Director's Message

By Brad S. Carlberg, P.E.
BSC Engineering

Honorable Members of PUPID,

Well, it is already the first week of August and as I write this I have just returned from a 9-month trip to Seoul, South Korea.

This last September, the ISA Automation Week 2012 was at the Orange County Convention Center in Orlando, Florida. If you couldn’t be there, you can listen to the audio and read the Powerpoint presentations and papers by going to the links on the PUPID website. As they say, it’s the next best thing to being there.

Our division membership has decreased from 432 to 411 members this quarter. The membership has stayed nearly constant with 49 new division members since last January. Welcome to the new members!

I am also pleased to be able to include Michel Ruel’s “Design and Application of Fuzzy Logic Control for Semi-Autogenous Grinding Mill System” Presented at the 56th ISA POWID Symposium on 2-7 June 2013, in Orlando, Florida

I hope to see you all at the ISA Automation Week 2013 the first week of November; come see my paper & learn how to put your HMI’s on your smartphone or tablet.

I hope it is an encouragement to you to become more involved with the Division and to enroll more members from the great international pulp & paper community.

Please do not hesitate to contact me at my email brad.carlberg@bsc-engineering.com to discuss how you can help PUPID.

Do feel free to forward the Newsletter to your friends and colleagues who may have an interest in it.
WHAT IS GOOD CONTROL?

Good setpoint response is easily rejected. Errors are small when a disturbance occurs, and disturbances are not easily rejected.

WHAT DO YOU WANT?

The characteristics of good control (Table I) are difficult to obtain. When tuning a loop, one must make compromises between robustness and speed of response. Robustness is the ability of the control loop to remain stable when the process (mainly dead time or process gain) changes. Usually, to obtain robustness:

- Speed of response is longer.
- Errors are greater when a disturbance occurs, and disturbances are not easily rejected.
- If the response is fast, it usually indicates:
  - The loop is less robust,
  - Errors are small when a disturbance occurs, and
  - Disturbances are quickly rejected.

Plant efficiency and consistent product quality depend on proper loop performance, but tuning the controller is only the last step. This is the first of a three-part series on loop optimization. In April, Part II will describe how to optimize loop characteristics. And finally, in May, Part III will cover PID tuning.

There is much to be gained by optimizing control loops. It has been estimated that 80% of process control loops are causing more variability running in automatic mode than in manual. The often-quoted EnTech study showed that some 30% of all loops oscillate due to nonlinearities such as hysteresis, stiction, deadband, and nonlinear process gain. Another 30% oscillate because of poor controller tuning.

With a poorly optimized loop, an upset in the direction towards inefficiency results in giving away product. Alternatively, a load may cause off-spec product. When a control loop is running optimally, variability is minimized. Better tuning keeps the process on spec and reduces giveaway of often expensive ingredients.

But tuning objectives vary for different types of processes. For example, in a steam header, the pressure has to be maintained at the maximum allowable without large errors so the safety valves will not open. The PID controller must be tuned tightly to ensure the valve that controls the flow from the main header will move quickly to eliminate effects of disturbances.

On the other hand, the PID controller of a robot arm that manipulates nitroglycerin vessels has a different objective. The control loop must be optimized to change the setpoint without overshoot or cycling.

Performance Objectives

Most engineers and technicians tune process control loops using trial and error, observing the response to setpoint changes. To achieve good setpoint response takes a skilled intuitive understanding of the shape and speed of response. Only experienced people are able to achieve good setpoint response this way.

Unfortunately, once a loop is tuned for good setpoint response, the response to upset is usually very sluggish. Good setpoint tuning does not automatically result in good recovery from upsets. Unfortunately, it is upsets that usually are the source of off-spec product and poor variability.

Using modern tools to analyze a loop will give the engineer or senior technician helpful hints about the process: numbers and graphics will inform the user about design, equipment performance, and interactions with other loops. Modern tools also let the engineer or the technician select appropriate tuning parameters for the control objective. And since the algorithms used in PID controllers are different from one manufacturer to another, in many cases the algorithm is user selectable.

WHAT DO YOU WANT?

The characteristics of good control (Table I) are difficult to obtain. When tuning a loop, one must make compromises between robustness and speed of response. Robustness is the ability of the control loop to remain stable when the process (mainly dead time or process gain) changes. Usually, to obtain robustness:

- Speed of response is longer.
- Errors are greater when a disturbance occurs, and disturbances are not easily rejected.
- If the response is fast, it usually indicates:
  - The loop is less robust,
  - Errors are small when a disturbance occurs, and
  - Disturbances are quickly rejected.

WHAT IS GOOD CONTROL?

- Good setpoint response without overshoot.

Calendar of Events

Get a quick overview of the ISA PUPID events for 2013 by going to the Calendar at:
http://www.isa.org/~pupid/2013_PUPID_Calendar.htm

28th Annual North American Forest Products Conference
October 7-9, 2013
Hotel Del Coronado, San Diego, CA USA
http://www.risinfo.com/events/na_conf/program.html?source=U081NA

2013 Pan Pacific Conference
11/20/2013 to 11/22/2013
Hotel Horison
Bandjung, West Java Indonesia
http://www.reptech2013.org/

2013 TAPPI PEERS Conference
09/15/2013 to 09/18/2013
Green Bay, WI USA
http://www.tappipeers.org/

2013 BLRBAC Fall Meeting
10/7/2012 to 10/9/2013
www.blrbac.org

2013 China Paper Technical Conference
9/02/2013 to 09/04/2013
China International Exhibition Center
Beijing
http://www.chinapaperexpo.cn/

2013 ISA FALL LEADERS MEETING
SATURDAY, NOVEMBER 2, 2013 AND SUNDAY, NOVEMBER 3, 2013

ISA AUTOMATION WEEK 2013
MONDAY, NOVEMBER 4, 2013 THROUGH THURSDAY, NOVEMBER 7, 2013
NASHVILLE CONVENTION CENTER
NASHVILLE, TN
Come meet your leaders & get involved!

