Storage

Silo aeration improves harvest flexibility

CSIRO Stored Grain Research Laboratory scientist James Darby explains why on-farm aeration has the potential to provide grain growers with more post-harvest management and marketing options and how the range of systems available could improve grain quality.

On-farm aeration of grain offers growers greater flexibility at harvest and has the potential to improve the final quality of the grain produced.

Use of aerated storage in Australia by growers and bulk handling companies is increasing due to deregulation of the domestic marketing and storage sectors and the success of break crops such as canola.

But CSIRO researchers believe the potential for aeration to improve growers' grain marketing options is yet to be reached.

There are three categories of aeration: aeration drying, aeration cooling and aeration maintenance. Depending on the specific aeration rate and control system used, aeration can dry grain, suppress self-heating, even out moisture and temperature, cool and change the air spaces between grain (see Figure 1).

The benefits of on-farm aeration to growers include more control over grain quality during storage, chemical-free suppression of insects, the capacity to dry wet grain, and prevention of storage–induced spoilage. Systems which integrate aeration and fumigation are on the drawing board.

Conditions for aeration

Grain aeration is the pumping of naturally occurring (ambient) air through a static grain bulk. It is usually carried out in a silo or shed using an arrangement of ducts, exhaust vents and fans to move air through the grain.

The aeration air is selected from the local ambient air by using an automatic controller, although growers often use timers, thermostats and manual selection.

Scott Boyle

Silo aeration systems such as drying, cooling and maintenance can offer grain growers improved flexibility and marketing options at harvest time and provide more control over grain quality.

Aeration allows grain moisture and grain temperature to be changed. These fronts are pushed through the grain bulk from the air inlet to the outlet at different speeds. For cooling, the air within the grain is exchanged up to 1500 times, while drying can exchange air up to 100,000 times.

The rate at which these temperature and moisture fronts move depends on the flow rate of the aeration system's fan relative to the amount of grain stored. This relative flow rate is referred to as the specific aeration rate measured in litres per second per tonne (L/s/t).

The final grain moisture or temperature conditions achieved depend on the air conditions selected and the moisture and temperature condition of the grain as it enters the storage.

Naturally occurring air conditions vary across Australia according to climate, location, time of the year, and time of day. If the design of the aeration system or type of controller used is not adequate then final grain conditions can vary.

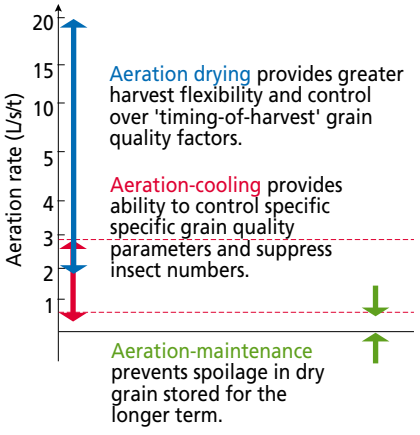
Range of systems

Aeration drying systems target a final grain moisture measurement and can dry grain at any time of the year, particularly during autumn and early-winter harvest periods common for summer crops.

Growers can achieve harvest flexibility and control more grain quality factors, depending on the timing of harvest. Aeration drying is important in summer crops and coastal grain harvesting regions. The benefits of aeration drying include:

- Harvesting at high moisture contents for safe storage.
- Early harvesting to achieve high grain-quality levels (legume colour, malt grade) and to avoid paddock losses (weather damage, shedding, lodging, birds and rodents).
- Drying of wet grain to meet receival standards of buyers.
- Capacity to direct harvest wet grain to avoid windrowing.

FIGURE 1 Aeration functions



Aeration drying systems target a final grain moisture and have the capacity to dry the drain during the autumn and early winter harvest period. This category is particulary relevant to summer crops and coastal grain harvesting locations.

Aeration cooling systems target a final grain temperature and have the capacity to cool the grain during summer. This category is most relevant to winter cropping.

Aeration maintenance systems are the most efficient for reliaby controlling storage losses without excess investment in capacity.

Source: CSIRO Stored Grain Research Laboratory.

in brief

- On-farm aeration offers grain growers increased flexibility at harvest time and improved marketing options.
- There are three categories of aeration: aeration drying, aeration cooling and aeration maintenance.
- Aeration changes grain moisture and temperature conditions in a storage unit to improve grain quality and reduce losses.
- A key factor in aeration performance is local weather conditions.

- A longer harvest day which reduces the risk of weather damage.
- Prevention of field moulding and toxin formation.
- Removal of respiration heat of wet grain.
- Reduced deterioration of wet grain before rapid drying.

Installing aeration drying into an existing storage can be a low-cost option.

Aeration-drying systems are most appropriate for steady drying when the drying process can take 1–6 weeks, and where drying loads are not excessive (for example, less than four per cent).

