Biosystems Engineering
2008 Senior Design Showcase

April 17, 2008
Kellogg Center
Michigan State University

BAE
Department of Biosystems
and Agricultural Engineering

Showcase Agenda

The Kellogg Center at Michigan State University

Big 10 Room A 2:15 - 2:45 p.m. Briefing of Industry Participants on Program Assessment
2:45 - 3:30 p.m. Employer-Student One-on-One Contact Session
3:30 - 5:30 p.m. Biosystems Engineering Capstone Design Presentations

-Extruder Modeling: The Kellogg Company
-Nutrient Separating Baffle Box for Agricultural Runoff Treatment
-Rapid Detection of E. coli in Recreational Waters
-Swine Facility Waste Management Model
-Biodiesel Production in Malawi
-Water Minimization and Wastewater Disposal at Leelanau Fruit Company

5:30 - 6:15 p.m. Concurrent Project Review Panels

Big 10 Room A 5:30 - 6:45 p.m. Reception

Big 10 Room B 6:45 - 8:30 p.m. Dinner (previous reservations required)

BE 487 - Biosystems Engineering Design Project Class of 2008

ABOUT THE SENIOR DESIGN SHOWCASE

Every year, teams of Biosystems Engineering students, enrolled in the two-semester senior design capstone experience, develop, evaluate, and select design alternatives in order to solve real world problems. The projects are diverse, but each reflects systems thinking by integrating interconnected issues impacting the problem, including critical biological constraints. The engineering design process is documented in a detailed technical report. The project designs are then presented to engineering faculty and a review panel of licensed professional engineers for evaluation.

The course instructors are: Professor Steve Safferman, Ph.D., P.E., and Hope Croskey, P.E.

Extruder Modeling

Sponsor: The Kellogg Company
Academic Advisor: Dr. Kirk Dolan, Food Science and Human Nutrition and Biosystems and Agricultural Engineering
Industry Advisor: Shelley Crawford, Morning Foods Process Engineer, The Kellogg Company

Team members (left to right):
Nathan Schroeder, Amanda Glass, Rebecca Roberts, and Tyler Wright.

The food industry uses extruders to process products with distinct shapes, sizes, colors, and textures. An extruder mixes, cooks, kneads, heats, shapes, and forms the product in one unit operation. The resulting product characteristics are a complex function of extruder independent variables, including but not limited to shear history, shear power intensity, and moisture content.

Experimental trial results using a pilot-scale extruder were statistically analyzed. Bar graphs and response surfaces between independent variables and dependent output characteristics were developed. Definitive trends were not identified in the bar graphs between shear history or shear power intensity with the dependent output characteristics. Response surfaces displayed distinct trends between moisture content and screw speed with water absorption and solubility indices and the expansion ratio.

A six-step protocol was developed for use in industry to increase predictability and consistency of a particular extruder. The protocol includes calibrating the extruder, selecting variables, performing extruder trials, measuring output characteristics, identifying trends, and applying trends to improve predictability and consistency of product output characteristics.

Nutrient Separating Baffle Box for Agricultural Runoff Treatment

Sponsor: Price and Company, Inc., and Suntree Technologies
Academic Advisor: Becky Larson, Dr. Steve Safferman, Hope Croskey, Biosystems and Agricultural Engineering

Team members (left to right):
Phillip VanDenBerge, Andrew Zawisza, Tara Franey, and Charles Teater

Nutrient Separating Baffle Boxes are currently used in urban settings as a cost effective stormwater treatment method. The technology requires minimal space and is easily retrofitted into existing stormwater conveyance systems. As stormwater passes through a screened basket, larger organic debris is held in an aerobic environment preventing decomposition. The filtered stormwater then passes through baffled concrete boxes where larger suspended solids are retained. A vacuum truck is used to remove accumulated debris and sediment.

Because significant differences exist in the composition of urban and agricultural runoff the team designed, constructed, and operated a bench scale physical model to evaluate the potential for using baffle boxes to remove organic pollutants from feedlot runoff. Simulated runoff was generated using known quantities of waste that represent the organic portion of agricultural runoff from three cattle farms that employ commonly used management practices.

Influent and effluent samples were collected and analyzed for total nitrogen, phosphorus, solids, and biological oxygen demand to determine the system's effectiveness for removing organic pollutants. The results were compared to other technologies to evaluate the baffle box as a viable treatment alternative. Recommendations for management practices to be incorporated along with a baffle box to minimize pollution runoff are provided.

Biodiesel Production in Malawi

Sponsor: Engineers Without Borders
Academic Advisor: Dr. Wei Liao, Biosystems and Agricultural Engineering

Team members (left to right):
Keith DeHenau, Jackie McNett, Tracy Svanda, and Joel Dupuis.

The design team worked to establish an MSU Student Chapter of Engineers Without Borders, a national organization that partners with underprivileged communities globally to improve access to energy, water, and sanitation. A community in Malawi, Africa, requested an engineering design for a biodiesel production facility to provide a stable energy supply and local enterprise.

