Researchers Use Ergonomic Risk Assessment Tool to Study the Effects of Line Speed on Deboning Techniques and Yield

Deboning lines are one of the more labor-intensive operations in poultry processing. Workers must perform constant repetitive movements at line speeds averaging 35-40 birds per minute. As consumer demand for deboned poultry products continues to increase, many believe processing plants will have to increase line speeds to meet that demand. The question, however, is will such increases affect deboning accuracy amounting to a decrease in yield?

“In the 1970s, the average line speed of a poultry deboning line was 28 birds per minute. Today, these lines run at speeds of up to 40 birds per minute, and deboners have to meet these demands. It is assumed that as the line speed increases, the accuracy of the deboner decreases, which could lead to a decrease in yield,” explains Sim Harbert, a research engineer at the Georgia Tech Research Institute (GTRI).

To help the industry assess that assumption, Harbert and a group of fellow GTRI engineers have built an Ergonomic Work Assessment System (EWAS) using commercially available technologies (Measurand ShapeTape, goniometer, and EMGs) to investigate various deboning techniques and the impact that line speed has on both yield and ergonomics.

EWAS consists of a “backpack” that captures upper back motion and contains a data acquisition and wireless relay mechanism. It also captures arm kinematics, wrist motion with an integrated dual-axis goniometer, muscle activation of three muscle groups using electromyography (EMG) sensors, and a specially instrumented knife (developed by the Liberty Mutual Research Institute for Safety) for measuring grip strength.

Tests using the EWAS were recently conducted with four volunteer participants who are actual deboners at local poultry processing plants. A laboratory-scale cone line was set up in a temperature-controlled cold room (40°F) at GTRI’s Food Processing Technology Building. The deboners performed left shoulder cuts at randomly set line speeds of 25, 30, 35, and 40 birds per minute spaced 2 feet apart. A total of 50 cuts per line speed per deboner were made, after which the breast meat was removed and yield was measured using standard industry practices.

Initial results suggest that there were no significant differences between line speed and yield. In addition, the results suggest that yield loss is independent of the size of the birds. Researchers are still continued on page 2
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continued from page 1

analyzing whether there is a change in deboning technique (based on collected biomechanics data) as the line speed increases.

“These tests integrate one variable that is particularly interesting to industry, namely, yield. Analysis of the preliminary data indicates that yield is not closely tied to line speed. While this result is interesting, more data needs to be collected to be able to draw more meaningful conclusions,” says Harbert.

Researchers are currently seeking an industry partner to conduct in-plant tests.

Pilot Study Examines the Viability of the WiiFit as an Exercise Intervention Tool to Reduce the Risk of Lower Back Injuries

Packers in poultry processing plants repetitively lift boxes that weigh up to 70 pounds and stack these boxes onto pallets. Such tasks can cause lower back injuries resulting in pain and possible absence from work. Strong hip flexor and extensor muscles are vital to lifting an object safely. Researchers with the Georgia Tech Research Institute’s (GTRI) Food Processing Technology Division in conjunction with the Georgia Tech Campus Recreation Center recently completed a pilot study that compared the WiiFit gaming system to traditional methods of strengthening hip flexor muscles as an intervention to reduce the risk of lower back injuries during lifting.

“By comparing kinematics and movement times of a lifting task before and after interventions, it would be possible to see how these methods influence behavior,” explains Sim Harbert, GTRI research engineer and study director. “The hypothesis is that WiiFit gaming will sufficiently strengthen the hip flexor muscles, thereby improving range of motion statistically enough to reduce the risk of lower back injuries.”

For the study, 25 subjects watched a safety video on proper lifting techniques and then were randomly assigned to one of three groups: a control group, a traditional exercise group, or a WiiFit group. All participants performed a set of lifting tasks at the beginning of the study and after a 5-week training program. The lifting tasks consisted of repetitively lifting a 20-pound weight between two different levels of approximately waist and knee height for 20 minutes. During the training program, the control group performed no exercises; the traditional exercise group, under the supervision of fitness coaches, performed normally prescribed exercises designed to strengthen the lower back; and the WiiFit group performed exercises using the WiiMotion system to strengthen the lower back.

According to Harbert, the overall goal is to identify a low-cost and yet effective physical conditioning program for poultry plant workers, and the WiiFit gaming system shows promise.

“Full kinematic data analysis is not complete, but the initial results show that subjects in the WiiFit group found the training more enjoyable, and they also were more likely to finish the prescribed exercise plan than participants in the traditional exercise group,” says Harbert.