ABTCP 2013-46th Pulp & Paper International Congress & Exhibition
10/8/2013 to 10/10/2013
Transamerica Expo Center
Sao Paulo, Brals
http://www.abtcp2013.org.br/ingles/
- Good setpoint response with a maximum overshoot.
- Response time matched with another loop so loops will be synchronized.
- Response time long enough to ensure the loop will not react with another loop.
- Load disturbance quickly rejected.
- Load disturbance rejected without cycling.
- Robust tuning so the loop will remain stable when the process changes.
- Aggressive tuning so the error will remain small enough to keep the product in specs.

A control loop consists of the process, measurement, controller, usually a current to pneumatic (I/P) transducer, and valve. Optimal process control depends on all of these components working properly. Hence, before tuning a loop, one must verify if each component is operating properly and if the design is appropriate.

Choosing the optimal PID tuning should be done after making sure all of the other components are working properly. The optimal tuning parameters ensure your equipment is used at maximum efficiency.

Questions to Be Answered
The following steps outline a procedure for approaching and optimizing a process control loop. Optimization requires observation in manual and automatic modes, and at various operating conditions. We need to answer the following questions:

1. Process gain: Is the control valve sized properly? Often, valves are oversized. If so, the controller output will be at one end of the range when the loop is in automatic. Also, oversizing the valve will amplify nonlinearities such as hysteresis, stiction, different response to small and large changes, and operating near the seat.
   The process gain should be between 0.3 and 3. The ideal process gain is 1. A process gain too high will not permit the controller to work at its full potential: the controller will have to be tuned with a small proportional gain.
2. Hysteresis/stiction: Does the control valve have harmful hysteresis and/or stiction? Hysteresis is a difficulty but stiction is really the main problem. Stiction occurs when friction is present.
   Hysteresis should be less than 3%, significantly less if the loop is to be tuned tightly. Stiction should be less than 1% and often 1% is too much.
3. Sensor/transmitter: Is the measurement sensor working properly? From your experience, do the numbers make sense? For example, is the dead time small enough? If a transmitter is not properly installed, the dead time can be too long; if a filter is added in the transmitter, the equivalent dead time could be longer.
4. Noise band: Is there an excessive amount of noise in the loop? When disturbances occur too fast to be removed by the PID controller, they are called noise. Filtering may help. The filter should be small enough to not increase the equivalent dead time and large enough to reduce the noise. Selecting the filter time constant is a tradeoff between increasing the equivalent dead time and reducing the amount of noise. When the noise is reduced, the controller output is smoother.
5. Nonlinearities: How nonlinear is the loop? A loop is nonlinear when the process gain varies. All loops are somewhat nonlinear. It is the degree of nonlinearity that we are interested in. If the loop gain varies by more than a factor of two or three, then linearization will help optimize the loop.
6. Asymmetry: Does the loop respond differently in one direction than in the other? Often, a valve responds more quickly in one direction than the other. Also, in temperature processes using one fluid to add heat and another to remove heat, the two fluids are different and the characteristics of the process are different.
   If the equivalent dead time or the equivalent time constant are different depending on the direction, use the worst case to tune the loop or use a special algorithm.
7. Tuning: Is the loop optimally tuned? If the loop is tuned aggressively to minimize error, the robustness is small; if the loop is tuned sluggishly to reduce variability, the recovery time after a disturbance is long.
   Tuning parameters are selected to make a compromise between robustness and performance. The loops upstream could interact—selecting the appropriate tuning parameters will allow decoupling. At the opposite, if loops need to be synchronized, selecting the appropriate tuning parameters will ensure they work in accordance.

Next: Diagnosis
Each of these problems has a characteristic signature, which can be found by performing a series of tests and analyzing the results. The tests, which will be covered in detail in the next installment of this series, start with collecting process variable and controller output data with the controller in automatic at normal operating conditions, then introducing a setpoint change. Data is also collected with the loop in manual mode.

You will be able to see how the operating range for the valve and its performance can tell you if the valve is sized correctly; whether loop cycling is being caused by hysteresis, nonlinearities, or poor tuning; and the other critical aspects of loop performance that must be understood before tuning the controller.

Michel Ruel, P.Eng. Expertise Centre Director, Optimization and Advanced Control (Top Control), BBA Inc., Québec City, Canada Michel.Ruel@bba.ca, an engineering company specializing in optimization of continuous and batch process control. Ruel has over 30 years of plant experience at companies including Monsanto, Domtar Paper, Dow Corning, and Shell Oil. Author of several publications on instrumentation and control and frequent university lecturer, Ruel is experienced in solving unusual process control problems and a pioneer in implementing fuzzy logic in process control.
## Welcome to the 49 New ISA Pulp & Paper Industry Division Members in 2013

