Director’s Message
By Michael S (Steve) Moon, P.E.
DES LLC– Birmingham, AL

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Calendar of Events

Get a quick overview of the ISA PUPID events for 2003 by going to the Calendar at: http://www.isa.org/~pupid/2004_PUPID_Calendar.htm

2004 Paper Summit & TAPPI Spring Technical Conference Georgia World Congress Center, Atlanta, GA 2004 ISA PUPID Spring Symposium at the with PCE&I, Paper & Board and Coating divisions. Come & See the PUPID sessions!
May 3 - 5, 2004

Asian Paper 2004
April 27-29, 2004
Suntec
Singapore

5th PulpPaper 2004
sponsored by Finnish Paper Engineers, Adforum
http://www.pulpaper2004.com
Helsinki, Finland
June 1 - 3, 2004

June 14 - 17, 2004
2004 Control Systems Conference with PAPTAC, SPCI, & the Finnish Pulp & Paper Engineers
Quebec City, PQ Canada

Tissue World Americas 2004
September 21-23, 2004
Miami Beach Convention Center (MBCC)
Miami Beach, Florida, USA

"ISA President's Fall Meeting"
Reliant Park, Houston, TX
October 2 - 4, 2004
Come meet your leaders & get involved!
ISA 2003
Reliant Park, Houston, TX
October 5 - 7, 2004

Upcoming ISA Conferences & Exhibitions

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<tr>
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<td>October 5 - 7</td>
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You can see the online calendar at [http://www.isa.org/~pupid/2004_PUPID_Calender.htm](http://www.isa.org/~pupid/2004_PUPID_Calender.htm)
WELCOME TO THE 121 NEW ISA PULP & PAPER INDUSTRY DIVISION MEMBERS FOR 2003

WELCOME TO NEW PUPID MEMBERS

Joel Desrosiers
Jamie J. Lizotte
Simon Roger Roy
Jason R. Smith
Peter W. Starr
Pat Cecchetti
Jean Simard
James Swords
Jonathon Michael Hutto
Wan Gui Li
Michael J. Tucker
George D. Jablonsky
Geoffrey G. Leblanc
Thomas C. Burger, PE
Thomas Lee Troxell
James Vincent Scales
Patrick J. Dixon
Michael Ballard
Alexandre House

Jensen D. Oberklein
Richard L. Scholtz
Jean-Benoit Barrette
Karel J. Cerny
Jonathan Beaumont
David Pineau
Jeremy Tremblay
Jean Pierre Rossi
Ms. Jean Willian Moraes
Thomas P. Barnett
Benoit Cote
Djoe Lalancette
Derek M. Guerrette
Nicolas Girard
James B. Williams
Guy Gaudreault
Michel Lambert
Yves Cyr

Ms. Julie Cayouette
Francois Asselin
Jack M. Jorgensen
Shaughn E. Lalonde
Lee A. Mattson
Kevin K. Witney
Ms. Josianne Gagnon
Francis Pilote
Brad Edwards
Charles Patrick Dixon
Justin M. Panek
Will E. Walkoviak
Tomas Nakao
Jean Francois Tardif
Gilles Lavoie
Jean Frederic Morose
Nicolas Laprise
Marc Andre Lefebvre
WE’RE SORRY TO SEE 320 ISA PULP & PAPER INDUSTRY DIVISION MEMBERS LEAVE IN 2003

