APEGM Progress Report for:

Period beginning: **Sep 4, 2009** and ending: **Dec 31, 2010. (16 months)**

Submission Date: Jan 13, 2011
Supervisor: P.Eng. Submitted on Feb 20, 2011
Period Employer:
Job Title: Postdoctoral Fellow

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1. Give a description of the Engineering work experience you have obtained during this reporting period. Include information supporting the rest of your answers.

During this period, I worked as a postdoctoral fellow in the Department of Biosystems Engineering. My primary area of research was studying structural and compositional changes in stored wheat due to fungal infection using synchrotron based infrared imaging. I conducted experiments at Canadian Light Source (CLS) synchrotron facility in Saskatoon, SK. I also worked as instructor in the Biosystems Engineering Department and taught two undergraduate courses (Engineering Fundamentals BIOE 3530 (alone) and Engineering Properties of Biological Materials BIOE 3320 (with another instructor)). Apart from my own research work, I also assisted master's students and visiting researcher at Canadian Wheat Board Centre for Grain Storage Research. I helped master's student in experimental design, data collection and analysis, and writing. I worked with the visiting researcher from Algeria on microwave drying of wheat. I also co-authored book chapters with my supervisor.

Application of theory:

Analysis/Interpretation

Significant amount of grain is lost both in quantity and quality due to fungal infection. Penicillium spp. (blue) and Aspergillus spp. (black, white, brown, blue, green, and yellow) are the two most common storage fungi found in stored grain. Mould or fungal growth in grains results in germination loss, discolouration, dry matter loss, increase in free fatty acids, heating, mustiness, and occasional production of mycotoxins. The fungal damage to grain also changes the composition of grain, e.g., change in fiber, lipid, protein, and starch content. We have successfully differentiated fungal damaged wheat kernels from healthy kernels using near-infrared (NIR) hyperspectral imaging. The NIR hyperspectral imaging provides the compositional information of the grain but at the macro-level. This compositional information is sufficient for developing optical instruments for sorting the damaged wheat samples but does not clearly explain the microstructural and compositional changes occurring due to fungal damage. Wet analysis relies on grinding bulk samples causing destruction of intrinsic structure of grain tissue. Due to recent advances in imaging and spectroscopy, it is now possible to study the compositional distribution in grain and other biological tissues at micro level (cellular/sub-cellular level) at very high resolution. The objective of this research was to study the microstructural and compositional changes in stored wheat due to fungal infection.

Project Design/Synthesis

Wheat samples were artificially infected with storage fungi namely Penicillium spp. (blue) and Aspergillus spp. at the Cereal Research Centre, Winnipeg. The damaged and healthy wheat samples were cut into 8 μm thick slices using cryomicrotome at the University of Manitoba and thaw mounted on BaF2 windows. These samples were scanned using synchrotron IR spectrometer at the Canadian

Light Source (CLS), Saskatoon, SK. The mid-infrared beamline (01B1-1) at the CLS was used to scan the wheat samples in transmission mode. The beamline is equipped with a powerful Fourier transform IR (FTIR) spectrometer and microscope to supply diffraction-limited spatial resolution (Bruker Optics IFS 66v/S FTIR with Hyperion confocal microscope with mapping stage). Spectral data were collected in 4000 -800 cm-1 IR range at a spectral resolution of 4 cm-1 and spatial resolution of 10 μm × 10 μm in transmittance mode. Data collection, system control, processing, and analysis were done using OPUS software (Bruker Optics Inc., Billerica, MA).

Test/Verification and Implementation

The collected data were analyzed using OPUS and MATLAB software to elucidate structural and compositional changes in damaged wheat samples. Spectra were extracted from various points in paricarp, alurone layer, and endosperm regions of infected and healthy wheat kernels. The spectra showed clear differences between healthy and control samples. The difference in the absorption of infrared radiation might have caused by reduced lipid (1740 cm-1), lignin (1595 cm-1) and cellulose (1240 cm-1) content in damaged wheat kernels. The functional group mapping (pseudo color maps) at these wavenumbers also showed the difference in distribution of these components between healthy and control samples.

Multivariate analysis was done to indentify significant absorption bands using principal component analysis (PCA). Three-dimensional original IR data (using full map) were reshaped into two dimensional arrays by rearranging the transmittance spectra of each pixel into a row vector, thus, considering spectra of each pixel as a sample and wavenumber as variable. The PCA, a well know data reduction method, highlights the major peaks and valleys in absorption/transmission spectra. The principal component loadings were used to indentify significant wavenumbers. These loadings also showed differences between healthy and damaged wheat kernels. The manuscript incorporating these findings has been submitted to the Applied Spectroscopy journal.

Practical Engineering Experience:

I gained hands on experience on safely operating and trouble shooting synchrotron source Fourier transform IR (FTIR) spectrometer at the CLS. The CLS requires all users to have Health and Safety training including Health & Safety Orientation (HSO), Workplace Hazardous Material Information System (WHMIS) training, and Radiation Awareness Module (RAM) training for the safety of its employees, users, general public, and environment. I successfully completed these trainings at CLS. I also gained engineering experience while teaching two engineering courses and conducting labs safely.