<table>
<thead>
<tr>
<th>Name</th>
<th>Name</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michael T. Alt</td>
<td>Marvin Michael Maddox</td>
<td>Riley James McKernan</td>
</tr>
<tr>
<td>Dean G. Apostolopoulos</td>
<td>Nicholas Anane-Agyei</td>
<td>Paul Oliveira</td>
</tr>
<tr>
<td>Arjun B K</td>
<td>William David Buie</td>
<td>Stefan Van Der Wal</td>
</tr>
<tr>
<td>Ms. Shilpa Bhat</td>
<td>Christopher Trino</td>
<td>Dr. Ky M. Vu</td>
</tr>
<tr>
<td>Ms. Devendra Deval</td>
<td>J Deepakumar V C Jothimani</td>
<td>Glenn Ashley Wrightsman, II</td>
</tr>
<tr>
<td>David Greer</td>
<td>Mark A. Chouananard</td>
<td>DeMario Marques Caldwell</td>
</tr>
<tr>
<td>Ms. Mahalakshmi H N</td>
<td>Dereck Charles Esteph</td>
<td>Kevin Anton DeWitt</td>
</tr>
<tr>
<td>Harshith John</td>
<td>Bonny T. Wadikonyana</td>
<td>Yanyu Duan</td>
</tr>
<tr>
<td>Heleno Amorim Linhares</td>
<td>Keneisha Williams</td>
<td>Matthew Ernst</td>
</tr>
<tr>
<td>Jerry Lyons</td>
<td>Gordon Baker, Jr.</td>
<td>Josep Fontgivell Mas</td>
</tr>
<tr>
<td>John Russ Nyquist, CCST</td>
<td>Stephane Chevrette</td>
<td>Mrs. Javier Frias Perea</td>
</tr>
<tr>
<td>Ms. Nalinakshi R</td>
<td>Chad E. Elliott</td>
<td>Glen M. Gallagher</td>
</tr>
<tr>
<td>Ms. Shilpa S</td>
<td>Francisco Javier Hervas Calle</td>
<td>Kevin Persig</td>
</tr>
<tr>
<td>Hiliard Richard Sumpter</td>
<td>Victoriano Jimenez Utrero</td>
<td>Miles Ray Reid</td>
</tr>
<tr>
<td>Carrie Boutilier</td>
<td>David W. Johnson</td>
<td>Michael J. Tucker</td>
</tr>
<tr>
<td>Sam Hassan</td>
<td>Abdelaziz Kaychouchi</td>
<td>James G. Weit</td>
</tr>
<tr>
<td>Hossein Izadi Lybidi</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Here's a Reminder to the 26 ISA Pulp & Paper Industry Division Members Who Need to Renew Their Membership

<table>
<thead>
<tr>
<th>Name</th>
<th>Name</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idelmar Barcelos</td>
<td>Don Kaster</td>
<td>Adilan Rodrigues Bittar</td>
</tr>
<tr>
<td>Bernie Beemster</td>
<td>John Kirkpatrick</td>
<td>Stanley Moses Sathianthan</td>
</tr>
<tr>
<td>Shubhojit Chatterjee</td>
<td>Celius Alessandro Lager</td>
<td>Hal A. Shaw</td>
</tr>
<tr>
<td>Cassio Divinio Silva Ribeiro</td>
<td>Bruce E. Manthey</td>
<td>Cristiano Konder Lins Silva</td>
</tr>
<tr>
<td>Norbert B. Eubanks, Jr.</td>
<td>Eduardo MOntalti</td>
<td>Dr. Daniel B. Smith</td>
</tr>
<tr>
<td>Bruno Santos Ferreira</td>
<td>John W. Morrison</td>
<td>Akbar Talebi, PE</td>
</tr>
<tr>
<td>Steven Forbes</td>
<td>Ms. Angela Pettinger</td>
<td>Daniel Tesch Liquer</td>
</tr>
<tr>
<td>Maxwell T. Gray</td>
<td>Marcelo Queiroz</td>
<td>Harish Verma</td>
</tr>
<tr>
<td>Steven C. Kaishian</td>
<td>Pritesh S. Rao</td>
<td></td>
</tr>
</tbody>
</table>

**Don't forget to renew!**
**Who's Doin' Anything?:**

Catalyst Paper closes newsprint mill in Arizona

“We understand and regret the difficult impact within the Snowflake community and surrounding region”

Catalyst Paper yesterday announced the permanent closure of its Snowflake recycle mill located in northeastern Arizona (USA) and its subsidiary the Apache Railway Company. The operations currently employ 308 salaried and hourly workers.

The operation is scheduled to shut production on September 30, 2012.

"The decision to close Snowflake is an extraordinarily difficult one given the exceptional effort that employees, unions and public officials have given to address the unique challenges at this mill, said President and CEO Kevin J. Clarke. "We understand and regret the difficult impact within the Snowflake community and surrounding region created by closure of the mill. I want to acknowledge and thank all who have given us their unwavering support and cooperation. There were no stones left unturned."

Catalyst implemented a number of measures since acquiring the Snowflake operation in 2008, to address market challenges and input cost pressures. These included production of higher-value specialty paper grades at what was formerly a newsprint-only mill, capital investment, productivity, quality and service improvements, full leverage of the mill's environmental attributes, and competitive labour agreements. Catalyst has also explored a range of alternatives, including attempting to sell the mill on a going concern basis.

However with newsprint demand down more than 10 per cent annually since the end of 2008, old newsprint (ONP) price volatility and higher freight costs as procurement and sales have been forced to go further afield to source recycled paper supply and secure product orders, the mill's profitability could not be restored. ONP prices have increased approximately 163% since 2009. A US$5 per ton increase in ONP price has a negative impact of approximately US$2 million on EBITDA and approximately US$1 million on net earnings. Snowflake generated negative EBITDA since 2009.

New containerboard mill in New York

Cascades announced that its Greenpac Mill LLC (Greenpac) manufactured its first roll of lightweight linerboard on July 15 at its new ultra-modern containerboard mill.

From the very beginning of the project in 2011, the construction of the mill was entrusted to Norampac, a division of Cascades, and the start-up took place on July 15, 2013 as planned under the initial schedule for the project. Norampac is also responsible for the management of Greenpac's operations.