**COME ON BACK!**

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<td>Emilio Moralo</td>
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<td>Mac Hashemian, P.E.</td>
<td>Manuel S. Zamorano</td>
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<td>David C. Riojas</td>
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<td>Fred W. Utick</td>
<td>Ms. Deborah A. Majeske</td>
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<td>Walt D. Vann</td>
<td>Jose Carlos Gregorio</td>
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<td>Timothy L. Cole</td>
<td>Timo H. Kuusisto</td>
<td>Ms. Kathryn J. Pence</td>
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<td>Jed Popiel</td>
<td>Charles D. Quick</td>
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<td>Randall R. Kirk</td>
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<td>Mihir Gangoly</td>
<td>Scott A. Buchanan</td>
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<td>Michael Brown</td>
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<td>Serge Miller</td>
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<td>Michael A. Lane</td>
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<td>Dr. Pedro Luis Arias</td>
<td>Marius Chilom</td>
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<td>Dr. Edward Ratnam, PhD</td>
<td>Stephen Zitin</td>
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<td>Shawn Dietrich</td>
<td>Robert Hopfensperger</td>
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<td>Martin G. Schweers</td>
<td>John Capra</td>
<td>William G. Anderson</td>
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WE'RE SORRY TO SEE 320 ISA PULP & PAPER INDUSTRY DIVISION MEMBERS LEAVE IN 2003

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Robert Engwert
Alan D. Weldon

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Brenda J. Lokey
Jim T. Lawrence

Rian Emil Spranger
Michael S. Bartsch
Stephen W. Knott
Francisco Villaseca Albizuri

Jeb Ellington
Kevin Payette
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Tony Galanis

Juan A. Spinler
Francis G. Snyder
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Lechard A. Aguere
George D. Jablonsky
Susanta Datta
Daniel Corriveau

Rayne Motiar
Daniel A. Strasse
Rakesh Nagibhai Gajjar
Herve Fontaine

Richard G. Cowan, Sr.
Gilles Lusignan
Kevin R. Cyca
John Andrew Wilson

Vade Howarth
Michael J. Tucker
Andrei Romanenko
Guy Trudel

Jarry Blackwell
Jeffrey K. Hoelle
Geoffrey Johnson
Donald C. Simmons

Idomsak Niphatomwong
Kenneth L. Regnier
Spencer David Vincent, Jr.
Jarmo Koskenen

ames Boyd Curtis
John F. Gleeson
William Stansbury Horne
Donald J. Jenkinson

Carlos Augusto Bandera
Robert L. Martinez
Venkata Ratnakar Kavi
William A. Polley

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Gerardo Orozco
Harold Beaujolle
Fernando A. Rathgeb

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H. R. Miller

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COME ON BACK!

PUPID Sessions at ISA Expo 2003

Here are the steps I recommend use to listen to AND page through a particular presentation or paper on the following page:

1. Open up Internet Explorer AND click the “Media” button on the toolbar to add a left-hand pane in your browser’s window which will have the controls for the audio recording AND Click on the red highlighted word “AUDIO” for a particular presentation

2. Click on either the green highlighted word “POWERPOINT” OR the magenta highlighted word “PAPER” for that particular presentation or paper you can then listen to AND page through the presentation or paper

3. To change which title you wish to listen to AND page through, simply hit the “BACK” button on your browser’s toolbar.
Where's the action?
Who's doin' anything?

Geoenergy division of AHLA announces contract with Longview Fibre

The Geoenergy division of A. H. Lundberg Associates Inc. (AHLA) has entered into a contract with Longview Fibre Company to provide four E-Tube wet electrostatic precipitators. The precipitators will be used to further reduce particulate emissions from three solid fuel-fired boilers at the Longview Fibre Pulp-Paper Mill in Longview, Wash.

Austria's GAW wins contract at Guangdong Guanhao

Austrian engineering company, GAW, has received an order to supply a coating plant to China's Guangdong Guanhao High Tech Co., Ltd. The Chinese company produces up to 23,000 tonnes/yr carbonless (NCR) paper and thermal recording paper at its mill in Zhanjiang, Guangdong province, China.

Aker Kvaerner to upgrade pulp mill in Brazil

Kvaerner Pulping AB and its subsidiary Kvaerner do Brasil, have signed a contract with Bahia Sul Celulose S/A in Brazil to upgrade the pulp mill’s fiberline and causticizing plant and through this increase the pulp manufacturing capacity from the existing 578,000 to 645,000 tons/year bleached eucalyptus pulp. The total order is worth more than $30 million. The first step of the expansion comprising an upgrade of the oxygen plant - including a Compact Press - was awarded in June 2003 and will be installed by the 2nd quarter of 2004.

