Minimize Shrink from Grain Drying and Aeration

Dry grain stored at cooler temperature has the minimal risk of spoilage from mold contamination and can be safely stored for longer periods (6-12 months). Freshly harvest grain is dried to safe storage moisture levels and then aerated (cooled) to nearly 35°F temperature for long term holding. For in-bin-drying, warm and dry air with high water holding capacity is preferred since cool air has lower drying potential due to its reduced water holding capacity. At the completion of in-bin grain drying (also throughout the drying) grain is usually warmer than recommended temperature for long term safe storage. Aeration is the process of cooling the warm grain which has already been dried to safe storage/straight grade moisture levels. In aeration grain is assumed to have reached the target moisture levels and the objective is to cool it to nearly 35°F without further reducing its moisture content causing shrink.

Shrink

‘Shrink’ is the grain weight loss that occurs during handling, drying, aeration, and storage (quality loss as dry matter loss). The weight loss during handling, over-drying in mechanical (high temperature) and in-bin drying, and storage are considered significant. However, ‘shrink’ due to grain moisture loss in ‘aeration’ process is often neglected by farmers which could result in significant losses.

Moisture Shrink

Shrink in this article is exclusively referred to as weight loss in the grain due water removal as result of over-drying in high temperature drying, in-bin natural air drying, and aeration. In simple terms, shrink is estimated based on the assumption that all the weight loss during these conditioning processes is the moisture loss only. The shrink loss is calculated by dividing the weight of moisture lost during conditioning divided by the total initial grain weight. The calculated shrink is often represented in percentage by multiplying this ratio by 100. The following examples shows the shrink loss for 10,000 lb corn at 15.5% wet basis (wb) which is over-dried to 14.5% (wb) and 13.5% (wb) in aeration and drying process, respectively. The maximum permitted moisture for the U.S. No. 2 grade corn is 15.5% (wb) (corn is typically priced for U.S. No. 2 grade) so it was assumed target moisture.

In 10,000 lb corn at 15.5% moisture, the amount of total water present is:

Weight of water (lb) = 10,000 lb × 15.5/100 = 1550 lb

The weight of dry matter (lb) = 10,000 lb – 1550 lb = 8450 lb

When the corn is over-dried to 14.5%, the weight of dry matter will remain same but the weight of water will reduce as the grain weight loss is due to moisture removal.
So, the total weight of corn when over-dried to 14.5% is:

Total grain weight = Weight of water + Weight of dry matter
Total grain weight = \( w \text{ lb} + 8450 \text{ lb} \) (assuming weight of water is reduced to \( w \) lb after drying to 14.5%)

Therefore,

Final moisture content (\%) = \( \frac{\text{Weight of water}}{\text{Total grain weight}} \times 100 \)

\[
14.5 = \frac{w}{w + 8450} \times 100
\]

\[
0.145 \times (w + 8450) = w
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\[
w - 0.145w = 1225.25
\]

\[
0.855w = 1225.25
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\[
w = \frac{1225.25}{0.855} = 1433 \text{ lb}
\]

Hence, the total water loss due to over-drying of corn to 14.5% from 15.5%:

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= 1550 \text{ lb} - 1433 \text{ lb} = 117 \text{ lb}
\]

**Shrink loss**

\[
= \frac{\text{Water loss}}{\text{Initial weight}} \times 100
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\[
= \frac{117 \text{ lb}}{10,000 \text{ lb}} \times 100
\]

\[
= 1.17 \%
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Similarly, we can calculate shrink loss for over-drying corn to 13.5% from 15.5% which will be about 2.31%. Though these losses seem to be a small percentage but they would result in significant savings as shown in Table 1 and in example below for corn (Grain with higher $ value such as soybean the savings would be twice).

Example,

1,000,000 bu of corn over-dried to 14.5% from 15.5% (1.17% shrink loss) would result in total water loss of:

\[
= 1,000,000 \times \frac{1.17}{100} = 11,700 \text{ bu}
\]

With corn priced at $6/bu, this could result in potential savings of:

\[
= 11,700 \times 6
\]

\[
= 70,200
\]
Table 1: Shrink loss calculation and potential saving estimates for corn

