Reducing Grain Drying Costs

Scott Sanford
Sr. Outreach Specialist
University of Wisconsin

Focus on Energy / Rural Energy Issues
Background

- Corn
  - US production 2004
    - 11,807,217,000 bushel
    - 73,632,000 acres
    - 160 bushels per acre
    - Average Market Price: $1.95 per bushel
  - L.P. Gas (rural areas), Natural gas & Electricity
- Drying costs
  - 2005 – 30 to 35% higher than 2004
  - 2004 – 25% higher than 2003
- Record diesel fuel prices
- Low cash prices – $1.40 to 1.77 per bushel
**Why Dry?**

Reduce moisture content so grain will not spoil.

<table>
<thead>
<tr>
<th>Storage Period</th>
<th>Corn</th>
<th>Soybeans</th>
<th>Small grains</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fed by early Spring</td>
<td>18%*</td>
<td>13%</td>
<td>13%</td>
</tr>
<tr>
<td>Fed or marketed by June</td>
<td>15.5%</td>
<td>13%</td>
<td>13%</td>
</tr>
<tr>
<td>Stored up to one year</td>
<td>14%</td>
<td>12%</td>
<td>13%</td>
</tr>
<tr>
<td>Stored more than one year</td>
<td>13%</td>
<td>11%</td>
<td>13%</td>
</tr>
</tbody>
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* If maintained at temperatures less than 40 F
Dry Clean Grain

- Screen before drying
- Screen before storage
  - Less volume to dry
  - Increased air flow in dryer
  - Less materials to plug screens and aeration floors
Dryer Energy Efficiency

- No dryer performance standards
- Limited independent dryer test data
- Limited research data

- Buyer beware!

- Rule of thumb fuel usage
- - High Temp. dryer w/o heat recovery
  - 0.02 gallon propane/ bushel / % moisture removed
  - 0.018 Therms NG / bushel / % moisture removed
  - 0.01 kWh Electricity
Types of Dryers
Names reflect air flow pattern

- Cross-Flow Column Dryer
  - (batch and continuous)
- Batch bin dryers (high temperature)
  - Bin Dryers
  - Roof Dryers
- Mixed-flow dryers  (Counter and concurrent flow)
- In-Bin Continuous flow dryers  (Counter-flow)
- Ambient Air / Low temperature bin dryer  
  (10°F increase in air temperature)
- Combination drying
Conventional Crossflow Column Dryer
In-Dryer Cooling
Cross-Flow Column Dryer

Diagram showing the relationship between airflow rate (100 CFM/BU), drying temperature (°F), and total energy (BTU/lb of H₂O evap) for crossflow dryer drying corn from 25 to 15% wet basis.
Cross-flow Column Dryer
Heat Recovery Options

Scavenge Heat from hot corn to pre-heat inlet air to dryer
  ● Reduces energy usage 10 to 20%

  ● Duct exhaust air from cooling section to air intake of heater
    And (optional)
  ● Recovered from lower portion of drying section of dryer

    Or

  ● Reverse air flow through Cooling Section of dryer
Duct Work for Heat Recovery

Retro-fitting Dryer with Heat Recovery

Heat Recovery Cooling section
Access needed for cleaning screens

Duct to Dryer Air Intake
Heat Recovery Lower Heating Section And Cooling Section
Reverse Flow Cooling

Courtesy of Zimmerman Dryers
BATCH-IN-BIN DRYING EQUIPMENT

ROOF HATCH

GRAIN SPREADER

L.P. GAS HEATER

POWER SWEEP AUGER

UNLOADING AUGER

PERFORATED DRYING FLOOR

Reference: On-Farm Drying and Storage System, ASAE Publication
Batch Bin Dryers

- High temperature dryer
  - Typical drying temperatures 100 - 160°F
- Stirring device
  - Reduce drying costs by up to 25%
  - Reduces over-drying
  - Run continuously during drying
  - Remove fines from floor before next batch
- Important to screen out fines
  - Restricts air flow through floor
Bin Dryer with stirring device

Fig 3-14. Batch-bin dryer with stirring.
Mixed-Flow Dryer
Mixed Flow Dryer - Air Flow Patterns

Grain Flow

Grain Flow

Grain Flow

Grain Flow

Grain Flow

Grain Flow

Grain Flow

Grain Flow
IN-BIN CONTINUOUS FLOW DRYING EQUIPMENT

Figure 3.26—In-bin continuous flow drying equipment.

Reference: On-Farm Drying and Storage System, ASAE Publication
In-Bin Continuous Flow Dryer Options

Fig 3-18. Continuous flow bin dryer. A transfer auger moves grain intermittently to cooling in storage bins.

Fig 3-19. Continuous flow recirculating bin dryer. At least one more storage bin equipped to properly cool hot grain is common.
In-Bin cooling

3-6a. With high temperature self-contained dryer.

