Global grain storage

Overcoming geographical & environmental challenges

by Andrew Wilkinson, Milling & Grain magazine

Globally, about one-third of the food produced for human consumption is lost or wasted. In developed countries, much of that loss is the result of consumers throwing away millions of tonnes of edible food each year.

In the developing world, most loss occurs either in the field before a crop is harvested, during harvest, handling or afterwards through inadequate storage facilities.

Storing harvested grain in silos is not only a reliable approach for securing good prices, owing to the automation of grain transport, they are also cost-effective, as they result in lower long term operational costs. It comes as no surprise then that the cost-effectiveness and large holding capacity of silos is driving the global sales of grain storage silos.

Such economic incentives mean grain is often stored for long periods, prior to processing. During this time, grain quality and safety may deteriorate without appropriate intervention - particularly when the location where the grain is to be stored presents its own unique set of challenges.

Securing crop quality & price

Throughout the world, where crops are farmed and grain is stored, operators are coming up with new and inventive ways of securing the quality and indeed the price, of their crop. This article will take a look at just a few examples of where they have got especially creative.

Though Covid-19 has impacted the silos business, there was no significant impact on the supply chain and global operations of silos. This is largely due to the widespread exemption of food and agricultural services from lockdown restrictions, meaning that the grain storage silos market was less affected by the pandemic.

The growing demand for grain storage from the leading grain-producing countries in the world, namely, the United States, Russia, India, Brazil, and others, has also been a big driver of grain silo sales during this period. Of these nations, America accounted for the largest share in the grain storage silos market in 2019, with the market concentration of grain storage silos being high.

According to statistics from the International Grains Council (IGC), the global stocks of wheat increased from 171 million metric tonnes in 2012-2013 to 268 million metric tonnes in 2017-2018, and in 2020, the stock accounted for 278 million metric tonnes.

With an increase in stored grain comes a somewhat predictable increase in demand for storage capacity. This combined with space being at a premium and the associated rise in storage costs across the world, the storage industry continues to enjoy a period of growth - particularly in North America.

When this particular region heads into winter, operators are always very mindful that if they harvest grain when the weather is hot and dry, bringing its temperature down prior to placing it into silos is of key importance. This is because doing so will ensure that it remains safely stored and doesn't spoil through the colder months.

Storing grain in cold climates

When storing grain in cooler climates, if the grain's moisture content is too high, then you will need to lower its temperature

prior to placing it in storage. This is because when the bin is first filled with grain, moisture content and temperature are relatively uniform throughout the bin.

However, as outside temperatures start to drop, this soon changes – so continuous monitoring of various parameters will be required. This is because as the ambient temperature outside the bin starts to drop, the bin walls will start to cool, which then cools the adjacent grain along with the air inside the bin.

As illustrated in Figure 1, the cool air then creates a current that is conducted downwards through the grain, travelling along the outside perimeter of the grain mass. This air current then transfers inward towards the centre of the bin, where it is warmed by the grain.

As the air warms, it starts to move upward in the centre of the bin and picks up moisture from the grain before carrying it to the top of the bin, where it starts to cool again. This results in a high moisture zone at the top centre of the bin, which is where we can expect spoilage to occur if it is not dealt with swiftly and comprehensively.

In order to prevent this from happening at all, the grain temperature in the bin should be lowered to, or just slightly below, the average ambient temperature for that time of year. This lowered temperature should then prevent the downward movement of the colder air, thus avoiding the formation of unwelcome and often ruinous condensation.

Preserving grain quality in warmer climates

Like with stored grain in cooler locations, the conditions need to be kept as stable as possible in warmer regions too.

Conical cereal silos near Acatlán, Hidalgo, Mexico.

This is because allowing grain to warm to average outdoor air temperatures during the summer can lead to insect infestations and mould growth, with the optimum grain temperature for insect activity being between 70 and 90 degrees.

Therefore, reducing grain temperatures to below 70 degrees should reduce the rate of insect reproduction and activity, with temperatures below 60 degrees reducing this even further.

A further challenge caused by the effects of the hot sun shining on the bin roof for several hours a day. The issue here is that the endless solar rays cause the temperature of the air above the grain to increase. The effects of this are then worsened by convection currents in the grain that flow up along the bin wall and down into the grain near the top middle of the bin, drawing this solar heated air down into the bulk of the grain.

One course of action to take would be to ensure that the space between the grain and the bin roof is well ventilated. This step can reduce the amount that the grain near the top of the bin is warmed. If the bin has openings near the eave and peak, then this more natural form of ventilation can also cause this space to cool.

This is largely because these openings work like the vents in a building's attic - the heated air rises and exits near the peak, drawing in cooler air near the eave. Roof exhaust fans controlled by a thermostat can also draw the heated air out of the bin if openings are available to allow air into the area above the grain.