Located in Niagara Falls in the State of New York, this state of the art mill has created 118 jobs in the region. Considered as the most advanced in its category in North America, Greenpac produces a lightweight linerboard, made of 100% recycled fiber, on a 328-inch machine (8.33 meters), with an annual production capacity of 540,000 short tons.

"The start-up of this new mill is a proud moment for Cascades. Equipped with the most advanced technology, this machine will enable us to better meet the needs of our customers,” said Marc-André Dépin, President and Chief Executive Officer of Norampac. "After two years of intensive construction activity, we are anxious for the opportunity to finally be able to demonstrate the possibilities of the quality products that we will be able to offer."

Greenpac Mill was designed for optimal energy efficiency and with many automated operations. The water is treated and reused in order to reduce consumption as much as possible. In addition, the water treatment system generates gases that are used for steam production, to dry the paper.
WHO’S DOIN’ ANYTHING?: (CONTINUED)

New forest management to mitigate declining log supplies in Canada

Published: Fri, 2012-08-03 11:38 Comments

Sharp reduction in timber harvest in British Columbia caused by mountain pine beetle infestation

Can changes in forest management regimes in British Columbia mitigate the sharp reductions in timber harvests caused by the mountain pine beetle? Timber harvests in British Columbia plunged by over 40 percent between 2005 and 2009, but have since recovered and were close to the 25-year average in 2011. As a consequence of the infestation of the mountain pine beetle, long-term log supply is estimated to be about 20 percent below historical levels unless different management regimes are implemented.

Timber harvest in British Columbia reached a record 90 million m3 in 2005 but fell dramatically the following four years to a 25-year low of just over 52 million m3 in 2009. Reduced demand for lumber in the US market, relatively high manufacturing costs, export tariffs for shipments to the US and deteriorating sawlog quality were the major reasons that consumption of sawlogs declined by over 40 percent in a relatively short period of time. Since the bottom in 2009, harvests have gone up thanks to a substantial increase in exports of logs and lumber China, reports the Wood Resource Quarterly.

In 2011, harvested volumes reached 70 million m3 or close the average annual harvest before the forests in the Interior of the province were hit by the mountain pine beetle infestation. The beetle has infected just over 18 million hectares of forests and an estimated 710 million m3 of pine trees (53 percent of all pine volume in the province) are dead or dying. Over the next 3-5 years, it is possible for harvest levels to increase in the Interior of the province because of the availability of beetled-killed trees that need to be utilized before the quality has deteriorated to the point when it can be used only for making pulp or for energy generation, including the manufacturing of wood pellets. Long-term, harvest levels are likely to be approximately 20 percent below historical levels.

In a recent study by the BC government, it was noted that the Annual Allowable Cut (AAC) in four Timber Supply Areas (TSA) in the Interior of the province could be reduced by almost 40 percent by 2020 as compared to the pre-beetle AAC. However, the report also discusses opportunities to mitigate the sharp reduction in available supply by:

A. Investing in harvesting and mill equipment able to harvest small-diameter trees in stands that are currently considered being uneconomical.

B. Intensifying silviculture management and increasing stand fertilization.

C. Harvesting in areas currently managed for non-timber values such as biodiversity and wildlife habitat.

The report predicts that by utilizing smaller trees, investing in intensive forest management and harvesting stands managed for non-timber values, future “mitigated-AAC” may be only 10 percent lower than the pre-beetle AAC. This may of course never happen, since the public will see the suggested changes in forest management regime as quite controversial.

Sappi starts dissolving pulp production at Ngodwana mill in South Africa

BRUSSELS, Aug. 2, 2013 (RISI) -

Sappi has completed the conversion project at its Ngodwana pulp mill in South Africa to dissolving pulp and production at the facility began in late July, a few weeks later than originally scheduled, the firm announced Friday.

Sappi expects to ramp up the new line, which has a capacity of 210,000 tonnes/yr and will use eucalyptus as furnish,
to full production before the end of the 2013 calendar year, a company spokesperson told RISI.

Major Russian pulp producer plans expansion in Brazil

Most of its production is exported to China

The Karelian Pitkaranta plant, one of Russia’s largest pulp producers, is considering foreign expansion, planning to take up to 30-50% of the Brazilian market of pulp, according to the company.

The company has currently taken steps to find new markets. According to the company’s corporate affairs director Natalie Danchenko, entering new markets will allow "CZ" Pitkaranta "to sell products at higher prices, as prices in Europe are by 30% higher than in Asian countries. However the CIS region and Central Asian states during the next several years will continue to remain priority sale markets for the company.

Metso finalizes major Brazilian order

Will supply key technology to CMPC’s Guaíba II pulp line in Brazil

Metso and CMPC Celulose Riograndense S.A. (CMPC) have finalized the agreement, according to which Metso will supply the key technology to CMPC’s Guaíba II pulp line in Brazil. The total value of the project is around EUR 800-900 million, of which around EUR 400 million consists of Metso’s own equipment and systems.

The new pulp line, which is an expansion to the existing Guaíba pulp mill, will have a capacity of 1.3 million tonnes per year and will be able to reach 1.5 million tonnes per year with minor investments. The new pulp line will be built in the state of Rio Grande do Sul in southern Brazil and is scheduled to be commissioned in the first half of 2015.

Metso’s delivery will include the main parts of the pulp line: the cooking plant and fiberline, pulp drying and baling, evaporation, a recovery boiler, causticizing and lime kiln, and an integrated automation solution and an operator training simulator for all mill process areas.

The main part of the order is included in Metso’s Pulp, Paper and Power orders received in the second quarter of 2013. The automation package is included in Metso Automation’s orders received in the second quarter of 2013.