Rapid drying for a few days with an aeration drying system can be costly and inconsistent. Aeration drying large moisture loads during several weeks can cause moulding problems.

When high-moisture grain is stored and aerated, mould will grow in any part of the bulk that is not dried. Moisture and temperature largely influence the rate moulds develop in bulk grain. Cereals stored at more than 14% moisture content and 25 degrees Celsius provide favourable conditions for mould development.

Aeration drying systems need to push the temperature and moisture fronts throughout the grain bulk to stop mould growth.

The higher the seed moisture content and temperature, the more rapid the rate of air flow needs to be to prevent moulding. Smaller aeration rates of 4–7L/s/t will not dry large moisture loads.

Cooling

Aeration cooling systems can cool grain at any time of the year, particularly during summer. This system is most relevant for winter cropping.

The benefits of aeration cooling include:

- Evening out of the moisture of inloaded grain.
- Suppresses insect infestation.
- Maintains oil quality (free fatty acid, rancidity, colour and odour).
- Maintains malting barley grade.
- Seed cooling ability maintains germination vigour of seed.
- Reduces need for chemical insecticide treatment.

The period in which significant loss can occur is longer (2–8 months) compared with drying and the design requirements are more flexible. Fan size, air-flow distribution, and control are less critical compared with drying but are still important.

Maintenance

Aeration maintenance systems prevent storage spoilage caused by seasonal weather change, low-level insect heating, or slow biological respiration.

These systems are the most efficient for reliably controlling storage losses in dry grain stored long-term, without excess capital investment. Maintenance systems are also ideal for integrating with fumigation systems. The benefits of aeration maintenance include:

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Kit aeration systems are often used on smaller storage units for cooling and maintenance. The specific aeration rates of these systems are 1–3 litres per second per tonne.

- Evening out of temperatures in the grain bulk.
- Removes heat from respiration of grain, insects and moulds.
- Prevents localised hot spot development.
- Maintains grain freshness and presentation.
- Prevents moisture migration and surface crusting.
- Maintains free-flowing characteristics of grain.
- Prevents condensation on cold walls and floors.
- Increases grain marketing flexibility.
- Rapidly removes fumigants from stored grain.

Aeration maintenance slows or prevents grain spoilage through the process of convection or moisture diffusion, which can increase during storage over the cooler months

The period for significant loss ranges from five months to more than nine months. This is substantially longer than cooling and the design requirements are more tolerant accordingly.

On-farm potential

Grain conditions need to change within a specified time frame to improve grain quality and reduce losses.

For example, the major aim of canola cooling is to prevent oxidative spoilage of its oil during longer term storage such as more than six months. This means reducing the seed bulk temperature to less than 25°C soon after harvest.

If only 60% of the grain bulk is cooled due to inappropriate control, non uniform airflow distribution; or an under-capacity system, downgrading of the entire canola bulk in storage will occur.

Different types and sizes of systems match the benefits sought. Generally, larger capacity systems need a dedicated design. The requirements for aeration drying are more precise than for cooling, which are more precise than for maintenance. This is a result of the different rates at which quality-related changes occur in the stored grain.

A given design may suddenly perform poorly if the inloaded grain moisture or temperature exceeds the original design levels. This is not uncommon with the seasonality of grain production.

A key factor in aeration performance is its dependence on the local weather. Weather can affect performance, especially reliability, and is highly variable and difficult to predict.

When the aeration benefits sought are more specific or require a high-capacity system, the influence of the weather is more critical.

Poor weather causing ineffective aeration is a major risk with aeration drying, even with a well-designed system.

The CSIRO Stored Grain Research Laboratory is working closely with aeration equipment suppliers to develop advanced control approaches to reduce weather risk by maximising the continuous selection of suitable air.

Currently dedicated controllers for aeration drying or aeration maintenance are not available. The popular time-proportioning controller, which is currently available, offers a compromise between the cooling and maintenance functions.

Aeration costs

The capital cost of an aeration system and its components is often the most critical issue for growers. As a result of the variable nature of grain production in Australia, aeration systems are usually costed on returns expected for one season (the first).

Based on one year of use, aeration maintenance systems are typically $3–5 per tonne, cooling systems $6–12/t and drying systems $10–30/t.

But factors such as power availability, noise pollution constraints and inflexible grain handling arrangements can increase these costs dramatically.

Operating costs range from 10–50 cents/t for maintenance, 30 cents–$2/t for cooling, and $2.50–14/t for drying.

The dollar return for the benefits can range from the operating cost to the capital cost.

Depending on what benefits growers want to achieve, specific grain conditions must be obtained throughout the storage unit and in a given length of time to maximise the return on investment.

For more information contact James Darby, CSIRO Entomology Stored Grain Research Laboratory, by email on james.darby@ento.csiro.au, phone (02) 6246 4197 or fax (02) 6246 4202.