Jet Burner Improves Kiln Performance

Gyro-Therm delivers for minerals processing operations

The kilns used in cement clinker, pulp, paper, lime and alumina processes are large volume energy users. Minerals processing kilns alone use over 450 trillion Btu in energy per year. With the development and commercialization of Gyro-Therm, a patented precessing jet burner technology, natural gas can now compete with coal and oil in this high-temperature market.

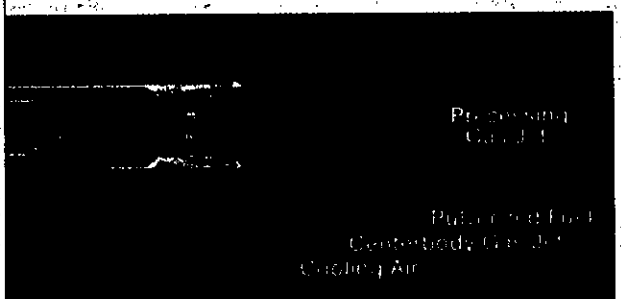

Figure 1. This cross-sectional diagram illustrates the precessing jet nozzle and the flow field it generates.

Gyro-Therm is used as a tool to improve minerals processing operations and provides some important benefits. Many processing companies are facing higher production requirements and need to increase kiln throughput. Gyro-Therm produces high heat transfer, increasing throughput and thus producing more product per energy dollar. Processors are also facing environmental regulations requiring lower NO_x emissions—Gyro-Therm provides these lower emissions. Gyro-Therm's steady flame under all load conditions and its high heat transfer can also improve overall product quality. The precessing jet technology is mechanically very simple and has no moving parts. Maintenance is minimal and projected service life is 20 years. Gyro-Therm can also be retrofitted easily to kilns within 24 to 48 hours, minimizing downtime. In most cases, no refractory profile change is required.

Gyro-Therm technology was developed by the University of Adelaide in Australia. Exclusive rights to the precessing jet technology are held by the Australian company Adelaide Brighton, Ltd. The technology is being commercialized and applied to minerals processing kilns in North America by the Adelaide Brighton subsidiary Fuel and Combustion Technology, Inc. (FCT) in Malvern, PA. The Chicago-based Gas Research Institute (GRI) is currently sponsoring a series of Gyro-Therm field tests. FCT is also partnering individually with GRI member companies and their customers.

Precessing Jet Technology

Precession is a term used to describe the gyroscopic-like rotation of a body about an axis other than its own center line, such as a spinning top that is leaning to one side. Using fluid mechanics, the precessing jet is directed at an angle to the nozzle axis, about which it precesses (Figure 1). Such a precession creates a much larger scale of mixing than occurs in a conventional jet. The motion is generated by the patented Gyro-Therm nozzle, without the use of any moving parts. According to Michael McCabe, President of FCT, "It is important to note that although the jet precesses, the frequency of precession is rapid—typically 10 revolutions per second, depending on the fuel flow rate—so that the flame itself does not precess."

The nozzle consists of an axi-symmetric chamber which has a large, sudden expansion at its inlet and a small lip at its exit. As the gas jet enters the chamber, it reattaches asymmetrically to the inside of the chamber wall, generating strong local pressure gradiants which deflect the jet out of the nozzle at a 45 degree angle. It is the strong azimuthal pressure gradiants which cause it to precess about the nozzle axis.

The effect of the jet precession on the gas flame is dramatic. Measurements conducted in industrial plants and in research facilities have shown that, in general, there is a simultaneous increase in flame luminosity, a reduction in peak flame temperature, a reduction in NO_x emissions, and an increase in flame stability.

Features

On the Cover

Applied Gas Technology

Jet Burner, cont.

Table I. Fuel Savings and Output Increases

Clinker Type	Fuel Used	Fuel Consumption (MMBtu/ton)	Output Ton/Hour
[illegible]	Gas, tires, oil	-2.7% (3.67 3.57)	+6.2% (62.7 66.7)
[illegible]	Gas, tires, oil	-3.4% (3.56 3.43)	+9.9% (63.2 69.5)
[illegible]	Gas, coal, tires, oil	-2.5% (3.58 3.49)	same
I	Gas, coal, tires, oil	-5.7% (3.50 3.30)	+5.1% (68.5 72.0)
[illegible]	100% Gas	-5.7% ([illegible] 3.33)	+11.0% (63.3 70.3)

[illegible] Output/Efficiency, Cut NO_x [illegible] and [illegible]

Table 1. Production at Ash Grove increased 11% when firing with 100% natural gas, and between 6.0 and 9.9% when firing natural gas with waste oil and tires. Fuel consumption dropped between 3 and 6%.

