The system for decreasing temperature by ventilation in grain silo

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Abstract
The necessity of augmenting the system for decreasing temperature by ventilation in grain silo is mainly described in the paper. For decreasing temperature, it is more economical and effective by using ventilation than by transferring grain from one silo to another. Three types of ventilation system used in silo were introduced. Among which, the tube ventilation is the most effective and the simplest in operation. Tube ventilation should be used as the principal type in silo ventilation. When design and management of the ventilation system, the design of air inlet, choice for ventilation chance and distribution of ventilation system should be noticed.

Introduction
For a long time, the experience of storing grain in silo is lacked because the flat storage is mainly used in China. Once grain heats up, dew and is infected by pests, grain must be transferred from one silo to another, because the silo built lacks of the necessary equipment for storage. This makes a lot of difficulties for the safe storage of grain, meanwhile, increases the lost. In order to solve the above problems, it is necessary to study the storage technology of grain in silo. The system for lowering temperature by ventilation in grain silo was discussed in this paper.

The Necessity Adding Ventilation and Lowing Temperature in Silo
Grain stored in silo is easy to be affected by the weather and humidity. The change on temperature of grain surface is obvious, on other hand, grain itself is a good insulator of heat. The heat can not easily spread. The grain is easy to heat up when affected by bad factors, such as temperature difference between the ambient and that inside the silo, the air current in grain bulk enhances. The damp-heat spread makes grain which is nearby the wall and surface dew. If heat and damp don’t be decreased immediately, it will cause heat heavily and water will transfer. If it continues, water will gather on the roof and wall, this will cause heavy loss of grain.

When grain heats up, the handling system of silo can be used to recirculate grain among silos for lowering temperature as an emergency way. The temperature of grain will rise up quickly after recirculation because potential heat has not been eliminated. If there is ventilation system in silo, ventilation can make out immediately when stored grain heats up. This can remove the heat, prevent grain from heating and from water transferring, and improve the stability for grain storage.

In addition, frequent recirculating of grain is not a good way in respect of economic aspects. The cost for transferring grain from one silo to another is about RMB 0.6-0.9Yuan/ton. Ventilation for lowering temperature costs two thirds less than recirculation and fumigation. So silo must be equipped with ventilation system for lowering temperature.

The Form of Ventilation System in Silo
The main forms of ventilation system in silo include radial and vertical ventilation. The radial ventilation refers that air duct is distributed on the wall which makes airflow cross the grain bulk in horizontal direction. The characteristics of diameter ventilation are that the airflow path is short, the system design is complex and the construction cost is high. It can be operated only if the silo is filled with grain. The vertical refers that air duct is distributed at floor of silo. The airflow crosses the grain layer from bottom to top (or from top to bottom). The characteristics of vertical ventilation are that the system design is simple, cost is low and ventilation can be carried out immediately after loading of the silo is started. But the airflow path is long, the resistance is big, and it needs high pressure fan.

According to different floor structure of silo, the vertical ventilation can be divided into two forms, that is, flat floor ventilation and hopper floor ventilation. The former includes full floor ventilation and hollow ventilation and so on. Full floor ventilation is one of the forms that found frequently in vertical ventilation systems. But the cost is high, and the extension and use is limited. The later includes parallel duct
ventilation (Figure 1) and standing duct ventilation (Figure 2). Vertical ventilation is widely used in silo in China for its low cost, easy construction and operation, and uniform airflow distribution.

**Several Problems Which Should Be Noticed During Design and Management of Ventilation System in Silo**

**Design of the inlet of air duct in vertical silo**

The design of the inlet of air duct of silo greatly affects the performance of ventilation system. Different air inlets are used in different structured hoppers. Generally there are three kinds of air inlet:

1. For parallel duct ventilation, direct hole above the angle under hopper is used as air inlet (Figure 1). It can not be used in concrete hopper.
2. The diameter of the outlet of the hopper in most of the silos is about 600 – 900mm. A steel hopper with a diameter of 300mm is often added to the concrete hopper for the convenience of unloading. In that case, the interval space can be used as air inlet of ventilation (Figure 2).
3. When hole can not be opened above the angle of hopper or hopper hole of silo is too small (diameter is only 300mm), the exchange equipment of inlet and discharge is recommended (Figure 3). It consists of two cylinders. By rotation of inner cylinder, unloading of grain and ventilating is shifted. It has been proven to be a simple and effective type of air inlet.