The order will be supplied by Metso’s units in Europe and Brazil. The total impact on employment will be approximately 300 man-years in Metso group and during the peak of the construction approximately 4,000 people will be working for Metso in the construction site.
DESIGN AND APPLICATION OF FUZZY LOGIC CONTROL FOR SEMI-AUTOGENOUS GRINDING MILL SYSTEM

MICHEL RUEL, P.ENG. EXPERTISE CENTRE DIRECTOR, OPTIMIZATION AND ADVANCED CONTROL (TOP CONTROL), BBA INC., QUÉBEC CITY, CANADA MICHEL.RUEL@BBA.CA

PRESENTED AT THE 56TH ISA POWID SYMPOSIUM
2-7 JUNE 2013, ORLANDO, FLORIDA
ABSTRACT

The paper is divided into three main sections. The first section gives an introduction in which the characteristics of model-based versus expert systems and fuzzy logic control are examined; it then goes on to describe the approach selection and the SAG mill process. The second section focuses on the design of experiments, goal-setting and the definition of the controller structure and its development. Finally, the third section is devoted to the implementation, commissioning and optimization of the controller. This section will also touch on training, maintenance, improvements and results achieved. Specific energy reduction, increased stability and throughput increase are among the main recommendations and conclusions.

SHOULD ADVANCED PROCESS CONTROL BE USED?

Advanced process control (APC)
Advanced process control (APC) is a popular topic. How can one decide if advanced control should be added to an existing system? Advanced control is used to improve performance, stabilize production, handle constraints, protect equipment and manage grade changes.

Most plants use feedback controllers, usually PID (proportional, integral, derivative) controllers. It is common to develop special control schemes to handle more complex processes.

In classic PID process control, a controller brings a single value close to a set-point using a single manipulated variable. On the other hand, APC brings several values close to optimal targets simultaneously using several manipulated variables.

APC's four main strategies are advanced regulatory control, model predictive control (MPC), fuzzy logic and neural networks.

Model-based or rule-based systems
APC can be divided into two categories: model-based and rule-based. Model-based control is essentially advanced regulatory control and model predictive control while rule-based control is mainly fuzzy logic control. Other techniques exist, such as genetic algorithm and neural networks.

Model-based approaches are usually the first choice. If models cannot be identified or if there is a wide variation in models, then rule-based systems are considered. In rule-based approaches, the best operator’s knowledge is used to manipulate set-points on control loops. In other words, the process models the best operator.

Advanced regulatory control
To achieve better performance, cascade control, feedforward and constraint control are commonly used. This approach is referred to as advanced regulatory control and is widely used because it is well understood and the plant’s personnel can maintain these solutions. The control scheme is based on mass and energy balance.

Model predictive control (MPC)
If process performances require more sophisticated control approaches, model predictive control (MPC) is usually the first choice. MPC is best used for processes with strong coupling among variables, competing optimization goals and limited process constraints.

MPC is an advanced method of process control that has been used in the petrochemical industry since the 1980s. Model predictive controllers predict future behaviour based on dynamic models of the process, most often linear empirical models obtained through system identification.

MPC is widely used in chemical and petrochemical plants where process reactions, energy balance and mass balance are well known. Not only are theoretical relationships known, but the actual process behaviour resembles theory. Although good models can be calculated, in practice tests are performed on the process and models are developed based on those tests.

Linear or nonlinear models can be handled by MPC but it is usually easier to consider nonlinear processes as a series of linear models and to switch models based on process conditions.

While chemical processes mirror closely to theory, physical processes are different. For example, crushing rocks or controlling power in a ball mill depends on many unknown variables. In the mining and metals industry, it is not always possible to measure disturbances. Variables that are difficult to measure include material hardness, material composition and granulometry.

Model-based control is not an option if models cannot be identified. Without good models, alternatives must be sought; in the mining and metals industry, fuzzy logic is usually the next choice. Results similar to those obtained through fuzzy logic can be achieved using neural networks and genetic algorithms. Fuzzy logic has the advantage of being easy to understand and modify.

**Fuzzy logic control**

A fuzzy control system is a control system based on fuzzy logic, where decisions are made based on analog inputs representing a value ranging from 0 (false) to 1 (true). The logic deals with partially true and partially false values.

Fuzzy logic control is used when an experienced operator has better control over a process than a PID controller. Fuzzy logic emulates an experienced operator and reacts to process behaviour and variable trends.

**TYPICAL FUZZY LOGIC CONTROLLER**

**Structure**

![Figure 1: Typical fuzzy logic controller](image)

**Fuzzification**

Each input variable is converted into linguistic rules. For example, a level of two metres becomes 25% low and 75% moderate; a flow of 100 l/min becomes 10% medium and 90% high. These values will be used in decision rules.
Each input is evaluated based on membership functions, usually three, five or seven. For example, flow could be Lo, Ok or Hi. If five membership functions are used, it would be: LLo, Lo, Ok, Hi, HHi.

- **Decisions**

Each time the function is evaluated, all rules fired are evaluated and an output is generated for each rule.

**Defuzzification**

Defuzzification consists of generating an output value based on multiple rules fired at the same time. The simplest method is to use the maximum, in our example, 0.75 LLO. Other methods use weighted averages.

If memberships are not symmetric or equidistant, the system becomes nonlinear.

Depending on the rules, the system is also nonlinear.

**DECISION TREE: IS ADVANCED CONTROL NEEDED?**

The first step is to determine whether we need more than just PID control.

The following questions must be answered:

- Are the performances adequate?
- Do the control systems handle disturbances?
- Do the control loops interact?
- Does an operator perform better than the control system?
- Have the loops been optimized?
- Do we get the best from our systems?

