

Mobile Grain Bin Inventory Solutions

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Objective:

The Indiana Grain Buyers and Warehousing Licensing Agency (IGBWLA) audits the inventory of grain locations throughout the state. The agency would like a technology to measure grain height without bin climbing by personnel. A feasible solution should greatly increase the safety of grain bin auditors, decrease the labor costs of auditing, and increase the auditors' efficiency.

Constraints

- No permanent installation required
- No climbing required
- Accurate within 1ft of actual height
- Cost Effective

Possible Solutions

- Sonographic Sensing- Measuring a sound profile of the bin wall to determine grain fill
 - A telescoping pole could be used to tap the bin sidewall
 - Unwieldy
 - Height limitations
 - A remote controlled bin climber could be fitted with a tapping device which would create a sound recording
 - Safety hazard
 - Time constraint for construction
- Thermal Imaging
 - Capture thermal images of the grain wall to detect differences in bin sidewall temperature
 - Cost effective
 - User Friendly

Preliminary Research

In order to verify that thermal imaging is a valid and reliable solution, the team:

- Investigated how grain and air effect bin wall temperature profile using small scale tests (Figures 1-3)
- Modeled full size bin based on lab test results using a FEA transient thermal analysis in ANSYS
- Captured thermal images of partially filled grain bins in variety of conditions (Figures 4-6)
- Analyzed grain bulk vs. headspace temperature data (collected 2002, by Dr. Klein Ileleji) to predict optimal inventory inspection times (Figures 8-9)

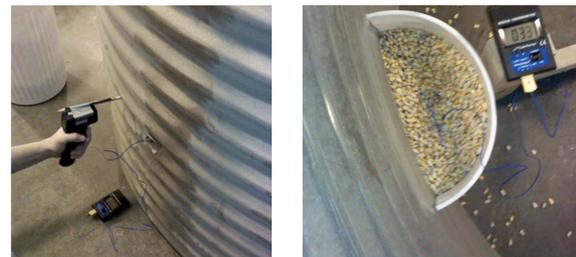


Figure 1 & 2: Small scale grain bin temperature test using IR sensor and thermocouple

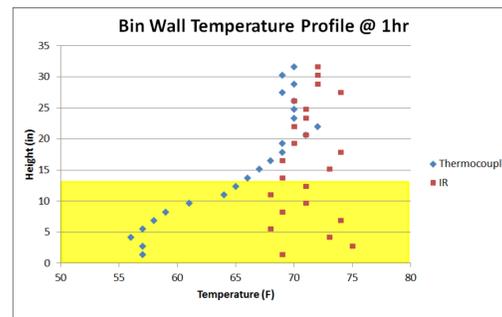


Figure 3: Small scale test results show temperature difference exists on bin wall

Thermal Imaging Solution Results

- Grain and air change temperature at different rates leading to a temperature difference between air headspace & grain bulk inside of a bin
- Thermal images reflect the temperature gradient along the outside of the bin wall
- Use of an infrared camera has been proven as a viable possibility for determining the height of grain in a bin

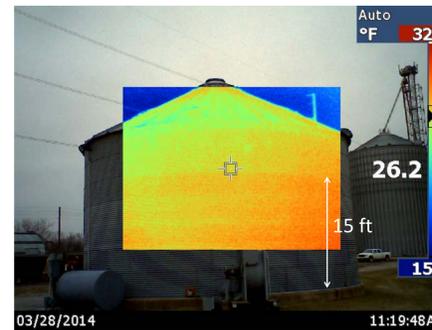


Figure 4: Grain Bin, Montmorenci, IN
Ambient temperature: 40° F

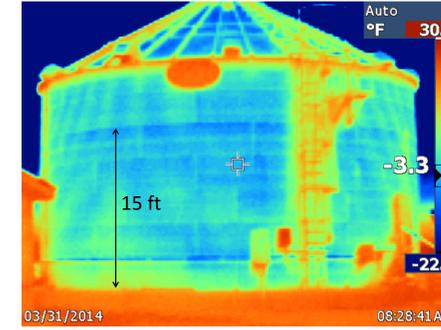


Figure 5: Throckmorton Farms
Ambient temperature: 37° F

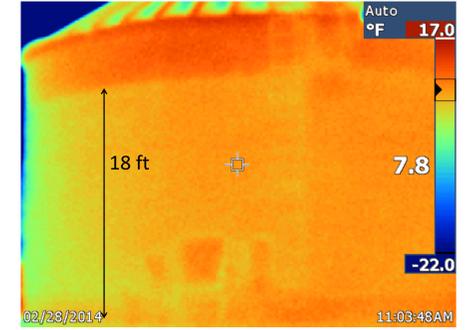


Figure 6: Throckmorton Farms
Ambient temperature: 20° F

Grain volume sample calculation:
$$V = height \times \pi \times \left(\frac{diameter}{2}\right)^2 \pm 0.14 \times \pi \times \left(\frac{diameter}{2}\right)^3$$
 ± for angle of repose: (+) filling (-) emptying



Figure 7: Fluke TiR1 thermal imager

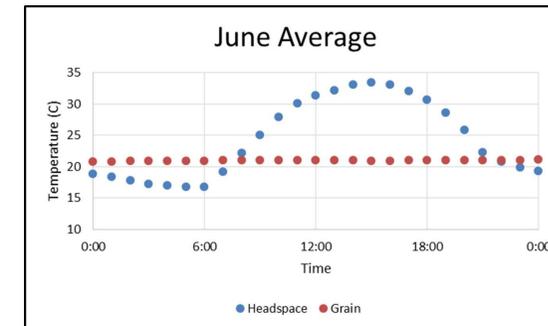


Figure 8: Temperature differences of grain and headspace on an average day in June 2002

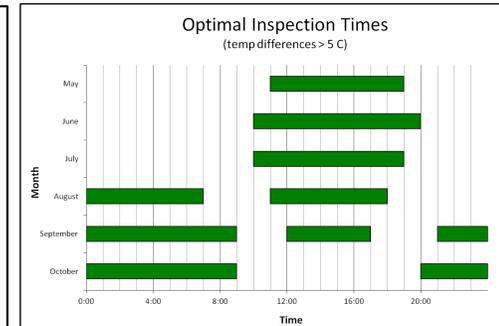


Figure 9: Optimal times of day with the greatest grain and air temperature differences

Financial Assessment

- Traditional labor costs: \$42,500/yr
- Thermal imaging labor costs: \$31,750/yr
- Total saving: \$10,750/yr
- Thermal imaging camera: \$5000-\$10000
- Payback time: 1 year

Outcomes & Impact

- Thermal imaging was verified as a viable solution, capable of accurately delineating grain height in metal bins. With further development, a thermal imaging solution will:
- Reduce risk of falling/entrapment for auditors
 - Decrease labor costs
 - Increase auditor efficiency