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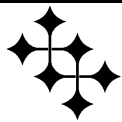
A Newsletter from the  
Computer Integrated Food Manufacturing  
Center and Pilot Plant  
at Purdue University

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# INProcess

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## Research in advanced process control

The CIFMC is currently investigating the benefits of using advanced process control methods for control of product temperature in plate heat exchangers. The different advanced process control techniques will be compared to determine how well they respond to process disturbances.

The heat exchanger system consists of a positive displacement pump, centrifugal pump, and two plate heat exchangers. The first heat exchanger heats the water, which becomes a heating media to heat the product.

All sensors and field devices involved in this setup are smart Foundation Fieldbus devices networked in a distributed control scheme and include several 'smart' temperature transmitters, a 'smart' valve positioner, a 'smart' pressure transmitter and two magnetic flowmeters to monitor hot water and product flow.

The algorithms being evaluated are (1) cascade PID control, (2) cascade Fuzzy Logic (FL) control, (3) cascade control with FL as master and PID as slave and (4) cascade control with PID as master and FL as slave. We are also looking at the effect of implementing time-delay compensation with the above control strategies to determine the very best control strategy.

In addition to response to

setpoint changes, we are evaluating the closed loop response to process disturbances including pressure change in incoming steam supply, increase and decrease in product flow, increase and decrease in hot water flow. Stay tuned to our website for progress notes on this research. ☺

## New equipment

### • Lee Industries donates steam-jacketed kettle

The Food Science department has just received a new kettle that was donated by Lee Industries in Philipsburg, PA. This Double Jacketed steam kettle has a working volume of 100 gallons. This is a great size for many tests that we conduct in the pilot laboratory. The double action agitator is inclined to 22.5°. This allows for a more gentle agitation and less breakage of particulates. This is important for tests that we conduct on fruits and vegetables with fragile pieces. The agitator is variable speed and can operate at 8-50 RPM.

The kettle surfaces are 316 stainless steel for easy cleaning. The jacketed kettle can withstand a steam pressure of 90 psig (332° F) and will allow rapid heating of foods. The product exit port is a flush bottom 3 inch ball valve with a tri-clamp end. This should allow for rapid evacuation of the product. The kettle will be getting use very shortly. The

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Send e-mail to [CIFMC@Purdue.edu](mailto:CIFMC@Purdue.edu) for an e-mail subscription

Senior Chili supper is coming up April 24. We will be preparing 60 gallons of chili that will be consumed by graduating seniors from the school of Agriculture and faculty. We are looking forward to using this kettle for this and various research activities in the pilot laboratory.

We really appreciate this donation from Lee Industries. Industry support with the latest technology allows us to better train our students with equipment that they will work with when they get into industry. Also this donation will help with research activities that we are conducting on particulate food processing with our graduate students as well as industrial clients.

If your company would like to utilize this or any other equipment that is located in our pilot lab, please feel free to contact Steve Smith (processing Specialist) at 765-494-7706 or e-mail at [smithrs@purdue.edu](mailto:smithrs@purdue.edu)

• **Brookfield R/S Rheometer**

The CIFMC recently purchased an R/S Controlled Stress Rheometer from Brookfield Engineering. Rheological evaluation through controlled stress measurement offers viscosity profiling, thixotropic response and yield stress determination.

The Brookfield R/S Rheometer offers both controlled rate and controlled stress measurement under flow characterization tools including ramp, loop, and single point testing for a wide range of shear rate, shear stress, and torque provide flexible flow analysis and yield measurement.

The rheometer will be used by

the CIFMC for research in the rheology of such products as oils, lubricants, polymers, dairy products, fruit and vegetable sauces, chocolates, gels, emulsions, suspensions, ointments, and dispersions.

*Rheo2000* software will enhance the utility of the R/S Rheometer through programmed control and data analysis with mathematical models of viscosity such as: Newton, Bingham, Casson, Ostwald, Steiger-Ory, Herschel-Bulkley. This analytical grade rheometer complements our in-line viscometers allowing better offline and online rheological analysis of foods. More information about the rheometer and other Brookfield products can be found at:

[www.brookfieldengineering.com](http://www.brookfieldengineering.com)

Please contact us if you would like to begin measuring and controlling the rheology of your food products.

• **Thermal Conductivity**

The CIFM center recently purchased a thermal conductivity measurement system. The heart of the system is a thermal conductivity probe model TP02 manufactured by Hukseflux Thermal Sensors.

The TP02 is a high quality probe that offers the possibility to do a practical and fast measurement of the thermal conductivity of the medium in which it is inserted. It works in compliance with the ASTM D 5334-92 and D 5930-97 standards.

The standard TP02 probe has proven suitability in foods and

various other materials. The Non-Steady-State Probe (NSSP) measurement method (also known as transient line source, thermal needle, hot needle, heat pulse and hot wire technique) has the fundamental advantages that it is fast and absolute while the sample size is not critical. Hukseflux is specialized in NSSP design.

Special probes have been developed for in-situ field experiments. The TP02 was designed and tested in collaboration with the Applied Physics Group of Wageningen University.