A common mistake is to start an advanced control project without doing housekeeping. In most APC projects, more than 50% of the benefits stem from the optimization of basic control loops.
Comparison

<table>
<thead>
<tr>
<th>Approach</th>
<th>Model</th>
<th>Rules</th>
<th>Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>PID control</td>
<td>ARC</td>
<td>MPC</td>
<td>FLC, Neural Network</td>
</tr>
<tr>
<td>Description</td>
<td>PID, Control strategies</td>
<td>Process is modelled</td>
<td>Operator is modelled</td>
</tr>
<tr>
<td>Usage</td>
<td>Few variables</td>
<td>Good models</td>
<td>Best operator</td>
</tr>
<tr>
<td>Development</td>
<td>Simple</td>
<td>Moderate</td>
<td>Complex</td>
</tr>
<tr>
<td>Commissioning</td>
<td>Simple</td>
<td>Moderate</td>
<td>Long but easy</td>
</tr>
<tr>
<td>Optimization</td>
<td>Simple</td>
<td>Part of design</td>
<td>Cumbersome</td>
</tr>
<tr>
<td>Process changes</td>
<td>Simple</td>
<td>Re-model</td>
<td>Add rules</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Simple</td>
<td>Needs expert</td>
<td>Easy</td>
</tr>
<tr>
<td>Cost</td>
<td>Low</td>
<td>High</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

Models

If the decision is to use an advanced control system, the next step is to identify process models. Before identifying process models, loops must be verified and optimized. Multivariable models are identified using modern tools by bump testing set-points or making small changes to set-points, for example with pseudo-random binary signals (PRBS) signals. A matrix of models is then obtained. If the models are of good quality, then an MPC controller can be designed. If models cannot be identified, one should verify if better models can be obtained by making more extensive changes. If models cannot be identified using identification techniques, the next step is to check whether historical data can be used to model the process using a neural network (handling nonlinearities). Usually, one can replace measurements by neural network usage; the neural network becomes a soft sensor. If models cannot be identified, the next step is to verify if an experienced operator can control this process; if so, fuzzy logic control can be used to mimic this experienced operator.

Decision tree

![Decision Tree Diagram](image)

Figure 2: APC Decision Tree
SAG MILL CONTROL

Process
The process is a semi-autogenous grinding (SAG) mill. The SAG mill process uses steel balls and large rocks for grinding, with a minimal ball charge of 6% to 15%. The mill is large in diameter but short in length and rotates, tumbling contents to produce a breaking action. The load consists of dry ore, steel balls and water, which account for 30% of the volume. In addition to stabilizing the process and increasing tonnage, the control system must protect the lining by ensuring that rocks fall on other rocks and not on the lining. A previous controller was developed in 2005 but was abandoned as it could not handle disturbances and new control objectives. The process is multivariable and highly nonlinear. Before implementing the system, the operators were actively manipulating many variables with varying degrees of success, depending on operator experience and disturbances. The process, including each loop and control strategy, has been optimized. Identification was attempted but with very limited results. In fact, the process is not monotonous and process gains vary wildly. Experienced operators can control the process with good results but performance varies from one team to another. Abnormal situations are difficult to handle and power consumption is high. Fuzzy logic control has been selected. The solution must be robust, simple and implemented in the actual control system, a programmable logic controller. This PLC has fuzzy logic function blocks.

Figure 3: SAG Circuit

CONTROLLER DESIGN

Objectives
The goals are to reduce power consumption per ton of ore, increase throughput, protect linings and stabilize quality and operation. The plant is off the grid and produces its own electricity using fossil fuels.
Variables
The controller structure reflects the process and its operations. Input variables are: load (using bearing pressure), ore size, recirculation, actual power and density. All rates of change for input variables are used as inputs.

The manipulated variables are: tonnage, water flow and rotation speed.

Determining Rules
The metallurgists prepared a design of experiments (DOE) to determine how the SAG mill should be operated. Some variables were manipulated while others were mostly maintained. These tests were conducted again in different conditions.

All tests were conducted during the summer of 2011 with the operation team, which resulted in hundreds of rules. Rules were then chosen to reach the selected goals and to push the feed rate to its maximum.

Table 2: Examples of rules

<table>
<thead>
<tr>
<th>Rule</th>
<th>Pressure</th>
<th>Pressure Rate</th>
<th>Power</th>
<th>Power Rate</th>
<th>Tonnage</th>
</tr>
</thead>
<tbody>
<tr>
<td>123</td>
<td>HH</td>
<td>H</td>
<td>L</td>
<td>H/OK/L/LL</td>
<td>L</td>
</tr>
<tr>
<td>124</td>
<td>HH</td>
<td>L/LL</td>
<td>OK/L</td>
<td>OK</td>
<td>OK</td>
</tr>
<tr>
<td>125</td>
<td>HH</td>
<td>HH/H</td>
<td>LL</td>
<td>L/LL</td>
<td>LLL</td>
</tr>
<tr>
<td>126</td>
<td>H</td>
<td>OK</td>
<td>OK</td>
<td>HH/H</td>
<td>OK</td>
</tr>
</tbody>
</table>

Implementation
The controller is implemented in a programmable logic controller using standard fuzzy logic functions. Tools were developed to commission the controller and to supervise its performance and tune rules. These tools were developed in the plant’s historian application and in the control performance monitoring system.

Special attention was required for interfaces. Metallurgists had to modify targets, constraints, production goals and limits. Process control engineers adjusted rules and tweaked the weight of each action.

Training was provided to operators, metallurgists, maintenance technicians and engineers. Plant personnel maintain the system, modify the controller, add rules and optimize the controller. The results exceeded expectations and the break-even point was achieved in under three months.