Metso Paper to rebuild board machine at Iggesund, Sweden

Metso Paper will supply a coating machine rebuild to the BM 1 line at Iggesunds Bruk pulp and paper mill in Sweden. The rebuilt line will be started up at the end of the year 2004. The rebuilt line will be capable to produce highest quality triple-coated solid bleached board (SBB) for consumer packages, with basis weights of 160 to 380 g/m². The coat weight range of the ValCoat station can be adjusted between 7 and 14 g/m². The web width on the coater is 4016 mm and the maximum machine speed 600m/min.

Crown Van Gelder contracts Voith Paper to upgrade PM 2

Voith Paper has received an order from Crown Van Gelder at the end of September 2003 to optimize their PM 2 in Velsen, Netherlands, and to increase the operating speed of the 5,500 mm wide machine to 1,000 m/min. Voith is the sole supplier of all components, including full installation, plant and detailed engineering, the control system and the electrical system for the machine and for power. The project is part of the long-term company strategy of Crown Van Gelder to strengthen competitiveness and increase output.
Dynamic process simulators offer the user a chance to examine the performance of a process as it reacts to disturbances. Unfortunately, becoming functional in the use of the simulator for a new process is often a time-consuming stumbling block, preventing casual application. One method of mimicking a process simulator is through the use of control system software. In this case, the 20SIM control system software is used to mimic the behavior of the wet end of a paper machine undergoing feed upsets.

The use of 20SIM is illustrated with a simple water recycle and dilution process where stream consistencies versus time are analyzed for an upset in fresh stock feed consistency. The model consists of a first-order lag and a short dead time, and is first analyzed in open-loop fashion. Plots of consistencies at various points around the flow loop are made, comparing results with practical papermaking experience. It is seen that very long times (many time constants) are necessary for the process to achieve steady-state. For closed-loop feedback control, when the objective was to return the process to its original condition, schemes of PI, PID and IMC control are employed which achieve rapid, robust results. Performance criteria were 5% settling time, and ITAE as the error integral. With PI control as the standard, modest improvement was achieved with PID control because of the relatively short dead time, while IMC control improved ITAE with some loss of settling performance.

In mining, the food industry and pulp manufacturing there are valve applications where the standard valves used do not function satisfactorily. When scale is formed on the moving elements of ball valves or gate valves the consequence is either blocking of the valve movement or damage to the valve seats and consequent leaking through the valves. A development of AS Stargate-O-Port valves was carried out in 1996, which lead to a good performance in pulp manufacturing. Later the same principle was used in the food industry. The most impressive application was in mining, where standard valves had to be exchanged every two weeks, whereas the Anti-Scale valves are in operation now for three to four years without any need for refurbishment. The increased production by eliminating downtime has paid many times already for the investment in the valves.

What is performance; common performance indices
? Variability, variance, standard deviation
? IAE, average error,
? Harris Index, minimum variance control,
? Valve travel, valve reversal, valve at limit
? Time in normal mode, number of mode changes
? Process model parameters
? Oscillation indices
Troubleshooting
? Worst loops
? Biggest payback loops
? Detecting oscillations
? Drilling down
Oscillation detection
? Tools, principles
Optimization and control loop analysis tools
- Process and valve analysis
- Controller structure and response validation
- Statistical analysis
- Time series analysis
- Power spectral density
- Performance analysis
- Process optimization

Expected results
- Performance improvement over time
- Return on investment
- Examples in chemical, petrochemical, pulp & paper, others

Presentation: ISA04-P006  Conference: ISA 2004
Title: Tools to Troubleshoot Processes

Author: Michel Ruel
Type: Paper
Solicited By: None

Interaction,

Loop health, performance

Tools (Basics, How to use them, Data interpretation and measurement)
- Cross Correlation
- Power spectral density
- Statistical analysis
- Oscillation detection, Tracking cycling
- Tools, principles
- Valve problems
- Load changes and interaction
- Tuning problems
- Tips and Tricks