Analysis comparing the leg and back motions of the subjects measured during the lifting tasks conducted before and after the training program is ongoing and expected to be published soon.

“The WiiFit gaming system is a relatively inexpensive physical conditioning intervention that poultry plants could introduce as an alternative to establishing a more costly gym facility or paying gym membership for employees,” says Harbert.
The team includes Dr. David Anderson, Georgia Tech engineering professor, whose work in audio signal processing focuses on enhancing the functionality of hearing aids. “Our lab has been working on speech processing, signal enhancement, and machine learning for signal processing. The poultry welfare project has been a great application for this research,” says Anderson. “The signals that we collect are a relatively new type of signal for signal processing; few researchers have been interested in what chickens have to say.”

The audio signals tend to be quite noisy due to the cooling fans within the grow-out house, explains Anderson. When the team focused on extracting useful information from the signals, they discovered the speech processing techniques did not work well, but the signal enhancement and machine learning aspects of their research were very useful.

“The behavior of chickens is one of the best and most immediate indicators of their well-being. Chickens are vocal creatures and produce different types of vocalizations at different rates and loudness depending on their circumstances,” explains Dr. Bruce Webster, UGA poultry science professor.

According to Webster, it is possible that monitoring of the auditory environment might give real-time ability to gauge the presence of different kinds of stressors that might impact the welfare of the flock and provide the ability to make rapid environmental adjustments by automated control systems to alleviate the stress.

The experimental system was installed in a research grow-out house on the UGA campus and recently underwent six weeks of testing where the team collected data under normal and stressed (temperature increased 10 degrees above normal) growing conditions.

An analysis of the data showed that it is possible to detect a change in the vocalizations of the birds due to a change in temperature. A filtering and extraction technique was developed to isolate the sounds being made by the birds (called vocalizations) from the background noises in the room (particularly the fans). Results showed that the number of vocalizations rose and fell commensurate with the change in temperature. An analysis technique using the time domain showed a similar result. Results from the video data, however, are not as conclusive. Air quality, as measured by ammonia levels in the poultry house, is an additional stressor that was included in this study, the results of which are currently being analyzed.

If successful, Daley believes the audio monitoring could be used to take preemptive or corrective actions to maintain the health and viability of the flock, which in turn could improve production efficiency and bird welfare.

Likewise, Dr. Casey Ritz, UGA poultry science associate professor, says detecting conditions conducive to increased levels of stress in the birds and alleviating the condition will improve the productivity and economic well-being of individual flocks. “Contract poultry producers are paid by the pound of birds sent to market. Improving the overall health and productivity of the birds will help to improve the bottom line for individual producers.”

Lacy says the grow-out monitoring project collaboration between Georgia Tech and UGA is a great example of where brainstorming between scientists and engineers resulted in a project that could have great potential for monitoring the health and well-being of poultry flocks.

“If one thinks about how U.S. farmers will continue their leadership in global poultry production, one has to conclude that application of technology will be one of the key factors that will allow our farmers to compete,” adds Lacy. “In fact, research, knowledge, and application of technology may be one of the few competitive advantages our farmers will have in the future.”
Advances in LED Lighting Provide More Efficiency and Accuracy for Vision Systems

WRITTEN BY COLIN USHER

This last decade has seen a significant increase in the popularity of food processing imaging systems to perform tasks such as quality assurance, food safety inspection, or process control. Nowadays, almost all major food processing enterprises have some kind of vision system in operation in their facilities. One thing almost universally required of these systems is a uniform and stable lighting configuration. Researchers at the Georgia Tech Research Institute (GTRI) continuously evaluate advancements that could improve the performance and utility of delivered systems. In this case, a study was conducted to evaluate the performance of the latest Light Emitting Diodes (LEDs) for industrial imaging illumination.

The early vision systems developed by GTRI used high-frequency fluorescent lights as they were more efficient and provided relatively uniform lighting distributions. While more efficient than incandescents, when enclosed and operated in industrial settings, fluorescent bulbs generate enough heat to require cooling in order to achieve the desired light intensity stability. This added need for cooling drives up costs and introduces an additional critical failure point for the imaging system.

