

# Design and application of multifunctional decompression tube in grain shallow silos

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**Abstract.** Experimental study on the small, medium and large scale silos by flat silo multifunctional decompression tube puts forward the use of multi-function in the grain silo in vacuum tube dynamic which can reduce super pressure in the cylinder wall, improve the silo fumigation effect and reduce the automatic grading of grain, and improve ventilation cooling effect.

**Key words.** Shallow silo, decompression tube, dynamic overpressure, fumigation.

## 1. Introduction

The dynamic overpressure of the cylinder wall and the funnel caused by the dynamic load of the grain shallow silo has been concerned by engineers from all over the world. Engineers around the world have also found and confirmed by experiments, if the flow mode can be change when discharge the grain, so it can eliminate the phenomenon of the dynamic pressure due to discharge of the grain [1].

The reason why super normal silo dynamic pressure happened is due to overall flow phenomenon of the grain when discharging the grain out of silo. The pressure is usually 3 to 10 times higher that the static pressure and can cause the silo inner wall cracking and surface wearing. Once the wall of the silo cracked, the reinforcing bar of wall is easy to corrode, and the air tightness and insulation of the silo will be destroyed in many places. It is not conducive to the ventilation, fumigation and heat insulation of the silo, which affects the service life and storage performance of the silo directly [2].

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## 2. Cylinder storage grain multi-function vacuum tube test

The purpose of the test: inspecting the relationship between the lateral pressure of the silo wall and the pressure of the grain silo in the grain outlet. The influence of different diameters decompression tube on the side wall of the pressure. Decompression tube of the same diameter tube with different opening rates on the effect of dynamic lateral pressure of silo. Loading wheat which bulk density  $0.74\text{--}0.78\text{ tons/m}^3$ , water content being  $13\%\text{--}15\%$  in the test silo. The size and distribution of grain horizontal pressure on the wall are calibrated by the mechanical sensing elements which are arranged at the heights of 2 m, 6.5 m, 12.5 m, 18.5 m. The test silo is depicted in Fig. 1



Fig. 1. The test silo

Laboratory small simulation silo is a real silo which high of 4 meters, a cone funnel of diameter 2 m round test silo, pressure box were buried in 0.5 meters, 1 meter, 2 meters, 2.5 meters, 3 meters, 3.5 meters of the silo wall, funnel mouth can be replaced with the form of different diameters of the mouth, the middle of the cylinder wall along the height direction is a observation window, the middle of the test silo can fix different diameter circular iron tube, around the iron pipe open many holes evenly along the height direction, form the decompression tube of different opening rate; test material is wheat [3].

As can be seen from the curves in Fig. 2, when loading the grain, the horizontal pressure of the silo wall in any section of height is 1.3–2.3 times smaller than that calculated by Yang Shen formula and lower than the silo with no decompression device. Using the grain decompression tube device can eliminate the overall flow of arch and food completely.

In the case of the decompression tube opening ratios were 7.85 %, 14.30 %, 21.98 %

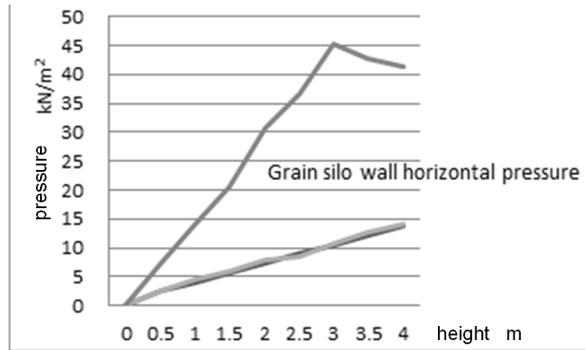


Fig. 2. Pressure exerted on wall of grain silo filled in with wheat. The curve above is Lateral pressure curve of tube wall without pressure reducing tube. The curve below is Lateral pressure curve of tube wall with pressure reducing tube.