Productivity Up, NO_x Down

The increased heat transfer produced by Gyro-Therm translates into increases in kiln productivity that range from 3 to 10%. Natural gas precession increases air entrainment, but reduces intensive fine scale mixing. This results in increased soot production at the interface of the fuel and air within the large flame structures. This, in turn, produces a luminous, more radiant flame closer to a coal or oil flame. The sooting is a local phenomenon only, and burns out completely within the flame.

Compared to previous natural gas systems in test kilns, Gyro-Therm produces NO_x emissions which are 30 to 50% lower. This is because hotter flames produce more NO_x and, with Gyro-Therm, the increased soot production at the interface of fuel and air within the large flame structures produces a low temperature flame front. The Gyro-Therm flame is also extremely stable, burning close to the nozzle over a wide turndown range.

Australian Prototype

A prototype was installed at Swan Portland Cement in Perth, Australia. Data collected over several months of operation at the Swan plant indicate a range of direct benefits. The burner was installed over an eight-week trial period and adjusted and optimized during that period while the kiln continued to operate normally.

During the eight-week period the burner was installed, fuel consumption was reduced an average of 5% in comparison with the original gas-fired burner. During the same period, average hourly outputs of the kiln increased by almost 10% over the original burner. Kiln operators attributed this to better heat efficiency and the ability to burn more fuel without losing operational stability.

NO_x levels were also reduced during the test period at Swan. The optimized design reduced NO_x emissions by 75%. CO levels were also kept low, typically less than 100 ppm.

Product quality was improved through a reduction in alite size, yielding an improved strength performance of approximately 5%. Within the kiln, the refractory built up a good, stable coating, which should result in longer refractory life.

Oregon Field Test

The first GRI-sponsored field test of Gyro-Therm has been completed at Ash Grove Cement in Durkee, OR. The technology has exceeded projections and increased production of Type I and Type II cement clinker by 6 to 10%, reduced fuel consumption by 3 to 6% (Table I), and lowered NO_x emissions by 37% (Figure 2).

The Ash Grove Cement plant installed Gyro-Therm on their preheater cement kiln. The kiln uses about 250 MMBtu/hr. and originally switched from coal to natural gas during the summer months to capture the lower natural gas prices. It also burned waste oil on occasion. "The original burner on the kiln was designed for 100% coal operation and was later retrofit to also burn natural gas," explained Ron Vidergar, Process Superintendent for Ash Grove's Oregon plant. "Whenever we switched between fuels, we would lose nearly a day of operation. The old burner was also tough to light. Clearly, we had to make some changes."

To meet the needs of this multi-fuel application, Gyro-Therm had to undergo some changes. According to McCabe, "We had not developed the technology for use on multiple fuels. This presented a new challenge, involving six months of design, mathematical and physical modeling, engineering, and fabrication."

The test began in August 1996 and ran through February 1997. Vidergar is very pleased with the results. "When salespeople walk through our door and promise the moon, we naturally view their promises with skepticism. However, Gyro-Therm is exceeding projections. It's taken very little time to recoup our investment. Ash Grove is now considering this technology for a couple of its other plants."

Another GRI-sponsored Gyro-Therm test is underway in a lime sludge kiln used in the pulp and paper industry. Lime is used as part of the chemical digester process to make pulp. The lime is extracted and then calcined in the kiln so it can be reused in the digester. According to GRI Principal Product Manager Les Donaldson, "GRI is planning field demonstrations of Gyro-Therm burners in a total of four markets: cement, pulp and paper, lime, and alumina."

Figure 2. Stack NO_x Emissions at Ash Grove Cement dropped by 37% when a typical fuel mix was fired with the precessing jet burner.

FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

Department of Environmental Protection

Lawton Chiles
Governor

Virginia B. Wetherell
Secretary

December 29, 1998

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

Mr. Joe Anderson, III
President
Suwannee American Cement Company, Inc.
PO Box 410
Branford, Florida 32008

Re: Request for Additional Information
DEP File No. 1210465-001-AC (PSD-FL-259)
Proposed Portland Cement Plant

Dear Mr. Anderson:

On November 30, 1998 the Department received your application and complete fee for an air construction permit for a Portland cement plant at US 27 at County Road 49, east of Branford. The application is incomplete. In order to continue processing your application, the Department will need the additional information requested below. Should your response to any of the below items require new calculations, please submit the new calculations, assumptions, reference material and appropriate revised pages of the application form.

1. Please finalize the design of the precalciner and submit revised drawings that do not show this process as "on hold". Provide a description of the final process design selected. We understand the applicant is considering utilizing a tire gasification system to fuel the precalciner burner. If this option has been selected, please provide a process description of the gasification system, describe how the solid byproducts of the gasification system will be utilized in the cement process, and discuss the impact of the gasification system on emissions.

2. The application proposes the use of tires to provide up to 40% of the heat input to the pyroprocessing system. Representatives from Krupp Polysius stated that firing no more than 10% tires is practically achievable without the use of a tire gasification system. Further, the proposed volume of tires may result in no fuel being fed to the precalciner which would provide no supplemental heat in the flue gas downstream of the kiln end feed shelf (which we presume will be the introduction point for tires). Operation of this sort seems to violate the principles of NOx control by process design described on page 49 of the supplemental report, in which more fuel is fired in the precalciner than the kiln. Please propose a volume of amount of tires that comports with the recommendation of the pyroprocessing system's manufacturer, or provide more information to support the requested feed rate. Please verify the location of the feed point for tires or TDF.

3. Please finalize the design of the particulate control devices for the in line kiln/raw mill and the clinker cooler and submit revised drawings that do not show the control device for the clinker coole. as "under review". Provide a description of the final control devices selected, and specifications for each device.

4. The Department believes that BACT at this facility for PM_{10} should at a minimum meet the same emission limits as at LaFarge Corporation's plant included in the BACT determinations shown in Table 14. Please comment.

5. The sample sulfur dioxide reduction calculations were based on coal with a sulfur content of 1.5%. Please evaluate the proposed sulfur limits and reduction required with the proposed coal and petcoke. Also comment on the relative merits of limiting percent sulfur in the fuel versus solely limiting emissions of sulfur dioxide. EPA has commented to the Department that the feasibility of a cement kiln SO2 emission rate limit of 0.27 lb/ton clinker (versus the proposed 0.28 lb/ton clinker limit) should be addressed. Please also address EPA's comment.

6. Please comment on the feasibility of combining the proposed selected BACT control technologies (process control, secondary combustion, indirect firing) with SNCR. It appears that the proposed selected technologies are integral to the plant design so such a combination appears possible. If the proposed selected technologies are not integral to the plant design, please provide a detailed cost analysis for them in terms of overall and marginal cost effectiveness (annualized dollars/ton of nitrogen oxides removed) for NOx control using these technologies, including all references and assumptions.

7. Please provide a detailed cost analysis in terms of overall and marginal cost effectiveness (annualized dollars/ton of nitrogen oxides removed) for NOx control using SNCR, including all references and assumptions. Krupp Polysius markets an SNCR system for Portland cement plants that should be directly applicable to this project so cost and effectiveness estimates for this project should be detailed. Although the Krupp Polysius system uses ammonia water transported to the site as the reactant, please comment on the feasibility of using anhydrous ammonia to generate the reactant on site.

8. Please compare other NOx limits established by BACT (for LaFarge and Great Star Cement, for example) with the proposed NOx limit and discuss the variables that affect emissions of NOx from Portland cement plants that are applicable to the proposed facility.

9. Although the temporary exemption language of Rule 62-212.400(3)(c), F.A.C., provides for exemption from certain PSD requirements for emissions lasting up to two years, such time period for NOx seems excessive given Krupp Polysius' experience with the startup of similar facilities, and the experience it will gain with the startup of the similar Florida Rock plant (which is scheduled to begin operation prior to completion of this facility). EPA has also commented to the Department that the applicant should address the feasibility of meeting the proposed BACT NOx emission limit at startup of the facility. Please address this issue.