In 2004, researchers began experimenting with LED lighting, and in 2005, they fielded the first prototype system using LEDs. While the LEDs are typically more expensive than fluorescents, they provide benefits such as longer operational life spans and strobing functionality. Food processing operations typically have relatively low throughputs; for example, broiler shackle lines run at approximately 3 birds per second. For an imaging system designed to capture images of each bird, the LED illumination can be strobed to only be “on” during the image acquisition, much like the flash on a camera. With a typical integration time of 3 milliseconds per image acquisition of each bird, the LEDs would be on for only 9 milliseconds of each second, or roughly one hundredth of a second! Strobing the LEDs in this way also significantly reduces the amount of heat generated by the lighting system, reducing the need for additional cooling.

The discontinuation of the original LEDs necessitated the identification of a suitable replacement for the illumination in both future imaging systems as well as in existing fielded systems. The research team reviewed several LED specifications and selected a tentative replacement for validation. While the team expected to find better efficiencies and tighter color specifications, they were impressed by the significant improvement in performance just in the last few years.

Multiple tests were designed to compare the obsolete LEDs (Luxeon Batwing LXHL-MWJE) with the new replacement (Cree MPLEZW-A1-R100). The evaluation procedure included: (1) establishing the worst-case efficiency for both LEDs, (2) measuring the peak reflected illumination intensity using a high-precision amplified silicon detector (Thorlabs PDA 250), and (3) comparing the spatial illumination profile and color conformity from collected image data. The results of these tests are summarized below.

The efficiency of the LEDs was calculated from the given specifications as the light output in lumens per unit of electrical power. A lumen is a measure of the power of light as seen by the human eye. In this case, an obsolete Luxeon LED outputs 450 lumens with a forward voltage of 24VDC at 1050 milliamps. A candidate replacement Cree LED generates 800 lumens with a forward voltage of 26VDC at 450 milliamps. Calculating power, the Luxeon LED consumes 25.2 watts compared to the Cree LED’s 11.7 watts under the same environmental operating conditions. Using the above numbers, the calculated efficiency is 17.9 lumens per watt for the old Luxeon LED compared to 68.4 lumens per watt for the new Cree LED, indicating an increase in efficiency of 283 percent. Performing a similar calculation to compare light output vs. purchase cost also shows a cost improvement of 390 percent when moving to the new Cree LED. Not only is the new LED far more efficient, it is also effectively less expensive. A chart illustrating this comparison is shown in Figure 1.

Reflectance tests were carried out to empirically compare the light output of the two LEDs. The test setup consisted of the LED being tested, a PDA 250 silicon photodiode, and a white reflectance standard placed at a fixed distance and angle. Reflectance data was collected for each LED at current levels ranging from 750 to 1.5 milliamps. Figure 2 shows the results, clearly demonstrating that the reflected light from the Cree LED is significantly higher than that of the Luxeon LED across the range of operating currents. In fact, these tests showed that the reflected light intensity from the Cree LED is more than 400 percent brighter than the reflected light intensity from the Luxeon LED at the same operating current.
Other important attributes of illumination sources are the color conformity and the spatial illumination profile. Imaging systems are often used to accurately classify product color for operations such as oven control and defect detection. Color conformity was measured using a color camera to capture an image of a MacBeth color tile board illuminated by each LED operating at 750 milliamps. Figure 3 shows these two images and the RGB color profiles across the top row of tiles in the image. The difference in overall brightness between the two images can clearly be seen. The similar color profiles indicate that algorithms designed for use with the Luxeon LED should not be significantly affected by a transition to the Cree LED as an illumination source.

With new applications, such as automotive lighting, spurring consumer and industrial demand, LED manufacturers have responded by making LEDs much more powerful, more efficient, less expensive, and more flexible. This has made LED lighting the illumination source of choice for most imaging and machine vision applications.

Colin Usher is a research scientist in the Georgia Tech Research Institute’s Food Processing Technology Division. His areas of research expertise are software development, intelligent systems, computer imaging, robotics, and automation technologies. He can be contacted by email at colin.usher@gtri.gatech.edu.

**Q & A**

**Detection of Salmonella with Lateral Flow Impedance-Based Assay**

The poultry industry has as one of its priorities the prevention of foodborne pathogens in its products. Many traditional detection methods require expensive equipment or take days to get results. As a result, the research community continues to explore novel technologies that are faster, more accurate, and cost-effective. Jie Xu, a research scientist at the Georgia Tech Research Institute, discusses her current project “Detection of Salmonella with Lateral Flow Impedance-Based Assay.”

**Q:** PoultryTech – What is the motivation for the project?

**A:** Xu – The goal of the project is to develop a rapid, multiplexed, and disposable field-usable device utilizing the combined lateral flow and interdigitated microelectrode array as the signal transducer for foodborne pathogen detection.