and 31.85 %, respectively, with a diameter of 300 mm. Through the experimental observation, despite the material flew faster with the large opening ratio of the decompression tube but there are no overall flow phenomenon of material in the silo. It shows that the size of the decompression tube opening ratio has nothing to do with the dynamic super-pressure. After several tests we found that the opening ratio of the decompression tube in the case of 21.98 %, the material flow is more smooth, but also there is no dynamic over-pressure phenomenon. At the same time, we can find that when the diameter of the discharge port was larger than the inner diameter of the decompression tube, and the whole flow phenomenon occurred when discharging, that is, the dynamic over-pressure phenomenon occurred. After preliminary analysis, we can draw the following conclusion: It is an ideal state when the diameter of the discharge port is 0.7–0.85 of diameter of the decompression tube. Neither the dynamic over-pressure phenomenon occurred nor the discharge speed was affected [5].

Tests show that the distance between the lower port of the decompression tube and the discharge port should not be greater than the outside diameter of the decompression tube and the minimum distance is advisable that the last grain of the funnel can flow smoothly out of the gap.

Multi-functional decompression tube device in addition to the discharge with the elimination of dynamic over-pressure function, but also has the inner loop fumigation insecticide, reduce the automatic grading phenomenon when loading the grain, ventilation cooling and material level display system and other functions. Various functional tests were conducted in the shallow silo No. 1, National Grain Reserve, De Zhou, Shandong Province. Tests were carried out 2 years after the installation and the results are pretty good.

Shallow silo No. 1 of height 23 m, diameter 23 m, capacity 9551 m<sup>3</sup>, floor type concrete silo cone. There are 7100 t durum wheat with water content 13 % and 0.9 % of impurities in the silo.

Circulation fumigation system is a product which is based on the theory of grain

storage, aerodynamic circulation theory, chemical control theory with the use of microcomputer control technology, in strict accordance with national GB/T17913-1999 standard manufacturing system of a strong function, good safety and insecticidal effect is ideal. Automation satisfies high degree of high-tech storage and the system is environmentally friendly.

In this project, the circulation fumigation system used the fixed way of circulation pipe. The fixed pipeline is fixed on the ground and the top of the silo by the multifunctional decompression tube, a ventilator is adopted at the top of the barn, besides, the air quantity regulating valve is fixed on the top of the barn and the air quantity balance adjusting device of the fan and the air outlet is arranged on the top of the barn. Bleed air duct and circulation between machine adopt the hose connection. Recirculation fumigation system according to the whole surface of the grain silo fumigation, the whole grain silo fumigation surface without paving plastic film, the fumigation gas reactor consisting of the entire warehouse internal circulation in the grain surface and grain.

Circulation mode is inner circulation. Domain flow fumigation system consists of axial flow fan, multi-function vacuum tube and connecting pipe forming in the silo. The inner loop fumigation device is shown in Fig. 3. The fan is placed at the top of the silo, the air volume is  $300 \text{ m}^3/\text{h}$ , the wind pressure is 980 Pa, the power is 0.25 kW. In the multi-function vacuum tube, the plum blossom shaped cross section of the arc tube and a half to make closed up and down through the inner ring channel, channel are connected to the circulation fan outlet top. Within 2 meters long section at the bottom of the multi-function vacuum tube connected to a half arc chamber ventilation with the mesh panel, PH<sub>3</sub> gas from multi-function vacuum tube flows into the grain heap, through the fan air supply to the inner loop of the gas.

Before the start of the fumigation operation, the whole silo has been treated with special seal and air tightness test. The half-life of the pressure from 500 Pa to 250 Pa is 54 S, so that the effect of fumigation in silo is better.

When the grain filling and sealing work is completed, open the circulation valve, so that the medicine feeding operator in the negative pressure environment put on 3 kg of aluminum phosphide medicine bag medicine ladder imports from under-bin share tube into the ventilation and fumigation. PH<sub>3</sub> gas produced by the natural deliquescence way with the effect of fan circulation distributed within the silo evenly and rapidly. The concentration of PH<sub>3</sub> gas was measured at the beginning of each hour gradually reduced to two times a day until the end of the experiment.

We can use the original pile pest mortality to measure recirculation fumigation insecticidal effect at the same time, the test insects, the original pests and grain samples were cultured under the conditions of culture 15d or 40d, to observe whether there is a resurgence of pests, to determine the effect of fumigation in the grain of immature insects. The results showed that the mortality rate was 100 %, and there was no viable insect in 15d or 40d, while the control group cultured with 15d or 40d showed the emergence of live insects, which indicated that the effect of fumigation was good.