Coordination with a non-governmental organization in Malawi resulted in the selection of soybean oil, methanol, and potassium hydroxide as inputs to the designed batch reactor biodiesel production facility. The system kinetics was simulated using MatLab and Simulink computer software to optimize energy consumption versus biodiesel production and to determine the most efficient operating conditions for temperature and mixing.

This project provides process, economic, and safety evaluation tools, as well as an engineering design report for project implementation by the Lansing Chapter of Engineers Without Borders.

Water Minimization and Wastewater Disposal at Leelanau Fruit Company

Sponsor: Leelanau Fruit Company
Academic Advisor: Dr. Dawn Reinhold and Isis Fernandez-Torres, Biosystems and Agricultural Engineering

Team members (left to right):
Sean McNamara, Chip Cogan, Danielle Habitz, and Mike Wozniak.

The Leelanau Fruit Company, located in Suttons Bay, Michigan, began processing fruit in 1967. The current washing and cleaning process is water intensive and uses pristine, northern Michigan well water. Process wastewater, along with excess pumped water used to prevent the irrigation system from freezing, is land applied. When irrigation rates exceed the soil infiltration capacity, saturation occurs. This often leads to anaerobic microbial presence in soil and the mobilization of metals, which results in environmental degradation of surrounding water resources.

Minimization of water use is a priority because a reduced hydraulic loading rate, below the infiltration capacity, will result in unsaturated soil conditions. The presence of sufficient oxygen in the soil is needed to support the aerobic microbial activity required to assimilate nutrients and organic materials in the wastewater without mobilizing metals.

Preliminary engineering design alternatives for water minimization and wastewater disposal are provided along with recommendations for further engineering evaluation prior to implementation. Each design alternative was evaluated based on payback period, installation and maintenance costs, downtime for installation, power consumption, and hydraulic/BOD loading rate reduction. Established criteria were weighed based on the impact to the overall goal of an economical means of wastewater reduction and disposal that protects the environment.

Rapid Detection of *E.coli* in Recreational Waters

Sponsor: Michigan Department of Environmental Quality (MDEQ) and Ingham County Health Department
Academic Advisor: Dr. Evangelyn Alocilja, Biosystems and Agricultural Engineering

Team members (left to right):
Michelle Slavin, Rebecca Busk, Ashley Varga, and Aubrey Higginbotham.

In Ingham County, large urban and suburban populations currently live downstream of major agricultural production sites. The close proximity allows contaminants to enter waters used for recreation including rivers and bathing beaches. To ensure public health, the Ingham County Health Department tests recreational waters for Escherichia coli (E. coli), a standard indicator of fecal contamination, using a process that takes up to four days to obtain results. This delays public notification of potential health risks.

The team engineered a rapid process for detecting E. coli that consists of four distinct design elements: sample collection, sediment filtration, bacteria concentration, and detection. A sample is obtained using a peristaltic pump, which pushes water through the integrated system. The next component, a standard 5 micron in-line cartridge filter, removes the sediments. Then, a 0.45 micron membrane filter captures and concentrates the bacteria. Detection is accomplished using an experimental assay, Beta-Glo, provided by Promega. This integrated system increases the E. coli measurement accuracy by removing sediment to reduce signal interference and concentrating E. coli to a detectable level before employing the assay.

The system is designed to collect and analyze samples on-site in under one hour and minimize travel, labor, equipment, and supplies needed for testing. Results demonstrate the capability to detect as few as 10 E. coli colonies per 100 milliliters of water. This is well below the daily limit of 300 colonies per 100 milliliters and therefore provides an accurate means of detection. Testing is completed on-site, by one person in approximately 35 minutes.

Swine Facility Waste Management Model

Sponsor: USDA Cooperative State Research, Education and Extension Service
Academic Advisor: Dr. Wendy Powers, Biosystems and Agricultural Engineering, and Animal Science
Industry Advisor: Norma McDonald, Phase 3 Renewables

Team members (left to right):
Brendon Somerfield, Matt Klein, Trista Gregorski, and Andy Austin.

Waste from swine feeding operations is commonly contained in storage lagoons until land applied. To combat the environmental effects of this practice, anaerobic digesters are being evaluated as a method to minimize phosphorus and nitrogen loading from land application, reduce harmful air emissions, and decrease the solid waste volume. Although the initial capital investment is high, digesters provide an economic return in energy production and reduced waste transportation costs. The economic viability is dependent on the number of swine, accessibility of acreage for land application, and energy costs.

The Swine Facility Waste Management Model provides a user-friendly computer interface for swine facilities to evaluate management alternatives such as manure application rates, crop selection, and the feasibility of installing an anaerobic digester. The model framework, written in MatLab, allows future researchers to modify the program to incorporate new study results, improved waste management techniques, economic factors, and environmental constraints.