Structure

Figure 4: Implemented fuzzy logic controller
Programming was done offline and tested using simple simulators. Membership functions for inputs and outputs were symmetric triangles and ranges were based on the previous summer’s design of experiments.

**Commissioning and optimization**

An advisory mode was used to validate the controller design. During the first few days, operators were manipulating all set-points themselves but were also observing results from the fuzzy logic controller (FLC). After three days, it was quite clear that the FLC’s results were anticipating the operators’ actions.

Over the next four days, FLC was used during the day and membership functions were modified to reproduce the best operator actions; both shapes and ranges were modified. Many rules were also modified while others were added. On the eighth day, FLC was used continuously and has been operational ever since. Every week, metallurgists validate the rules and make slight adjustments. Special attention was required for interfaces. Metallurgists had to modify targets, constraints, production goals and limits. Process control engineers adjusted rules and tweaked the weight of each action.

Training was provided to operators, metallurgists, maintenance technicians and engineers. Plant personnel maintain the system, modify the controller, add rules and optimize the controller.

**Statistical tools**

Tools were developed to support metallurgists:
- Rules used (% time, strength, etc.)
- Statistical data on rules and inputs
- Key performance indices: Tons/d, kW/ton, average error, etc.

The results are stored in the historian application to facilitate analysis, diagnostics and optimization.

**Benefits**

The main benefit is the reduction of specific energy; also, as expected, stability is improved and throughput is increased. System service time is in excess of 98%.
CONCLUSIONS AND RESULTS

This project was carried out over six months. The team consisted of consultant personnel, metallurgists from the plant and operators. The controller has been in use for six months and uptime is above 98%. Operators have quickly gained confidence and performances have been improved:

- Energy per ton has been reduced by 8%
- Tonnage per day has been increased by 14%

A production record was achieved in the first week. The savings generated by the fuzzy logic controller covered the project’s cost in less than three months.

REFERENCES

### Conference Schedule and Overview

Identify the sessions most relevant to you, by education track, or by career path using PathFinder Icons.

For the latest schedule updates, please visit www.isaautomationweek.org

<table>
<thead>
<tr>
<th>Time</th>
<th>Session Title</th>
<th>Track</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00 AM - 9:00 AM</td>
<td>Networking Break</td>
<td>Networking Break</td>
</tr>
<tr>
<td>9:00 AM - 9:30 AM</td>
<td>Keynote Address: Major General Robert E. Wheeler, USAF (Ret.) - “The Cyber Threat to the Automation Industry”</td>
<td>Networking Break</td>
</tr>
<tr>
<td>9:15 AM - 10:45 AM</td>
<td>Alarm Management Rationalization: Methods, Experience, and Advice</td>
<td>Business Value Tutorial</td>
</tr>
<tr>
<td>10:45 AM - 11:00 AM</td>
<td>Networking Break</td>
<td>Networking Break</td>
</tr>
<tr>
<td>11:00 AM - 12:30 PM</td>
<td>Cybersecurity Executive Panel: General Session</td>
<td>Cybersecurity Executive Panel: General Session</td>
</tr>
<tr>
<td>12:30 PM - 2:00 PM</td>
<td>Lunch &quot;Eat with the Experts&quot;</td>
<td>Lunch &quot;Eat with the Experts&quot;</td>
</tr>
<tr>
<td>2:30 PM - 3:30 PM</td>
<td>Attendee Networking Hub Open</td>
<td>Attendee Networking Hub Open</td>
</tr>
<tr>
<td>3:30 PM - 4:30 PM</td>
<td>Network Break</td>
<td>Network Break</td>
</tr>
<tr>
<td>3:45 PM - 5:15 PM</td>
<td>Smart Field Device Integration</td>
<td>Security in the Connected Enterprise - Tutorial</td>
</tr>
<tr>
<td>5:15 PM - 7:00 PM</td>
<td>Evening Reception (HUB)</td>
<td>Evening Reception (HUB)</td>
</tr>
</tbody>
</table>

**Wednesday, November**

<table>
<thead>
<tr>
<th>Time</th>
<th>Session Title</th>
<th>Track</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00 AM - 9:00 AM</td>
<td>Networking Break</td>
<td>Networking Break</td>
</tr>
<tr>
<td>9:00 AM - 9:30 AM</td>
<td>Technician Session 1 (See page 66)</td>
<td>Technician Session 1</td>
</tr>
<tr>
<td>9:15 AM - 10:45 AM</td>
<td>Alarm Management Panel: A Practical Alarm Management Discussion</td>
<td>The Business Impact of the Future Workplace</td>
</tr>
<tr>
<td>10:45 AM - 11:00 AM</td>
<td>Networking Break</td>
<td>Networking Break</td>
</tr>
<tr>
<td>11:00 AM - 12:30 PM</td>
<td>Technician Session 2 (See page 66)</td>
<td>The Business Impact of Generation Issues</td>
</tr>
<tr>
<td>12:30 PM - 2:00 PM</td>
<td>Lunch</td>
<td>Lunch</td>
</tr>
<tr>
<td>2:30 PM - 3:30 PM</td>
<td>Attendee Networking Hub Open</td>
<td>Attendee Networking Hub Open</td>
</tr>
<tr>
<td>3:30 PM - 4:30 PM</td>
<td>Network Break</td>
<td>Network Break</td>
</tr>
<tr>
<td>3:45 PM - 5:15 PM</td>
<td>Plant Asset Management</td>
<td>The Business Impact of Effective Decision Support</td>
</tr>
<tr>
<td>5:15 PM - 7:00 PM</td>
<td>Evening Reception (HUB)</td>
<td>Evening Reception (HUB)</td>
</tr>
</tbody>
</table>