Expected results, examples
- Hidden cycling
- Loops interacting
- Examples in chemical, petrochemical, pulp & paper, others

Presentation: ISA04-P029  Conference: ISA 2004
Title: Improvement in AC Electromagnetic Excitation Increases Efficiency, Improves Quality and Conserves Energy

Author: Greg Livelli
Type: Paper
Solicited By: None

The pulp and paper industry holds some of the most aggressive and challenging applications for electromagnetic flowmeter measurement. Changing operating conditions, higher pulp consistencies and tighter process control are pushing the boundaries of electromagnetic flowmeters.

Conventional electromagnetic flowmeters using DC excitation have been used to measure pulp stock into the head box. However, since pulp stock tends to be a noisy measurement with a magnetic flowmeter, long dampening times are traditionally used to smooth the output of the meters. This results in slow response times from the meter and ultimately leads to wasted pulp. Reducing the dampening will result in quicker response times, however a noisy signal compromises the thickness or "basis weight" of the end product.
Improvements in AC electromagnetic flowmeters now provides paper mills improved performance, quick response and a noise free output that traditionally achieved with DC technology. An improved excitation process and advanced digital signal processing results in tighter process control, faster response, greater profits and a direct cost savings. The improvement in the excitation process also eliminates the zero drift problems associated with traditional AC meters and provides greater noise handling capabilities than DC magmeters. Therefore, lower dampening values can be used to maintain tighter controls resulting in less product variability. Now user can obtain ±0.5% rate accuracy with extremely quick response times.

Pulp and paper mills require accurate and timely information to maintain operational cost efficiency while meeting customer quality expectations and regulatory demands. The improved excitation method in AC electromagnetic flowmeters has set a new standard for flow measurement in the pulp & paper and allows users to increase efficiency, improve quality and conserve raw materials and energy. AC magmeters now have the versatility to measure the simplest to the most extreme flow applications making the process more productive and profitable.

**Presentation**  ISA04-P091  **Conference**  ISA 2004

**Title:**  Robust Automation Technology Serving the US Navy Comes Ashore to Enhance Industrial Productivity

**Author:**  Gary Cane  **Type:**  Paper  **Solicited By:**  0-None

A new high performance Hybrid Controller designed to meet the extreme environments governed by MIL-SPECs is beginning to serve a wide variety of applications on the combat and support vessels of the United States Navy. This paper describes the successful deployment and sea trial testing of Chameleon Programmable Automation Controllers (PACs) onboard the USS Boone (FFG-28). The decentralized Chameleon system provides full regulatory control and integrated condition monitoring for auxiliary processes and machinery supporting the Frigate’s four Ship Service Diesel Generators (SSDGs). Since successful sea trials on the USS Boone, the system has been duplicated on the USS McHenry (FFG-8) and is slated for installation in four additional Frigates. The USS Boone success has also led to the adoption of a similar Ship Service Turbine Generator (SSTG) control system on the USS Essex (LHD-2), an amphibious assault ship.

Chameleon's high performance Regulatory, Discrete, and State control capability, in it's environmentally hardened yet compact implementation, has significant potential to enable new quality and productivity applications in a variety of industries. Chameleon PACs also offer superior solutions to existing industrial control applications.

The paper will enable process owners and designers to evaluate the cost and quality implications of coordinated regulatory, discrete, and state control that delivers in excess of 100 freshly sampled and calculated control values per second to each system output. Chameleon's control ware is already serving dozens of applications in a predecessor sea borne platform—applications that are very prevalent in the Industrial Automation Market today.

These circumstances, when coupled with Chameleon's ability to operate in extreme environments without requiring protection from the elements, are expected to stimulate increased applications within the Fleet and in civilian industries.

Power Generation and Distribution, Metals and Mining, and Pulp and Paper are expected to be the first industries to benefit from Chameleon's abilities to change the constraints on today's control application design.