The TP02 will be used with Campbell Scientific CR10X data acquisition system for research involving the measurement of the thermal conductivity of foods and how thermal conductivity changes as foods undergo physico-chemical reactions.

The results of such research is required for better process design and automation. ☐

**Recent publications**

The following publications represent the results of recent CIFMC research:

- Ilyukhin, Sasha V., Haley, Timothy A., Singh, Rakesh K. (2001) *A Survey of Automation Practices In the Food Industry*. Food Control
- Ilyukhin, Sasha V., Haley, Timothy A., Singh, Rakesh K. (2001) *A Survey of Control System Validation Practices In the Food Industry*. Food Control
- Laura Zimmer, Timothy A. Haley, Osvaldo Campanella (2001) *A Comparative Study of the Performance of Selected In-*

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*line Viscometers on Newtonian and Non-Newtonian Fluids.*  
Journal of Texture Studies.

Reprints of any CIFMC publications are available free upon request. 📄

## CIFMC makes NCFST presentation

CIFMC manager Sasha Ilyukhin recently gave a presentation at the National Center for Food Safety and Technology (NCFST) entitled "Providing Analytical Redundancy for Control Systems Used In Thermal Processing of Foods".

In his presentation Mr. Ilyukhin discussed techniques and methodologies of establishing real-time control system validation in food processing by means of analytical or hardware redundancy.

As an example of providing analytical redundancy Mr. Ilyukhin demonstrated the results of the experiment with electronic monitoring of mercury-in-glass thermometer indication. 📄

## Integration of pilot plant facilities

As many new plant communication technologies emerge, the CIFM center at Purdue University tries to implement them in the pilot plant facility, investigate the benefits of their use, and promote their implementation in food manufacturing.

The CIFM center is proud to announce that the pilot plant is now fully integrated with

Foundation Fieldbus, one of the most powerful digital communication protocols for plant floor integration available on today's market.

The pilot plant facility is also fully integrated with LAN/Ethernet, which allows instant access to pilot plant data from any point on the Food Science Department network and the Internet.

The CIFM center has recently established a hot data link between an Allen-Bradley PLC 5/15 and the Delta V control system via Data Highway Plus/RS 232 interface. This connection provides full data exchange between two different platforms, and allows the CIFM center to implement advanced process control capabilities built in the Delta V control system while using traditional input/output devices connected to the Allen-Bradley PLC.

Let us share our experiences with you! If your company is conducting a major integration project and is interested in details about various communication standards and system interoperability please contact CIFMC manager Sasha Ilyukhin at (765) 496-7224 or send e-mail to: [ilyukhin@foodsci.purdue.edu](mailto:ilyukhin@foodsci.purdue.edu) 📄

## What keeps plant managers up at night?

One of the biggest issues that "keep plant managers up at night" is equipment failures, including, of course, the control system equipment and field devices. Generally, there are two major reasons for such failures.

The first reason is equipment failure due to improper

maintenance or wear and tear, or both. Modern control systems as integral components of the plant-wide process control architecture, address these issues with powerful asset management programs. For example, if a customer has a valve with a 'smart' positioner then he/she could set the positioner to record the number of travels in accordance with the specifications provided by the valve manufacturer until the next scheduled maintenance or stem replacement. 'Smart' devices also remember the date, location and person's name for the last instance of calibration, which facilitates the development of proper maintenance activities and promotes better engineering practices.

Perhaps, the second major reason for equipment failures is the human factor. This scenario occurs when authorized or unauthorized personnel operates the control system abnormally causing it to malfunction or to proceed to a critical stop. Ideally, all system hardware and software components should be protected from any intervention by an unauthorized individual or any abnormal entry from an authorized operator.

In case of hardware security it is usually up to the food manufacturer to establish sufficient hardware protection according to good engineering practices.

In case of control system software, however, it becomes mostly an issue of security that is built-in the software itself and the

flexibility that the software offers in that regard. To maximize software security, the control system can be configured to work as an operator workstation only with no or very limited access to critical system files from the plant floor. The control system administrator should assign permissions to every user according to their predetermined access level. And, most importantly, all process records kept electronically should be protected from tampering by no less than two levels of security and in full compliance with 21 CFR Part 11.

Another issue that "keeps plant managers up at night" are problems resulting product recipe changes. This is one of the major concerns for batch processing. The last batch that the shift produces is usually an incomplete batch. Subjecting the incomplete batch to the same treatment as a normal batch may cause significant degradation in product quality. Modern control systems address this issue with the flexibility built-in to the batch software. Plant managers could establish the correlation between the batch size and the required processing time, and incorporate the results of such correlation into their batch recipe structure. The recipe scaling feature that comes standard with most modern control systems may not always be suitable for the food processes, since the correlation between the batch size and processing time may not always be linear.

The control system software flexibility is also very important

in case of a product change in batch processing. When the production line needs to be re-configured to run another product it is critical to conduct such changeover as fast as possible. The biggest determination factor for the speed of such changeover is the batch software flexibility. It may seem obvious, but many control systems available on today's market are not batch-oriented by design, and require a lot of extra work to conduct a recipe change.