2008 Scholarship Recipients

UNDERGRADUATE

F. W. Bakker-Arkema Scholarship
Hanna Miller

A.W. Farrall Scholarship
Natalie Bouchard
Rebecca Busk
Louis Faivor
Jacqueline Palmer
Heather Stewart

Robert J. Gustafson
Amber Jablonski

Clarence & Thelma Hansen Scholarship
Brad J. Wardynski
Gerald Hessell
Abby Lynn Johnson
Nancy Maschke
Michael Baker

Howard & Esther McColly Scholarship
Ellen Bornhorst
Christopher Gancsos
Thomas Skrocki

George and Betty Merva Scholarship
Alyse Egner

GRADUATE

BAE Endowed Fellowship
Dharmendra Kumar Mishra

Merle & Catherine Esmay Scholarship
Edith Torres-Chavolla

Bill & Rita Stout Scholarship
Rabiha Sulaiman

DR. TRUMAN SURBROOK

Winner of the 2007-2008 Withrow Teaching Excellence Award

Dr Truman Surbrook is a 38 year teaching veteran of the Department of Biosystems and Agricultural Engineering. He had demonstrated a rare ability to adapt new technology and systems, and integrate the boundries of knowledge. He is praised by his students for his ability to make difficult concepts easy. His secret is an unrelenting desire to examine what the students need to know and adapt the material to different learning styles. He is a singularly dedicated professor with a sincere desire for students to understand and succeed.

What is Biosystems Engeering?

Biosystems Engineering (BE) is an ABET accredited B.S. degree program at MSU that prepares students to:

- Identify and solve problems at the interface of biology and engineering, using modern engineering techniques and the systems approach.
- Analyze, design, and control components systems, and processes that involve critical biological components.

Biosystems and Agricultural Enginnering
2008 Distinguished Alumni Award Winner

Dr. John Larkin Ph.D.

Dr. John Larkin received his Ph.D. degree in Agricultural Engineering and Food Science from Michigan State University in 1984. After graduation, he worked as an Assistant Professor at Virginia Polytechnic Institute and State University before joining the Food Processing Science and Technology Division of the FDA (Food and Drug Administration). For the past sixteen years, he has worked as the Branch Chief of the Process Engineering Branch of the Food Processing Science and Technology Division where he evaluates regulatory issues to extend the shelf life of food.

He has worked in the area of thermal processing for over twenty years. His research pertaining to thermal processing and food production has played a significant role in the regulatory review of low-acid food processing systems. Dr. Larkin is a sought-after authority on the regulatory validation of thermal and non-thermal processing technologies.

Biosystems and Agricultural Enginnering
2008 Outstanding Alumnus Award

Dr. Stephen Radke Ph.D.

Steve Radke currently works for FMC FoodTech and is employed as an account manager in the processed foods industry. His major responsbililites include working with clients such as Campbell's Soup, Pepperidge Farms, Unilever, and Cargill to develop food processing solutions for everyday branded and store brand consumer food products. He currently lives and works in Philadelphia but has already relocated twice with FMC FoodTech, starting out in Minnesota and relocating from Georgia.

He is currently attending the Wharton School of Business at the University of Pennsylvania where he is completing a weekend business executive education program. Prior to working for FMC FoodTech and attending Wharton, he graduated with a Ph.D. in Biosystems Engineering from Michigan State University in 2004. His research was the development of a microfabricated biosensor to detect pathogenic bacteria with Dr. Evangelyn Alocilja as the major professor and Dr. Dan Guyer as a committee member. Along with Professor Alocilja, he has published journal articles, presentated at conferences and submitted grant proposals. Prior to graduate school, he graduated from the ABE undergraduate program as well in 2000 with a BS in Biosystems Engineering. He was active in ASABE as a student member and is a current member of IFT and ASB. His hometown is Windsor, Ontario, Canada, where he was born and raised prior to attending Michigan State University.

Special Thanks

Industry Advisory Board:

Board Chairperson, Kevin Evans - QTG-Quaker-Tropicana-Gatorade
Lisa Buchholz - Pfizer
Frank Cousin - Natural Resources Conservation Service/USDA
Michelle Crook - Michigan Department of Agriculture
Paul Eisele - Retired
Todd Forbush - Techmark, Inc.
Jeff Friedle - Ledy Design Group
Marc Groenleer - Groenleer Consulting
David Hamilton - Michigan Dept. of Env. Quality, Land & Water
Scott Keeler - Dow AgScience
Nicole McPherson - Tetra Tech
Scott Millsap - FMC FoodTech
Steve Richey - Kellogg Company
Paul Satoh - Neogen Corporation
Steve Shine - Michigan Department of Agriculture
Larry Stephens - Stephens Consulting Services
Rebecca Larson - Graduate Student Representative
Michael Wiederoder - Undergraduate Student Representative

Ex-Officio

Ajit Srivastava, Professor and Chairperson
Hope Croskey, P.E., Industry Liaison
Elaine Johnson, College of Engineering, Academic Advisor

Showcase Coordinator: Barb DeLong

BAE
Department of Biosystems and Agricultural Engineering

Since 1906, the Department of Biosystems & Agricultural Engineering has responded to the changing needs of society by integrating and applying principles of engineering and biology in a systems context. Today, biosystem engineers at MSU solve complex, rapidly-changing problems related to food quality and safety, ecosystems protection, homeland security and health protection, biomass utilization, and renewable energy development.

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