**Q:** PoultryTech – What makes this method different from other pathogen detection methods (i.e., commercially available lateral flow kits, interferometric optical sensor)?

**A:** Xu – An interferometric optical sensor provides sensitive, rapid, and multiplexed detection. The drawback is that a pump is always required for liquid handling. Lateral flow-based diagnostics have been used for detecting pathogens, drugs, hormones, and metabolites in biomedical, veterinary, food, and environmental settings. They are designed for single-use at point-of-care or non-laboratory environments. Although lateral flow-based technology is fast, simple, and low-cost, its weaknesses include qualitative, less sensitive, and not high-throughput screening. We propose using an interdigitated electrode (IDE) array with high-throughput screening capabilities under the lateral flow membrane to overcome the requirement for the pump on the interferometric optical sensor and the poor sensitivities common with lateral flow-based methods.

**Q:** PoultryTech – How does this method work?

**A:** Xu – The capture antibodies specific to the target (pathogen) of interest will be applied on the transducer surface. The testing samples applied on the sample pad will be wicked through the membrane on the top of the IDE. The antibody conjugated on the IDE will capture the analytes on the membrane. The antigen-antibody binding will generate an increased resistance on the IDE, and this signal will be processed to generate a concentration value.

**Q:** PoultryTech – What are the initial testing results?

**A:** Xu – We have fabricated our IDE array using the standard microfabrication technology and covalently linked polyclonal antibody specific to Salmonella on the surface of the IDE. The high-flow membrane was added on the IDE for liquid application. We have successfully demonstrated a lateral flow delivery of the sample over the electrode array. The proof of concept has been demonstrated using 108 cfu/ml of Salmonella. In addition, we have confirmed the binding of bacteria cells on top of the electrodes using a scanning electron microscope and a confocal microscope.

**Q:** PoultryTech – What are the future research plans?

**A:** Xu – We are planning to optimize the system, so sensitive and reproducible detection can be achieved.

**Q:** PoultryTech – What are the potential benefits for industry?

**A:** Xu – Pathogen detection is of the utmost importance primarily for health and safety. Development of a low-cost sensor for accurate detection of pathogens in production conditions would be a great help to the food industry for quality control and food safety assurance.
“It depends,” is usually my answer when I am talking to poultry customers. It depends on how a plant operates and how flexible the plant might be to shifting loads from on-peak hours to off-peak hours.

Before answering this question, let’s provide some background on electric utility rates. There are more than 3,273 traditional electric utilities in the United States responsible for ensuring an adequate and reliable source of electricity to all consumers in their service territories at a reasonable cost.

Electric utilities use customer classifications for planning (i.e., load growth and peak demand) and for determining their projected sales and revenue requirements (cost-of-service) in order to derive their rates. Utilities typically employ a number of rate schedules. The various rate schedules reflect customer’s varying consumption levels and patterns and the associated impact on the utility’s costs of providing electric service.

Electric rates may consist of a number of separate components, including energy charges, demand charges, service charges, nuclear and environmental surcharges, fuel charges, and other miscellaneous charges. These rate components allow the utility to recover the costs it incurs in providing service. The elements of the cost-of-service include operating and maintenance expenses, fuel expenses, purchased power expenses, capital costs (e.g., depreciation, interest expenses, and return on equity), State and Federal income taxes, and taxes other than income taxes.

Historically, the rate schedules used by electric utilities were designed so that as the volume of sales increased the average price of electricity would fall. Through the years as the cost of producing electricity has increased, along with concerns about the impact of electricity production on the environment, utilities are now implementing rates and other programs that more closely reflect the costs of serving customers during various price periods. These activities include demand response programs, time-of-use rates, and real-time pricing rates.

Industrial rates vary slightly from utility to utility, but in addition to “base charges,” there are two other types of charges for large users: an “energy charge,” and a “demand charge.”

The monthly demand charge for large customers is a dollar amount usually based on the highest average demand by the plant over a 15- or 30-minute interval for the previous month. It reflects the cost to the utility to maintain generating capacity to meet the plant’s maximum power demand in kilowatts (KW). Most industrial plant managers are very sensitive to this demand charge (it can be quite substantial), and thus strive to operate in a way that minimizes their maximum demand at all times (e.g., don’t start all the motors in the plant at the same time!).

Consumption is the amount of electricity a plant uses during the entire monthly billing cycle. The electric utility determines consumption, typically called energy and measured in kilowatt-hours (kwh), by taking the difference between the current and previous meter readings.
So, what is the best rate for your poultry processing plant, feed mill, or hatchery?