**Presentation**  ISA04-P  **Conference**  ISA 2004

**Title:**  Web-Based HMI's (Panel)

**Author:**  Brad Carlberg  **Type:**  Panel  **Solicited By:**  PUPID

Using active server pages, intelligent serial devices, HTML, SOAP, WML, XSL, FTP, WML, OPC and ActiveX, and internet/intranet technologies to create web-based HMIs. Web technologies provide new opportunities to implement Human Machine Interfaces (HMI) applications using new technologies that leverage high-speed communication to industrial hardware to view real-time plant/production data over a Plant Intranet. This future communication architecture will provide a bridge between current proprietary systems to an open environment based on Ethernet and Web technology. The evolution of web-based HMI has allowed real-time information from automation systems to be accessible to anyone in the corporation and offer interoperability using a flexible, open standard giving us new ways to access and deliver data in industrial automation.
Because of the proliferation of "browser-based", thin-client, operator interfaces in all of the major HMIs, this panel is a continuation of the Web-Based HMI panel from last year's Expo 2001. Like last year's panel of the same name, five or six representatives from the major vendors/providers (YTBID) will sit on the panel each giving a 5-7 minute PowerPoint presentation followed by an audience Q&A period.

**Presentation**  
ISA04-P  
**Conference**  
ISA 2004  
**Title:** Ethernet I/O (Panel)  
**Author:** Brad Carlberg  
**Type:** Panel  
**Solicited By:** PUPID

A five-member panel will discuss de-factor standard ethernet-based I/O, data acquisition and control, networking, for cost-effective, distributed monitoring and control solutions with practical applications. Explore quick and simple programming using a web browser. Explore modular I/O.
Petcoke Firing in Lime Recovery Kilns Becomes Option as Energy Costs Rise

Use of alternative fuel can have a significant impact on energy savings, but engineering, operation, and emission issues must be weighed carefully

By RICHARD MANNING, SAM COOPER, and JOHN MACFADYEN

RICHARD MANNING is director, and SAM COOPER is commercial and marketing manager, Kiln Flame Systems, High Wycombe, U.K. JOHN MACFADYEN is director, Phoenix Process Engineering, St. Louis, Mo

With continuing pressure on pulp and paper prices, producers are looking for ways to contain burgeoning energy bills to remain competitive in difficult times. A key opportunity is the possible fuel cost savings available through use of less expensive fuels such as petroleum coke (petcoke).

Petcoke is a widely used fuel in the cement and pebble lime industries but has been slow to find favor in the paper industry due to lack of knowledge and perceived risks associated with the very “blackness” of the fuel. The firing of petcoke in lime recovery kilns is not new however, and considering the potential benefits in fuel costs and energy savings, surprisingly few mills use it as their primary fuel source.

PETCOKE QUALITY AND HANDLING. Petcoke is a byproduct of the oil refinery process and is essentially “the bottom of the barrel.” As such, its properties vary with the crude oil source and the refining processes used. Petcoke quality is characterized by its heating value, chemical composition (e.g. content of sulfur and trace metal such as vanadium), contaminants, and its physical properties, in particular its hardness, which is graded by the Hardgrove Grindability Index (HGI).

Lime recovery kiln operators are concerned with contamination and emissions. Therefore, the sulfur levels in petcoke—typically 3 to 5% by weight—can have significant impact. For a 300-tpd kiln operation, the sulfur load would be approximately 13 to 26 lb/hr, and this is captured in either the kiln product or the exit gas cleanup system. For fuel handling and preparation, material hardness is a prime concern, with typical HGI values ranging from 35 (relatively hard) to 80 (relatively soft). With a harder material, there is more energy consumed and more component wear in the grinding process to achieve the required particle sizing for combustion. Moisture level in the petcoke will also play a role in defining the requirements of the fuel preparation system. There are two areas of engineering expertise associated with introduction of petcoke into a rotary kiln: Fuel handling systems, which include grinding, storage, and transportation to the kiln burner Combustion equipment design and operation, including the unique characteristics of the fuel