A further step that operators in a warmer climate could adopt is the unloading of some of the grain periodically in order to remove the warmed or "peaked" grain from the top of the silo, thus reducing the potential for the grain at the top of the bin to become warm and spoil.

Like with cooler climates, ensuring grain how the correct moisture content is important in warmer temperatures too. The market moisture content may be higher but storing warm grain at higher moisture contents may lead to mould growth on the grain.

The recommended long-term storage moisture contents are: 13.5% for wheat, 12% for barley, 13.5% for corn, 11% for soybeans and 13% for grain sorghum.

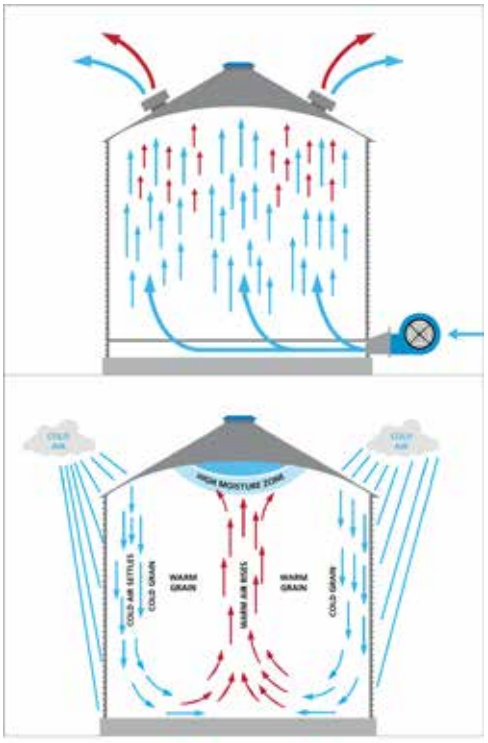

Figure 1: Moisture movement in stored grain as the result of temperature variations

Storage in Africa

In Eastern and Southern Africa, maize provides food and income to more than 300 million smallholder farmers in the region. After harvest, farmers typically remove maize grains from the cobs by hand, dry them in the sun and then store them in sacks kept in their home, in a shed or a traditional store.

Cereal grains constitute about 55 percent of the African food basket and present a challenging task towards its preservation and storage. Storage is particularly important in Africa because agricultural production is mostly seasonal, whilst the demand for agricultural commodities is more evenly spread throughout the year.

This creates a situation where demand on the average day is met by storing excess supply during the harvesting period for release into the market during the off-season period.

The storage methods used on this continent include rhombus, traditional cribs, underground pits, open stack storage, woven baskets, grain silos, farm store, communal warehouses and domestic storage techniques.

Some farmers are able to apply pesticides, such as actellic dust, to their stored grain but these are expensive and need to be reapplied every few months to be effective. In fact, most of the storage methods experience the problem of insect infestation though at varying levels depending on the structure.

Therefore, the use of metal silo is the most effective method of storing grains in Africa, with a very high rate of use in South Africa. Despite this fact, it still has the lowest adoption level in Africa as a continent.

Consequently, it is common for 20-30 percent of the region's maize crop to be lost to storage pests each year. For families already living on the edge in terms of food security and income that loss represents a major problem.

Fortunately, metal silos have been more widely adopted throughout Africa in recent years. Organisations such as the Effective Grain Storage Project (EGSP) have trained local African artisans to construct metal grain silos from 0.5 mm thick galvanised metal sheet. The small cylindrical drums, with a storage capacity of 90 kilograms to 1.8 tonnes, have soldered seams, making them airtight and impervious to pests such as weevils and rats.

First piloted in Kenya and Malawi, the effectiveness of the silos has been tested alongside traditional and alternative modern storage methods and are showing promising results.

Storage system in Europe

Returning to cooler climes, the following is a case study of an installation required for the storage of grain for a company in Germany carried out by Bentall Rowlands.

Constructing this Eurocode designed silo facility, in white with a green band (pictured) came with engineering challenges. Most notable amongst these being the fact that the area available for the silos was very limited.

Faced with a number of obstacles to overcome, the company designed and manufactured a 13.5 metre diameter silo specifically designed to meet the requirements of the customer.

In order to conform to the local planning requirements, each of the silos also received a powder coat finish that was applied to the treated galvanised steel. This extra coating will also provide an extra layer of protection, in addition to the sheet galvanisation that is already in place.

For a further project carried out by the Bentall Rowlands, the end user was a Belgium based animal feed company. Their requirement was for a silo to be used for the storage of raw material prior to it going to the processing plant.

In order to meet this brief, the company erected two five metre diameter 10.5 ring hopper bottom silos each holding 200 tonnes and a 1.2 metre wide top catwalk. The catwalk was connected to the existing building and produced a galvanised steel stairwell to allow access for workers on-site.