<table>
<thead>
<tr>
<th>Grain in bu</th>
<th>Water loss, bu</th>
<th>Potential savings ($)*</th>
<th>Grain in Bu</th>
<th>Water loss, bu</th>
<th>Potential savings ($)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>10,000</td>
<td>117</td>
<td>702</td>
<td>10,000</td>
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<td>1,386</td>
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<tr>
<td>25,000</td>
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<td>50,000</td>
<td>1,155</td>
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<td>5,775</td>
<td>34,650</td>
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<td>35,100</td>
<td>500,000</td>
<td>11,550</td>
<td>69,300</td>
</tr>
<tr>
<td>1,000,000</td>
<td>11,700</td>
<td>70,200</td>
<td>1,000,000</td>
<td>23,100</td>
<td>138,600</td>
</tr>
</tbody>
</table>

*Corn priced at $6/bu (Based on Manhattan Coop September 1st, 2013 price)

Manage Shrink
The calculation in previous example and Table 1 show that there is huge potential for significant savings by minimizing the shrink loss in drying and aeration.

In-bin Drying
In natural air in-bin drying, several factors could lead to shrink loss. Traditional way of running the fan continuously often results in major shrink loss as bottom layer highly over-dries by the time top grain reaches the target moisture. Fan control strategies that only allow the fan to run when good quality air with drying potential is available can significantly reduce the shrink by uniformly drying the grain with minimum moisture spread. Fan controls in IntegrisPro allow the fan to run when plenum air equilibrium moisture content (EMC) is in the desired range. The fan does not operate below lower EMC band which minimizes over-drying and shrink loss. Sometimes in hot and dry ambient conditions, EMC may not be in the target range for significant portion of the day reducing fan run time per day leading to the extended drying time (calendar-wise). Self-adapting variable heat (SAVH) control strategy in IntegrisPro uses a lower EMC band initially to increase the daily fan hours and then rehydrates the bottom layers by moving up the lower EMC band.

Insufficient and non-uniform airflow rate is another significant factor that may cause the shrink. If airflow rate is insufficient (< 0.5 cfm/bu), the drying time (total number of fan hours) may increase 2-3 times compared to drying time with recommended 1 cfm/bu airflow rate. The increased fan run time will over-dry the bottom layers causing the shrink loss while top grain moisture may remain unchanged/under-dried. Non-uniform airflow distribution may also cause significant shrink loss. Bins are sometimes peaked
with higher concentration of broken, fines, and foreign materials accumulated around the ‘core’ causing increased resistance to airflow. Since, air flow takes the path of least resistance; airflow rate may be 2-3 times higher near the bin side walls (with shallower grain depth and less fines, broken and foreign material) compared to the central core. Therefore, drying of grain in around core will take 2-3 times longer to reach the target moisture compared to the grain near bin walls. Due to this increased fan run time, grain close the bin walls will be highly over-dried by the time grain around central column reaches the target moisture causing major shrink loss and excessive energy consumption. To minimize the shrink loss, grain bins should be cored and if possible the grain should be leveled.

Heaters installed in the grain bins are often operated with misunderstanding that additional heat will accelerate the drying in cold weather. However, the objective to add small amount of supplemental heat is to reduce the humidity of highly humid air so that plenum EMC is in the desired range. Running the heater when the ambient relative humidity is below 70% will significantly reduce the plenum EMC resulting in over-drying and high shrink loss. Increasing the amount of heat (>12-15°F temperature rise) also does not accelerate drying process and only results in increased shrink.

Aeration
The objective of aeration is to cool the grain which has been dried to a safe storage target moisture level. Traditional way of aerating the grain by running the fan continuously or in multiple cooling cycles (2-3) could result in excessive fan run time and large shrink. A fan control based on running the fan below a set temperature (e.g., below 60°F in early autumn and below 45°F in late autumn) or when ‘ambient air daily average temperature is 10-15°F below the grain temperature’ is not an efficient way of aerating the grain. It ignores the effect of fan warming, particularly, in tall bins, where fan warming could be 5-8°F resulting in increased plenum air temperature. Also, this strategy does not consider ambient RH (thus EMC) so the cooling may be achieved but there could be significant shrink loss (Table 1 shows the $ value of 1% of over-drying). Aeration fan control strategy in IntegrisPro considers both air temperature and EMC so that fan only operates when EMC is close to the grain moisture and grain can be cooled to the target temperature (35°F) without over-drying and shrink loss. The IntegrisPro aeration fan control strategy consumes less fan hours compared to aeration in multiple cycles.

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grain assets. We are the recognized world leading supplier of grain storage management solutions. In 2014 OPI launched OPI Blue - putting 30 years of grain monitoring expertise in the palm of your hand.