SOLID FUEL PROCESSING SYSTEMS. The principal elements of solid fuel processing include:

- Petcoke receiving, storage, and reclaim
- Weight-controlled feeding to a grinding mill
- Grinding and drying
- Delivery of solid fuel to the kiln burner

The key characteristics to successful firing systems are fineness of the pulverized petcoke, moisture reduction of the coke, and optimized burner design. The key to satisfactory return from the use of petcoke is in economy of design, raw petcoke cost, and content of sulfur and other contaminants. Petcoke storage requirements for a mill need to be sufficient to contend with interruptions in delivery, holiday weekends, and unloading period limitations, such as day shift Monday to Friday. It is not advisable to store petcoke outside since windblown fines can contaminate the process and contribute to petcoke moisture level increases. The most economical storage solution is a simple covered storage structure in which arriving trucks can dump their loads without concern for fugitive emissions.

Petcoke is reclaimed by the front end loader to an abovegrade hopper and then conveyed to a mill feed bin and released from the bin by weigh feeder to the grinding mill. The size of the “raw” petcoke bin is determined by cost and operating factors. From an operational standpoint, raw
petcoke receiving and unloading (on a day shift-only basis) results in a bin sized to hold at least 30 hours of mill feed. For a system that fires 120 tons of petcoke a day, a bin of 150 tons of capacity will suffice. The bulk density of both stockpiled and bin-stored petcoke varies with the fines content. While theoretically it is 50 lb/ft³, as a practical matter one should plan on about 60% of this value.

The flow characteristics of petcoke dictate steep bin bottom slopes, carefully proportioned slotted bin bottom openings, pin gates, and a belt weigh feeder or screw conveyor. Since the entire petcoke grinding and burner feed system is an automated and unattended process, attention to detail is justified. If the preferred petcoke source is known during the engineering design, samples should be submitted to a reputable testing firm so that the design requirements of the bin bottom and grinding mill feed system can be determined.

There are three types of grinding mills that are suitable for lime recovery kiln operations, as shown in Table 1.

All grinding mills require a source of hot air or kiln exhaust gases to dry the petcoke. The ring roller mill and the vertical roller mill are air-swept mills, therefore all ground petcoke is extracted from the mill in an air stream. The air and petcoke removed from these mills are either ducted directly to the kiln burner or, more commonly, to a conservatively sized baghouse filter and then conveyed to the pulverized petcoke storage bin. In ball mills when configured as air swept, the petcoke and air mixture is first ducted to an external classifier and the coarse fraction ("rejects") returned to the mill. Fundamentally, there are three methods of firing ground petcoke: direct, semi-direct, and indirect. The direct-fired system begins with the raw coke withdrawn from the main storage bin by a weigh feeder, fed to the grinding mill and the air/petcoke mixture is first swept from the mill ducted to the kiln burner and fired in the kiln. The advantage is the cost savings inherent in the simpler flow sheet. The disadvantages include high primary air ratio, slightly higher fuel consumption (due to reduced preheated secondary air quantity), kiln operation reliance on operation of the grinding mill, and the inability to shut down the grinding mill for maintenance without either reverting to 100% natural gas or shutting down the kiln.

Semi-direct systems offset many of these disadvantages by reducing the amount of primary air through splitting the air downstream of a cyclone, using one stream to convey the pulverized petcoke to the kiln burner while discharging the remaining air into the firing hood. A system has been developed that allows semi-direct firing of two kilns with only one grinding mill. Even with a backup mill to allow maintenance on the operating mill, the capital and operating costs are lower than an indirect-fired system. Indirect systems resolve the disadvantages of the direct and semi-direct systems at a capital cost penalty. The additional capital cost is offset to some degree by the ability to store pulverized petcoke, which allows maintenance downtime on the mill without interrupting petcoke firing of the kilns, installation of one mill to fire two kilns, and an optimized burner design and potentially lower primary air and greater preheated secondary air. It should be noted that a direct-fired system depends on the weigh feeder ahead of the mill as the means to set the fuel firing rate. The firing rate of indirect and semi-direct systems is controlled either by a weigh bin or a flowmeter system, providing more timely and accurate firing rate response. Petcoke firing is subject to the stringent National Fire Protection Association regulations for solid fuel firing and deflagration prevention. The difficulty of igniting petcoke dictates the need for fine grinding and co-firing with natural gas (or other volatile fuel), and this provides additional safety through flame stabilization.

