Grain Bin Storage Monitoring via Microwave Imaging

Ian Jeffrey[1], Joe LoVetri[2], Amer Zakaria[2], Majid Ostadrahimi[2], Mohammad Asefi[2], Colin Gilmore[1], Paul Card[1], and Jitendra Paliwal[3]

[1] 151 Research Inc., Winnipeg, MB, Canada
[2] Department of Electrical and Computer Engineering, University of Manitoba, Winnipeg, MB, Canada
[3] Department of Biosystems Engineering, University of Manitoba, Winnipeg, MB, Canada

Global wheat harvests exceed hundreds of millions of tons each year and require storage. Stored grain can spoil due to changes in temperature and/or moisture content resulting in significant economic losses. It is typical practice to monitor grain storage periodically, either by testing a sample of grain from the bin or by some in situ method such as temperature probes. It has been documented that there is a strong correlation between grain's dielectric properties and its bulk temperature and moisture content. This suggests that microwave imaging (MWI) may provide an in situ monitoring technique that enables farmers to continuously ensure the quality of their product. One major benefit of MWI would be the possibility of producing a global map of grain moisture and/or temperature within the bin with a minimal number of local measurements.

In this work we investigate the use of MWI as a technique for monitoring the conditions of stored wheat and discuss the obstacles to be overcome for MWI to be a cost-effective solution to the grain spoilage problem. Experimental results obtained on a small scale, from a novel near-field MWI system developed in the Electromagnetic Imaging Lab (EIL) at the University of Manitoba, show that the difference between dry and wet grain can be detected in principle. The challenges of performing MWI imaging inside of full-size hopper bins, where the boundary of the imaging domain is modeled by a perfect electric conductor, are investigated. Included are: comparisons of the sensitivities of different measurement systems, including the microwave scatterer technique (MST); results from different inversion algorithms such as FEM-CSI and eigenfunction Gauss-Newton inversion; a discussion of antenna designs suitable for the pressures, sheer forces and abrasion conditions inside grain bins; and a discussion of calibration methods.