10. EPA has commented to the Department that the applicant should discuss why a reduced kiln CO emission rate limit would not be proposed as BACT, given that the RBLC listings have several kilns with lower CO emission rate limits. EPA has suggested that such a discussion should include a technical and economic analysis regarding the feasibility of a 1.64 lb/ton clinker (LaFarge Corporation, Sugar Creek, Missouri, Permit No. 0897-019, issued August 20, 1997) kiln CO emission rate limit, or a CO emission rate limit of 2.77 lb/ton clinker (June 3,1998, dry process kiln operations at Signal Mountain Cement Company located at Chattanooga, Tennessee). Please address this issue.

11. Provide the worst case startup and shutdown emissions estimates for the inline kiln/raw mill including duration of excess emissions. The Department plans to address excess emissions in its BACT determination.

12. Please comment on the need to include estimated emissions of PM_{10} from prescribed burning at Ichetucknee Springs State Park in the PM_{10} impact analysis for the proposed facility.

13. Please discuss the basis for the estimated emissions of mercury and provide illustrative calculations. Please estimate the possible impact or deposition of mercury at the Ichetucknee Springs State Park and the Santa Fe and Suwannee Rivers in the vicinity of the proposed facility.

14. Please perform an additional impact analysis in the PSD Class II area near the facility including the Ichetucknee Springs State Park and the Santa Fe and Suwannee Rivers in the vicinity of the proposed facility. This analysis must include impacts on growth, soils and vegetation, and visibility.

15. Please submit overlays (isopleths) of the maximum ground-level concentrations of NOx, PM/PM_{10}, CO, and SO_2 with respect to residential communities up to 2 miles (3.2 kilometers) from the proposed site.

16. The PSD application does not contain discussions of the modeling procedures, selected model options, source emission information, and receptor information associated with the area of significance, PSD increment, and NAAQS modeling. This information is needed to adequately understand the modeling results presented in the application. In addition, please provide a detailed map showing the location of all of the fence-line receptors used in the air quality impact analysis. These receptor locations should be shown in the coordinate system used in the modeling. This detailed map should also display the location and dimensions of the various plant components.

17. The emission sources used for both the NAAQS and PSD compliance modeling were selected based on the 20D rule. This rule does not consider the additive effects of a number of sources located in the same general location. Review of the 20D rule eliminated sources reveals a few NO_x and many PM_{10} sources that may need to be included in the impact modeling emission inventories. In addition, the application of the 20D rule starts at the edge of the significant impact area (7 km in this case) instead of at the center of the facility.

18. Regarding secondary emissions, the PSD application does not address any increase in quarry production due to the operation of the Portland cement facility. Any increase in quarry emissions associated solely with the operation of the cement plant must be included in the cement company's PSD air quality impact assessment.

19. The PSD application does not provide specific modeling emission information associated with the cement company's operation. The individual emission sources for each applicable pollutant should be provided along with the location, emission rates, and stack/vent exit variables (e.g., exit temperature, velocity, etc.) for each appropriate level of operation (e.g., 50%, 75% and 100% loads). Where applicable, the emission rates and exit variables should be provided for each fuel source. The basis for each pollutant emission rate should be provided.

20. Lennon Anderson of the Bureau of Air Regulation provided comments related to the MACT determination for the proposed facility. Please provide a proposed MACT pursuant to 40 CFR 63.43(d) and (e). Please provide a MACT analysis including any new, similar emission sources contacted (best performing source).

21. In addition to addressing the previous comments from Mr. Anderson, please comment on the likely emissions of hydrogen chloride from the proposed process considering the design, fuels, and raw materials.

The Air Quality Branch, National Park Service–Denver (NPS) provided comments to the Department. Those comments are enclosed for your information and the significant requests have been reiterated below.

22. The NPS commented to the Department that the applicant should re-evaluate the feasibility of applying SNCR to control NO_x emissions from its proposed cement kiln. The NPS commented that the applicant incorrectly rejected SNCR by questioning its availability, by failing to document and compare estimated control costs, and by overstating environmental risks associated with the use of ammonia. The NPS suggested that the applicant provide well-documented costs for application of SNCR as well as a comparison to the costs of applying SNCR to the similar Great Star Cement facility. Please address these comments.