COMBUSTION EQUIPMENT. The heat flux profile for petcoke differs significantly from natural gas and, to a lesser extent, fuel oil, which must be taken into account when designing the firing system. In lime recovery kilns, particularly those without coolers, secondary air temperatures are relatively low. This makes petcoke, with its low volatile content, slow to ignite. It is also relatively difficult fuel to burn and stabilize without co-firing with natural gas or oil. Targets of between 75 to 85% petcoke substitutions are generally achievable. Radiation is the dominant mechanism of heat transfer in the burning zone of a rotary kiln, with more than 95% of the heat transferred in this way. The rate at which heat is transferred to or from a flame is controlled predominantly by the radiative exchange in the combustion chamber. The factors that affect this exchange are the temperatures, emissivity, and relative geometry of the flame and surroundings.

The emissive properties of a flame are a function of the concentrations of the spectrally emissive and absorptive gases (CO2, CO, H2O) from the combustion process and the particulates burden in the flame. Flames in rotary kilns fired with petcoke have a high particulates burden and hence a high emissivity, while natural gas flames have a low particulates burden and low emissivity. Natural gas flames are therefore at a disadvantage because the low emissivity results in a peak heat flux further down the kiln (Figure 1).
Physical modeling of the fuel/air mixing and mathematical modeling of the heat transfer along with an optimized burner design can minimize this effect but not eliminate it.

Everything else being equal, a petcoke flame will produce a more effective combustion profile compared with natural gas. For any given kiln, the flame length and heat transfer are determined by the fuel characteristics, the fuel/air mixing rate, and the quantity of excess air. The fuel/air mixing rate is primarily dependent on the ratio of the burner momentum and that of the secondary air. Aerodynamic and combustion modeling is the best method for assessing optimal burner engineering given the unique design characteristics of each kiln and the specific firing properties of the fuels used. Figure 2 shows the acid/alkali combustion modeling technique used to evaluate the dynamic and transient nature of the combustion process. The pink color represents unburned fuel such that when the fuel is completely consumed, the pink color disappears. The technique uses the principle that given the very high temperatures that exist in most combustion processes, combustion takes place immediately when fuel and oxygen meet, and hence the flame shape is controlled by the rate of mixing of fuel and air rather than the kinetic rates of reaction. The acid/alkali techniques based on exact engineering scaled models of the kiln hoods and coolers where appropriate encompass the critical nature of the fuel and air mixing in a non-ideal flow pattern regime.

Petcoke requires less air for combustion due to its lower hydrogen content in the fuel. This ultimately leads to lower kiln gas volume flows and hence lower feed end temperatures. Additionally, improved heat transfer from petcoke firing results in lower overall fuel requirements and further reduction in flue gas volume flows. The combined effect is to reduce load on the kiln ID fan, and this can de-bottleneck kilns that are ID fan limited.

EMISSIONS ISSUES. The primary concern in petcoke conversion projects is the perceived effect of emissions of nitrogen oxides, sulfur dioxide, and metals. NOx emissions. The NOx formation in kiln flames is generally by both thermal and fuel routes (for coal, oil, and petcoke). In natural gas-fired kilns, fuel NOx is absent, and all NOx is produced through the thermal NOx route. The chemical (ultimate) analysis of petcoke provides data on fuel nitrogen levels, which are typically in the range of 2 to 5% weight. In high-temperature environments (greater than 2,900°F), thermal NOx is generally the dominant mechanism. Despite the absence of fuel NOx in natural gas-fired kilns, thermal NOx is significant since natural gas flame temperatures are often higher than those of coal, oil, or petcoke. In addition, the in-flame oxygen concentration (both as a result of burner primary air levels and fuel/air mixing rates) and the residence time in the high-temperature zones influence the final thermal NOx emissions.

