Distribution in the Experiment Storehouse

Because the ozone generator was placed inside the storehouse and ozone was sent into

the grain, the ozone concentration of the grain surface could represent the one inside the grain bulk. The ozone concentration depended on the number of ozone generators. The maximum ozone concentration was 30ppm and the minimum was 10ppm.

3.2 Effect of Ozone on Stored Grain Insects

The mortality of the stored grain insects caused by ozone is shown in table 1.

Table 1. the death of the stored grain insects caused by ozone

Time(h)	Interval of time(h)	Ozone density (ppm)	CT value (mg·h/L)	Total CT value (mg·h/L)	Number of insects(Number/kg)			Moisture (%)
					Live insects	Dead insects	Mortality (%)	
0	0	0	0	0	30	2	6	16.0
40	40	15	1.28	1.28	37	3	8	16.0
72	32	30	2.05	3.33	15	4	21	15.5
134	62	20	2.65	5.98	10	1	9	15.0
226	92	10	1.97	7.95	10	20	67	15.0
284	58	10	1.24	9.19	0	20	100	15.0

The change of the ozone concentration was large if it was detected by the detecting tube. The average ozone concentration was used to calculate CT values.

The stored grain insects were mainly *S. zeamais* Motschulsky and a few others, such as *R. dominica* (Fabricius), *T. castaneum* (Herbst) and *C. ferrugineus* (Stephens).

For complete mortality, the CT value should reach 9.19 mg·h/L(mg. hours/litre), the average ozone concentration 15ppm and the minimum should be bove 10ppm for approximately 12 days (table 1). These results were consistent with those of Linda J. M s(1998).

3.3 The change of Temperature, Moisture and Quality of the Grain

3.3.1 temperature change

The whole grain temperature rose up to 40℃, it was more 15℃ than the air temperature, after ozone aeration. The whole grain temperature decreased to a little more than the air temperature through the blower and the ventilation ducts in 1 day after the experiment was finished.

3.3.2 the change of the grain moisture

The grain moisture decreased 1% during the fumigation from an initial high value of 16% (table 1).

3.3.3 the change in grain quality

The experimental and control wheat samples were all examined by the Jilin Quality Detect Central (table 2).

Table 2. the wheat quality change

Detecting item	Before	After
Water absorption of gluten(%)	194	194
Falling number(s)	305	294
Fatty acid (mgKOH/100g dry basis)	14.5	20.9
viscosity(mm^2/s)	7.7	6.4
Steamed bread taste grade(grade)	77	80
Germination rate(%)	94	61
Percentage of flour(%)	67.6	67.6
Value of farinograph	45	47

After ozone fumigation, some quality indicators, such as fatty acid, viscosity, falling number and water absorption of gluten, were almost the same as before. Others such as steamed bread taste grade, percentage of flour, value of farinograph, were better than before. The germination rate decreased obviously. It is concluded that the ozone had no bad effect on wheat quality if it was not used as seed.

Table 3. contrast of the microorganism activity before and after ozone treatment

	Before treatment		After treatment	
	Sampling point	average	Sampling point	average
Microorganism activity(u)	541 668 591 608 531 627 549 619 592 620	595	638 639 635 666 645 626 602 625 628 642 639 659 638 596 645	635

3.4 Microorganism Activity

Microorganism activity was detected in some sampling points before and after treatment. The average microorganism activity was almost the same before and after treatment. It

was concluded that microorganism activity was restrained and not increased.

3.5 Expense and Efficiency

3.5.1 expense

The expense included equipment and operating costs such as energy change cost.

Equipment costs included 123 thousand yuan for 6 ozone generators, 156 thousand yuan for 6 sets of partial ventilators, 46.2 thousand yuan for some ventilation ducts.

Operating costs were mainly energy changes: the cost of 6 ozone generators with 16.8 kW and 6 axial fans with 6.6 kW. The experiment lasted about 294 hours and used 6880 kW power. 819t wheat was treated. Average cost of one ton grain was 8.4 kW or 7.56 yuan according to 0.9 yuan per kilowatt.

3.5.2 efficiency

The stored grain insects were all dead in the experiment and there was no residue, no harm to human, animals and environment, because the ozone dissociation product was oxygen. Pesticide residue in the grain was reduced because the ozone resolved the pesticide, while the grain quality remained unchanged. So it met pollution – free food requirements.

References

[1] Erdman, H. E. 1979. Ecological aspects of control of a stored product insect by ozonation. PP. 75 – 90 in: Proc. int. Work. Conf. Stored Prod. Entomol., 2nd

[2] Li changguo, et al, Discussion on application ozone against pests for grain storage, Chinese Journal of Grain andoils, 1995, (3) P1 – 5

[3] Lianda J. Masom, 1998, Controlling Stored Grain Insects with Ozone Fumigation, Proc. of the 7th int. Work. Conf. on Stored – Prod. Prot. Volume1, P532 – 547