If your plant has the ability to shift electricity usage to off-peak hours, the best electric rate may be one that rewards a customer through the rate structure for moving usage away from the on-peak times. Typically, time-of-use rates or real-time or marginal cost rates provide these price incentives.

Real-time or marginal cost pricing allows customers to save substantially on their energy costs during peak hours by shifting their usages in response to higher energy prices. Utilities that have real-time rate programs provide the hourly prices either an hour or a day in advance. The customer then has the option to purchase electricity at that hourly price or avoid that price by reducing their usage in that hour.

Some utilities provide additional rate incentives for being able to curtail predetermined loads for short periods of time. Some hatcheries may be able to run a generator for an hour or two during a curtailment period in order to take advantage of these price incentives. There are penalties associated with not being able to respond to a curtailment, so make sure you know them before signing up for an interruptible rate.

The best rate for your poultry plant will depend on how it operates and how flexible the plant is to shifting electric usage to off-peak hours. There are rates designed to help you manage your electric energy costs, so meet with your local electric utility sales representative to find out what rate works best for you.

Gary Floyd is an alumnus of Georgia Tech and an industrial segment manager for Georgia Power Company.

Suggestions for reducing demand and consumption:

- Turn off motors, lights, and equipment you are not using.
- Turn off equipment that will be idle for long periods of time between operation.
- Maintain equipment for efficient performance.
- Add insulation to reduce heating and cooling requirements.

Modify production

- Minimize the amount of equipment you operate simultaneously.
- Start pressure-controlled and temperature-controlled equipment before beginning a shift or operating other equipment.
- Match power needs to production output. Bigger is not always better; it may result in higher demand and consumption.
- Defer less critical operations such as refuse shredding, trash compacting, and fork lift charging to non-production times.
- Distribute workload evenly between shifts.
- Defer electricity use to off-peak hours if you have a time-of-day rate option.

Modernize equipment

- Replace old, inefficient equipment and lighting with energy-efficient equipment.
- Install an energy management system that can automatically diversify loads and lower consumption by operating equipment only when needed.
- Install heat exchangers to reduce demand and consumption for heating, cooling, water heating, and process heating without affecting production.
- Install pressure- and temperature-controlled equipment before beginning a shift or operating other equipment.
- Match power needs to production output. Bigger is not always better; it may result in higher demand and consumption.
- Defer less critical operations such as refuse shredding, trash compacting, and fork lift charging to non-production times.
- Distribute workload evenly between shifts.
- Defer electricity use to off-peak hours if you have a time-of-day rate option.
LEARNING EVENTS

National Safety Conference for the Poultry Industry

June 1-3, 2011
Marriott Savannah Riverfront Hotel
Savannah, Georgia

Mark your calendars today and plan to attend the only national conference focused on safety management in today’s poultry industry. Come hear presentations on an array of industry topics, participate in informative round-table discussions, network with other safety professionals, and visit with vendors as they display the latest safety equipment and services geared toward the poultry industry.

In addition to the conference, you will have the opportunity to enjoy the southern charm, fabulous dining options, shopping, and historic tours Savannah has to offer. The Savannah Marriott is located steps away from the world-famous River Street.

This annual conference is supported by the National Chicken Council, the National Turkey Federation, the Georgia Poultry Federation, and the Georgia Tech Research Institute’s Agricultural Technology Research Program.

For more information, visit www.poultrysafetyconference.gatech.edu

Workshop on Novel Sampling and Sensing for Improving Food Safety

June 16-17, 2011
GTRI Conference Center
Atlanta, Georgia

This workshop will feature two days of keynote presentations, poster discussions, and round-table breakout, networking, and social interactions. Presentations will address current challenges in food safety pertaining to sample preparation and sensing methods for the detection of bacteria, viruses, microbial toxins, and parasites in food. Particular emphasis will be placed on innovations in sample concentration and processing methodologies, ligand immobilization technologies, and novel transducer and biosensor technologies.

Participation will be limited to 200 people, with an equal number of slots reserved for academics, industry, government agency, and students to ensure that the discussions are not dominated by one particular sector. Registration is $125, $50 (students).

The workshop is sponsored by the Georgia Institute of Technology, University of Georgia, Agricultural Technology Research Program of the Georgia Tech Research Institute, and the Center for Food Safety in the College of Agricultural and Environmental Sciences at the University of Georgia.

For more information, visit www.foodsensing.gatech.edu

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