The following points tend to be observed in lime recovery kilns: Petcoke contains greater levels of nitrogen than natural gas, providing reasonably confident prediction of greater NOx emissions of between 50 and 100%. Higher fuel nitrogen petcoke, compared with heavy fuel oils, does not translate into a proportionate increase in NOx emissions compared with gas firing. This is due to lower flame temperatures with petcoke and in-flame consumption of NOx by a series of complex chemical reduction mechanisms. The combination of computational modeling techniques (computational fluid dynamics) and experience specific to petcoke firing assist to ensure that the thermal emissions fall within required mill limits. Currently, CFD is the only tool available to predict trends of NOx formation with change in flame conditions and fuel type (Figure 3). In many cases, the existing inefficiencies of the current firing systems are such that the conversion to petcoke, including an optimized burner, will produce a relatively minor increase in NOx emissions. SO2 emissions. Sulfur occurs both in the raw materials (usually from poor filter operation or from introduction through noncondensible gas/stripper off-gas components) and in the petcoke fuel when fired in kilns. Sulfur compounds can build up complex cycles in rotary kilns and can lead to calcium sulfate deposits, resulting in buildup and blockages. These cycles are critically dependent on a number of factors, including the chemistry of the dry mud feed, NCG/SOG feed and fuel, the design of the kiln system, and the heat transfer pattern in the burning zone.

Petcoke will add additional sulfur into the kiln, but generally this will not affect the SO2 emissions since typically 60 to 80% of the sulfur is captured by the lime in the kiln with the remaining sulfur removed in the wet scrubber. Metals. Metals other than vanadium, sodium, and mercury are usually low in the gaseous emissions due to their low volatility. If the combustion temperatures are excessively high, the vanadium can stay in the vapor phase and be carried through to the wet scrubber.

ECONOMIC CONSIDERATIONS. Projects to convert lime recovery kilns to petcoke firing are often initiated as a reaction to prevailing prices of existing fuels, particularly natural gas. Projects often stall if prices recede back to levels that mill management finds acceptable. This approach ignores the inevitable return of spiking fuel prices and the long-term benefit from firing petcoke, which has an average cost advantage of $2 to $3/million Btu compared with fuel oil and natural gas. Current forecasts suggest that energy demands will grow steadily in North America driven by growth in electricity demand. While summer gas prices in 2003 fell below expectations, average cost advantage of $2 to $3/million Btu is still in the range of $5 to $5.6/million Btu, while oil and natural gas will range between $4 to $4.5 and $5 to $5.8/million Btu, respectively.

As a low-value by-product from the refinery process, petcoke will be more economical than either fuel oil or natural gas, but is the difference sufficient to
justify the capital investment required? The answer to this will depend on many factors, the most important being:

- Firing method chosen-direct, semi-direct, or indirect firing
- Equipment purchase-reconditioned or new
- Size and current efficiency of the kiln
- Primary fuel currently fired

Also important are the economies of scale available by servicing multiple kilns using the same grinding equipment. Purchasing of pre-ground petcoke is an option that has lower capital costs but carries inherent risk and should be considered carefully. Often, the savings in capital costs are offset by uncompetitive petcoke prices and poor fuel efficiency due to oversized particles and high sulfur and moisture levels. Figure 4 illustrates the typical capital costs of various solid fuel systems, comparing them with expected savings from substituting 80% of the natural gas fired in a kiln with petcoke. The black arrow denotes the price differential between gas and petcoke at the time of writing and demonstrates that the payback on investment can be relatively short, particularly if the system is engineered using reconditioned equipment.

The current price of oil also provides significant justification for converting to petcoke firing. However, with the price differential being less, the ROI is not as attractive (nor the payback period as short) as is the case with gas-fired lime recovery kilns.

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