Loading the grain into silos is commonly in the form of scatters and throwing

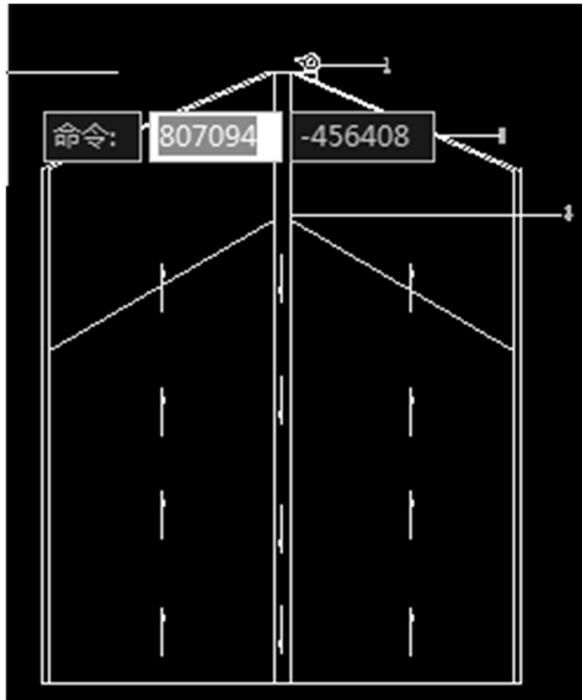


Fig. 3. Inner circulation fumigation system of shallow silo

the grain from dozens of meters high inlet directly into the warehouse, resulting in a lot of dust which is a huge hidden danger. At the same time throwing the grain into the silo, which results in serious phenomenon of grain automatic grading.

After the installation of multifunctional decompression tube, the form of loading for the grain change of orderly pipeline, which the top of the barn is connected with the outlet of the multifunctional pressure decompression tube device. The multifunctional decompression pipe dust is plum-shaped cross-section of four semi-circular arc tubes in the two symmetrical semi-circular tubes, semi-circular tube installed on the side of the screen plate. The negative pressure is generated by the dust removing fan to eliminate the dust generated when the grain is fed, turning the dust removal fan on when the grain through pipeline flow into the silo, there will be less dust. After the grain fall and then through the pressure tube around the hole into the silo, the momentum will be reduced and the automatic grading phenomenon is reduced greatly.

Ventilation cooling system is similar to the principle of inner loop fumigation. When the ventilation cooling system is working, open the bottom of the storage silo in the air inlet, the circulating fan suction will be open under the action of cold air into the vacuum chamber bottom tube of the lower section of ventilation, fumigation of common duct and then through the sieve plate 4 semi-circular arc evenly into and

across the grain. The grain will be hot air row to the top by the circulation fan discharge outside the warehouse. The warehouse grain other than similar low, no fever, mildew, vermin and caking. In the top circulating fan suction opening under the action of wind, cold air into the vacuum chamber bottom tube of the lower section of ventilation, fumigation of common duct, and then through the sieve plate 4 semi-circular arc evenly into and across the grain. The grain will be the hot air discharged to the top by the circulation fan is discharged outside the warehouse.

### 3. Conclusion

Aiming at the problems of grain silos, comprehensive domestic and foreign related equipment characteristics, combined with China's national conditions, we developed a multifunctional vacuum safe storage tube, through small and large scale production test which showed that it can solve the problems in the process of storage completely. The utility model eliminated the dynamic pressure and the automatic grading phenomenon of the silo, and the dynamic pressure and the impact force generated when the grain is loaded in and out of the silos, so as to overcome the impact and friction of the grain to the wall, the temperature measuring cable and other fixed facilities. In addition, multi-functional decompression tube can be a silo ventilation cooling, circulation fumigation and dust explosion, and the level of continuous display and alarm display, full warehouse positions. The device is advanced in design, reasonable in structure, economical and practical, safe and reliable and it is a new technology, new product with low investment, quick effect and low energy consumption.

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