**Distribution of ventilation duct**

In order to ensure effective ventilation, distribution of ventilation duct must be made according to ratio of distances. When ventilation by duct, the distance between ducts where ducts collect should be noticed. Too small...
Determination of specific air volume

Because of the special structure of silo, ventilation of silo can only be used to decrease grain temperature with small air flow rate, but it can not be used to dry grain. Increasing air volume will increase resistance of grain layer. There is success in ventilation by weak air, it can ensure safety of stored grain. It has been proved by the results of electrical simulated test (Zhang Lailm 1992)

Determination of super-facial air velocity

Duct diameter is determined generally by air velocity in duct. Duct apparent air velocity is used to collate duct diameter in design. In order to minimize the system resistance, the super-facial velocity of the duct shall be less than 0.15m/s and the perforated ratio of the air ducts shall be as big as possible.

Ventilation at appropriate time is important in ventilation management, it relates to effect of ventilation.

Equilibrium moisture theory of grain is the base for the selection of appropriate ventilation time. Ventilation must accord with the following temperature and humidity condition. If any condition can not be fixed, ventilation should be stopped.

Humidity condition: According to atmospheric temperature and humidity, the equilibrium moisture content of grain can be calculated. Compare the equilibrium moisture content with grain moisture content, if the former is less than the later, ventilation will not increase the grain moisture content, ventilation can be made; if the former is greater, ventilation will increase the grain moisture content, ventilation can not be made.

Temperature

When average temperature of grain bulk is 8°C greater than atmosphere temperature, ventilation effect is obvious, ventilation can be made.

If the following conditions are fit, ventilation can be stopped: I. When the difference between average temperature of grain bulk and atmospheric temperature is less or equal to 4°C, continuous ventilation has no obvious effect. II. Gradient of grain bulk temperature is less than or equal to 1°C/m. III. Gradient of moisture content of grain bulk is less than or equal to 0.3%/m.

There are two forms of fan working, that is, press and suction. Ventilation form should be adopted according to practical condition. If grain in the top heats up, ventilation by suction on top of the silo or by blowing on the bottom of the silo should be adopted. Because cold air enter grain bulk from bottom of silo, grain in bottom is first cooled, damp and hot waste gas goes away from the top directly, the effect of lowering temperature is good.

Operating management of ventilation

Silo provided with good ventilating system guarantees the safe storage of grain. The ventilation system is effective only if it is performed properly. Therefore, in practice, ventilation is determined according to the change in the ambient temperature, the grain temperature and temperature of air in the headspace of the silo. If ventilation is to be conducted, first the appropriate ventilation time shall be determined; second, the surface of the grain bulk shall be leveled; third, all the outlet of air shall be opened for the easy exhausting of waste air and avoiding water condensing on the surface of grain bulk; fourth, ventilation shall be implemented in several steps to decrease the grain temperature gradually, and to prevent water condensing in grain bulk; fifth, insects are found in the silo, a recirculating ducting system can be added to the silo forming a closed loop system to perform fumigation.

Conclusions

Ventilation for lowering temperature is an important way to keep safety of stored grain. Silo auguring ventilation and lowering temperature system can eliminate temperature difference, balance grain temperature and increase stability of stored grain. For lowering temperature, ventilation is more economical and effective than recirculation of grain among silos. Nowadays, ventilation in silo have three forms, vertical ventilation has the first priority for its less cost, simple operation and good effect. But the resistance of vertical ventilation is great, it should be considered when choosing fans. When design and management of ventilation system, the rule 'safety, effective, economical' should be obeyed. Design of air inlet, appropriate time of starting ventilation and the operation of ventilation shall be fully considered.

References