**Thursday, November**

<table>
<thead>
<tr>
<th>Time</th>
<th>Session Title</th>
<th>Track</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00 AM - 9:00 AM</td>
<td>Networking Break</td>
<td>Networking Break</td>
</tr>
<tr>
<td>9:00 AM - 9:30 AM</td>
<td>Keynote Audience: ISA AIA</td>
<td>Networking Break</td>
</tr>
<tr>
<td>9:15 AM - 10:45 AM</td>
<td>Alarm Management - Project Results</td>
<td>Business Integration: Taking it to the Next Level</td>
</tr>
<tr>
<td>10:45 AM - 11:00 AM</td>
<td>Networking Break</td>
<td>Networking Break</td>
</tr>
<tr>
<td>11:00 AM - 12:30 PM</td>
<td>Automation System Lifecycle Management</td>
<td>Industry Business Value Examples</td>
</tr>
<tr>
<td>12:30 PM - 2:00 PM</td>
<td>Lunch</td>
<td>Lunch</td>
</tr>
<tr>
<td>2:30 PM - 3:30 PM</td>
<td>Attendee Networking Hub Open</td>
<td>Attendee Networking Hub Open</td>
</tr>
<tr>
<td>3:30 PM - 4:30 PM</td>
<td>Network Break</td>
<td>Network Break</td>
</tr>
<tr>
<td>3:45 PM - 5:15 PM</td>
<td>Plant Performance Optimization</td>
<td>Design &amp; Implementation of Plant Automation Networks</td>
</tr>
</tbody>
</table>

**Friday, November**

<table>
<thead>
<tr>
<th>Time</th>
<th>Session Title</th>
<th>Track</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00 AM - 9:00 AM</td>
<td>Networking Break</td>
<td>Networking Break</td>
</tr>
<tr>
<td>9:15 AM - 10:45 AM</td>
<td>Oscillations and Algorithms</td>
<td>High Business Value Technologies</td>
</tr>
<tr>
<td>10:45 AM - 11:00 AM</td>
<td>Practicing Automation: Making Automation Do More &amp; Achieve Benefits</td>
<td>IHI Performance and Instrumentation</td>
</tr>
<tr>
<td>11:00 AM - 12:30 PM</td>
<td>High Business Value Technologies</td>
<td>Critical Peripheral Technologies for Wireless Systems</td>
</tr>
<tr>
<td>12:30 PM - 2:00 PM</td>
<td>Lunch</td>
<td>Lunch</td>
</tr>
<tr>
<td>2:30 PM - 3:30 PM</td>
<td>Attendee Networking Hub Open</td>
<td>Attendee Networking Hub Open</td>
</tr>
<tr>
<td>3:30 PM - 4:30 PM</td>
<td>Network Break</td>
<td>Network Break</td>
</tr>
</tbody>
</table>
LETTERS TO THE EDITOR

Send your comments on this newsletter to me at brad.carlberg@bsc-engineering.com or post a message to the ISA PUPID Technical Discussion Forum List Serve & “get something started”!

You can reach the site at http://www.isa-online.org/cgi-bin/wa.exe?A0=PUPID or by going to the PUPID or the main ISA websites and looking for the “ISA Technical Divisions”
**Quickies**

**ISA Pulp & Paper Technical Discussion Forum**
Anybody (not necessarily an ISA or PUPID member) can subscribe to the PUPID Pulp & Paper Technical Discussion Forum. To subscribe, go to the PUPID homepage at [http://www.isa.org/~pupid/](http://www.isa.org/~pupid/), select "Pulp & Paper Technical Discussion Forum" in the pick box, click "Go", and enter you email address and a password.

**ISA Email address for ALL Members**
Any ISA member can register for a free email address and online mailbox. If you set it up, your ISA email address will be yourname@member.ISA.org. To register, go to [http://www.isa.org/membership/benies/](http://www.isa.org/membership/benies/), and follow the registration instructions.

**ISA PUPID Calendar**
Get a quick overview of ISA PUPID events for 2002 by going to the Calendar at: [http://www.isa.org/~pupid/2002_PUPID_Calendar.htm](http://www.isa.org/~pupid/2002_PUPID_Calendar.htm)
## WORLD CORNERS

### CANADA CORNER

Nothing from anyone there this time!

### CENTRAL & SOUTH AMERICAN CORNER

Nothing from anyone there this time!

### FAR EAST CORNER

Nothing from anyone there this time!

### FROM THE LAND OF THE MIDNIGHT SUN

Nothing from anyone there this time!

### EUROPEAN CORNER

Nothing from anyone there this time!
2012 Pulp & Paper Industry Division Officers

**Director**
Brad S. Carlberg, P.E.
Hyundai Engineering & Construction
brad.carlberg@bsc-engineering.com

**Education Chairman**
Patrick J. Dixon
Dixon Process Automation Services, Inc.
PatJDixon@DPAS-INC.com

**Advisor**
Richard E. Britton, P.E.
Retired – International Paper
richardbritton1@comcast.net
(251) 342-0998

**Paper Review Coordinator**
vacant

**Environmental Chairman**
vacant

**Secretary / Treasurer:**
Vacant

**Past-Director**
Paul Burnett
(203) 482-3553
paulburnett@att.net

**Director - Elect**
vacant

**Associate Newsletter Editor**
Frank Wilson
Pacific Lumber Company
fwilson@palco.com
(707) 764-4210

**Advisor**
Larry E. Wells, P.E.
CCSA, LLC
ccsallc@bellsouth.net

ISA Pulp & Paper Industry Division
P.O. Box 12277
Research Triangle Park, NC 27709

ADDRESS CORRECTION REQUESTED