Engineering Management:

The time allotment at CLS facility is highly competitive. Time in each cycle is allotted after peer review of a research proposal by three independent reviewers. Our proposal was successful. I planed the experimental design, prepared the sample with help of technician and successfully collected the experimental data using beam time allotted to us at CLS.

Communication Skill:

I wrote a manuscript from my research work and two manuscripts with fellow researchers in the group. I also presented a paper at Sensing for Agriculture and Food Quality and Safety, SPIE Conference, in Orlando, FL. I also co-authored two book chapters on spectroscopy and optical image sensing techniques for food quality and safety. I also taught third level undergraduate engineering courses in the Biosystems Engineering Department at the University of Manitoba.

Supervisor Agrees.

2. Please check the following options that apply:

2.1: During this reporting period, I have applied theory in:

- ✓ Analysis/Interpretation
- ✓ Project Design/Synthesis
- ✓ Testing/Verification
- ✓ Implementation

Supervisor Agrees.

2.2: I have obtained experience by:

- ✓ Studying or being exposed to existing Engineering works
- ✓ Applying Designs as part of larger systems
- Experiencing the limitations of Engineering designs
- ✓ Experiencing time as a factor in the Engineering process

Supervisor Agrees.

2.3: I was exposed to the following areas of Engineering management:

- ✓ Planning
- ✓ Scheduling
- ✓ Budgeting
- Supervision
- ✓ Project Management
- ✓ Risk Assessment

Supervisor Agrees.

2.4: I was required to make decisions based on professional and ethical responsibilities to:

- ✓ The Public
- ✓ The Profession
- ✓ The Client and/or Employer
- ✓ Co-Workers
- ✓ The Environment

Supervisor Agrees.

3. Describe any activities that have improved your Communication, Teamwork, or Interpersonal Skills in the following areas:

Oral Presentations:
I gave oral presentation on 'near-infrared hyperspectral imaging for quality analysis of agricultural and food products' at Sensing for Agriculture and Food Quality and Safety, SPIE Defense Security and Sensing Conference in Orlando, FL, US.

Written Documents:
During this period I co-authored three international publications, one conference paper, two book chapters, and two successful research proposals for beam time allotment at CLS in two consecutive cycles.

Interaction with Others:
In my project I worked with biologists, technicians, and CLS beam light scientists. I needed to coordinate with all of them in order to get infected samples prepared on time, timely sectioning of the samples, and scheduling the IR beam time for data collection. I interacted with engineers and scientists at the SPIE conference. As an instructor, I got opportunity to interact with very bright engineering students on and off the class.

Other:

Supervisor Agrees.

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4. During this period, I had to consider the social implications of my work in the following areas:

The research project was intended to study the changes in stored wheat due to fungal damage. The research findings will be useful for the breeders, grain and food processing industry, and researchers in grain quality monitoring and functional foods and nutraceuticals area.

Supervisor Agrees.

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5. Examples of my ability to work effectively as part of a team, during this period, include:

During this study, I worked with department technicians, biologist at the Cereal Research Centre, and CLS beam line scientists. I successfully completed the data collection at CLS.

Supervisor Agrees.

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6. Examples of my ability to assume responsibility include:

I was responsible for operating and maintain the spectroscopic and imaging equipments in lab and handling the project. I also assisted graduate students, postdoctoral fellow, and visiting researcher in our research group.

Supervisor Agrees.

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7. I have shown progress since the last report (where applicable) as follows:

Improved communication, analytical, and programming skills. My knowledge about Canadian grain handling system and regulations by Canadian Grain Commission also improved.
I also gained hands on experience on operating synchrotron source based spectrophotometer at CLS, Saskatoon, SK.
My knowledge of optical instrumentation and imaging hardware also improved.

Supervisor Agrees.

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8. I feel myself to be lacking in exposure to, or requiring improvement in, the following areas:

I need more knowledge and exposure in the field of cereal chemistry.

Supervisor Agrees.

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9. I would like to provide the following additional, relevant information:

I volunteered as reviewer in the following Peer-reviewed International Journals:
Computers and Electronics in Agriculture, Elsevier, Amsterdam, Netherlands.
Biosystems Engineering, Elsevier, Amsterdam, Netherlands.
Drying Technology, Taylor & Francis, Oxford, UK.
International Journal of Food Properties, Taylor & Francis, Oxford, UK.

I also volunteered as Special Judge for CSBE awards in Manitoba Schools Science Symposium 2010, Winnipeg, Manitoba.

Supervisor: P.Eng. (First Registered:)

I make the following evaluation and recommendation regarding the progress report for this MIT:

He was exposed to the biggest science project (CLS) in Canada. He has learnt the technique and is continuing to use CLS to answer other research questions.

In my opinion, during this reporting period, (Sep 4, 2009 - Dec 31, 2010) (16 months), C has completed an equivalent of *16* months full time experience.

Please show my comments to the MIT.