3-6b. With high temperature bin dryer.

Fig 3-6. In-bin cooling.
Grain dried in a high temperature dryer or bin and cooled in a separate storage.
In-Bin Cooling

- Used with high-temperature full-heat dryer
  - Continuous-flow or batch
- Transfer hot grain (120 to 140°F) to storage bin
- Moisture: 1 to 1.5% above desired storage moisture
  - Remainder of drying occurs as grain cools
  - Moisture reduction: ~0.2% per 10°F of temperature decrease
- Start cooling fans immediately
- Reduce fuel costs at least 10-15%
- Increase dryer capacity about 33%
  - Batch dryer – reduces batch time by 15-30 minutes
  - Continuous-flow - ~50% more area for drying
Dryeration

Dryeration Bins
Delay cooling for at least 4 hr, preferably 12 hr.
Dryeration

- Transfer hot grain (120 to 140°F) to cooling bin
- Moisture: 2-3% above storage moisture content
- Grain allowed to “Temper” for 4 to 12 hours
- Cool grain
  - Remainder of drying occurs as grain cools
  - Moisture reduction: ~0.4% per 10°F of temperature decrease
- Transfer grain to storage bin

- Energy savings: 15% - 25%
- Dryer capacity: increases up to 70%
- Improved grain quality
  - Fewer stress cracked kernels and breakage

<table>
<thead>
<tr>
<th>Method</th>
<th>Cracks</th>
<th>Breakage</th>
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<tbody>
<tr>
<td>Rapid cooling</td>
<td>43.6%</td>
<td>11.3%</td>
</tr>
<tr>
<td>Dryeration</td>
<td>7.6%</td>
<td>6.7%</td>
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</table>
Fig 3-8. Typical dryeration 24 hr cycle with 2 bins.
Reference: On-Farm Drying and Storage System, ASAE Publication
In-Bin natural or low heat drying

- Forces ambient or warmed air (10°F temperature rise) through grain bed
- Batch / layered drying
- Energy efficient if dry weather
  - Early harvest advantageous
- High fan horsepower requirement over extended time
  - Three 10 HP blowers for 10,000 bushel bin
  - 30 to 45 with good weather - 90+ days if wet
  - 1.25 cfm per bushel minimum
- Energy: 100% electricity
- Maximum grain moisture ~ 22% - 24%
- Only handle grain once
- Stirring device – saves 20 – 25% in energy costs
  - Reduces over-drying
  - Increases air-flow
  - Stirring 2 or 3 times maximum recommended
  - Over stirring can reduce air flow
Combination drying

3-9a. With wet holding and high temp self-contained dryer.

3-9b. With high temperature bin dryer.

3-9c. High and low temperature drying in one bin. Fan, heater, and stirrer dry grain to 20%, then the fan alone finishes drying with unheated air.
Combination Drying

- High Temperature drying down to 20-22% moisture
  - Continuous-flow or batch
- Transfer hot grain to low temperature bin dryer
- Start fans immediately and dry using natural air
  - Don’t Delay fan start!!!
- Capital cost higher – fans needed on all bins
- High drying capacity
- High quality grain
- Uses more electricity but less LP or natural gas
- High energy efficiency –
  - ~ 50% of energy use for cross-flow dryer
  - ~ 75% LP gas or Natural gas
  - ~ 25% electricity
Comparison of cooling / drying methods

- In-dryer cooling $28.85 / 100 bu
- In-bin cooling $25.18 / 100 bu (12%)
- Dryeration $20.90 / 100 bu (27%)
- Combination drying $18.85 / 100 bu (35%)

Assumptions:
- Corn dried from 25.5% to 15.5%
- Energy Costs only
- Electricity $0.085 / kWh
- LP gas $1.40 / gallon

(Reference: Midwest Plan Service, MWPS-13, 1987)
Energy Efficiency and Energy Cost
Drying corn from 23% to 15%

Assumptions: LP Gas cost = $1.40/gal
               Electricity = $0.085/kWh
Dryer Maintenance

- Keep screens and aeration floors clean
- Check and tighten belts
- Check burner operation – blue flame
- Calibrate moisture sensors and testers
- Check that bearing mountings are tight
- Lubricate as recommended by mfg.
Moisture Sensors / Testers

- Inaccurate readings
  - Spoilage / Overdrying
- Replace battery before season
- Testers not accurate
  - Above 22%
  - underestimate hot grain (above 90F) by at least 1 to 2 %.

- Checking Calibration:
  - Compare to certified unit (coop or feed mill)

Refer to Purdue U Fact Sheet #14
Contact Information

Scott Sanford
Sr. Outreach Specialist
Focus on Energy / Rural Energy Issues
Biological Systems Engineering
University of Wisconsin – Madison
608-262-5062
sasanford@wisc.edu

Wisconsin Energy Efficiency and Renewable Energy
www.uwex.edu/energy