Another big concern for the food industry and one that "keeps plant managers up at night" is process deviations. Since most food processes are very complex in nature, they require extremely precise control. Once the production equipment is up and running under normal conditions, most modern control systems can efficiently supervise it. However, given a deviation (i.e., sensor failure, steam pressure drop, etc.) some control systems on today's market would not have a built-in functionality to handle the situation properly. To address this issue, the many modern control systems offer such beneficial components as built-in I/O redundancy modules, advanced control (e.g., Fuzzy Logic and Artificial Neural Networks), dead-time compensation and predictive control capability.

In case of a sensor failure the control system would automatically switch to the redundant probe and, if a 'smart' transmitter were used in conjunction with a digital bus network, the redundant sensor

would prompt maintenance to replace the failed probe. There are a number of redundant devices available on the market today but a system of automatically notifying the operator or maintenance of sensor problems requires the right control system software and bus topology.

Deviations in feed stream, such as a pressure drop in a steam supply line, can be measured and their effects predicted by a well-designed and properly tuned feed-forward predictive control algorithm that comes standard with a few modern control systems.

In addition to all of the above, modern control systems offer a comprehensive variety of components and functions beneficial to the food industry, some of which are not available in traditional control systems. To name a few, some of the advanced control capabilities (e.g., Fuzzy Logic) if properly tuned, could be used for more precise process control. The U.S. Food and Drug Administration specifically addressed Fuzzy Logic in its "*Guide to Inspections of Computerized Systems in the Food Processing Industry*" (GICSFPI) and advised its inspectors to perform a more detailed review of Fuzzy Logic algorithms compared to traditional PID control algorithms. This is due to the fact that in some instances a Fuzzy Logic algorithm may not have a definite setpoint, which must be recorded for regulatory purposes.

Another advantage of a modern control system is its

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ability to implement efficient distributed control architecture using 'smart' field devices across a digital sensor bus network. An example of such a device network is *FOUNDATION Fieldbus*. Because control strategies can be downloaded into *FOUNDATION Fieldbus* transmitters, they are capable of continuing to run critical process segments even if the main control system is down.

Modern control systems also offer software version control functionality as an excellent tool for the development of proper control system validation plan. Software version control has been specifically addressed by FDA for electronic control systems and, if properly implemented, may greatly facilitate plant inspections and initial system approval.

Simulation capabilities built into many modern control systems could be very useful for R&D facilities and pilot laboratories. New production line designs could be tested by software prior to their physical implementation, which would significantly reduce the start-up costs. Simulation tools are also essential for proper prospective validation activities.

Fisher-Rosemount's Delta V system is a perfect example of a modern control system that accomplishes all tasks indicated in this article.

Please visit the FOUNDATION Fieldbus website at: <http://www.fieldbus.org>

Please visit the Delta V system website at: <http://www.easydeltav.com> 

## May aseptic workshop

The workshop is for food processors that are processing or

## *Upcoming Aseptic Workshop*


We are gearing up for our 18<sup>th</sup> annual aseptic processing workshop to be held in the new Food Science building and pilot plant on May 14-17. The workshop will consist of lecture and hands-on laboratory session. Some of the topics will include:

- Microbiological Principles in Aseptic Processing
- Chemical Considerations of Aseptic Processing
- Aseptic Packaging Technology
- Principles of Thermal Processing as Related to Aseptic Processing
- Thermal Process Calculations
- Quality Assurance and FDA Regulations for Aseptic Processing and Packaging

The hands-on laboratory sessions will include quality evaluation, packaging, engineering concepts and equipment features. A Social Mixer and Dinner are included. For more information, contact Steve Smith at (765) 494-8256.

are thinking of processing foods aseptically. The workshop is designed to give individuals the basic knowledge involved in the development and operation of an aseptic system.

The course is appropriate for food scientists, food and packaging engineers, microbiologists, chemists, and anyone wanting an in-depth knowledge of Aseptic Food Processing and Packaging.

For more information, contact Steve Smith at (765) 494-8256 or send an e-mail message to [smithrs@purdue.edu](mailto:smithrs@purdue.edu). 

## Virtual Food Laboratory

The CIFMC has begun development of vPRO (Virtual Processing Reusable Objects) software. The software will eventually allow educators to build virtual food processing

plants from reusable software objects. Each object will have multiple properties and methods based on well-documented transport models and will enable construction of virtual unit operations that exhibit real-world behavior. The CIFMC plans to release its first CD of virtual food processing unit operations built using vPRO in the third quarter of 2001 for FS 442, a unit operations course in food processing. Students will be asked to use the CD to conduct experiments on the virtual unit operations, and collect and analyze the resulting data. This CD will be followed by other CDs to be released in the 1st quarter of 2002 for use with statistical process control and food process automation courses.

For more information about vPRO, contact Dr. Tim Haley at

[TimHaley@Purdue.edu](mailto:TimHaley@Purdue.edu). 