23. The NPS commented to the Department that the applicant did not perform visibility analyses to evaluate potential impacts to regional haze at Okefenokee or Chassahowitzka wildernesses. The NPS commented that the applicant incorrectly concluded that because predicted impacts to the Class I increments were less than significant, no air quality related values (AQRV) analyses were required. The NPS stated that increment analyses are independent of AQRV analyses; Class I increments were never intended to protect Class I AQRVs. Therefore, the applicant should perform regional haze analyses, following the recommendations of the Interagency Workgroup on Air Quality Modeling at: http://www.epa.gov/scram001/; "Model Support"; "6th Modeling Conference"; "IWAQM". Please address these comments.

24. In addition to addressing the previous comments from the NPS for the Okefenokee or Chassahowitzka wildernesses, please address these issues for the St. Marks and Bradwell Bay wilderness areas, and perform an increment analysis and analysis of other AQRVs for these areas as well.

Because of significant public interest in this project, the Department will conduct a public meeting regarding this project. We will advise you of the schedule should you wish to attend.

Rule 62-4.050(3), F.A.C. requires that all applications for a Department permit must be certified by a professional engineer registered in the State of Florida. This requirement also applies to responses to Department requests for additional information of an engineering nature. Permit applicants are advised that Rule 62-4.055(1), F.A.C. now requires applicants to respond to requests for information within 90 days. If there are any questions, please call me at 850/921-9519. Matters regarding modeling issues should be directed to Cleve Holladay (meteorologist) at 850/921-8986. Matters regarding the MACT determination may be directed to Lennon Anderson at 850/921-9588.

Sincerely,

Joseph Kahn, P.E.
New Source Review Section

/jk

Enclosure

cc: Mr. Frank Darabi, P.E.
Mr. Steve Cullen, P.E.
Mr. Gregg Worley, EPA
Mr. John Bunyak, NPS
Mr. Chris Kirts, NED
Mr. Jim Stevenson, DEP Ecosystem Mgmt.
Mr. Tom Workman, DEP Recreation & Parks
Ms. December McSherry
Mr. Svenn Lindskold
Mr. Tom Greenhalgh
Mr. Al Mueller

Fold at line over top of envelope to the right of the return address

Is your RETURN ADDRESS completed on the reverse side?

SENDER:
- Complete items 1 and/or 2 for additional services.
- Complete items 3, 4a, and 4b.
- Print your name and address on the reverse of this form so that we can return this card to you.
- Attach this form to the front of the mailpiece, or on the back if space does not permit.
- Write "*Return Receipt Requested*" on the mailpiece below the article number.
- The Return Receipt will show to whom the article was delivered and the date delivered.

I also wish to receive the following services (for an extra fee):

1. ☐ Addressee's Address
2. ☐ Restricted Delivery

Consult postmaster for fee.

3. Article Addressed to:
Joe Anderson, Pres.
Suwannee American
PO Box 40
Branford, Fl
32008

4a. Article Number
Z 333 612 579

4b. Service Type
- ☐ Registered
- ☒ Certified
- ☐ Express Mail
- ☐ Insured
- ☐ Return Receipt for Merchandise
- ☐ COD

7. Date of Delivery
1-20-99

5. Received By: *(Print Name)*

8. Addressee's Address *(Only if requested and fee is paid)*

6. Signature: *(Addressee or Agent)*
X [signature]

PS Form 3811, December 1994 102595-97-B-0179 Domestic Return Receipt

Thank you for using Return Receipt Service.

Z 333 612 579

US Postal Service

Receipt for Certified Mail

No Insurance Coverage Provided.
Do not use for International Mail *(See reverse)*

Sent to: Joe Anderson	
Street & Number: Suwannee American	
Post Office, State, & ZIP Code: Branford Fl	
Postage	$
Certified Fee	
Special Delivery Fee	
Restricted Delivery Fee	
Return Receipt Showing to Whom & Date Delivered	
Return Receipt Showing to Whom, Date, & Addressee's Address	
TOTAL Postage & Fees	$
Postmark or Date: 12-29-98	

1210465-001-AC
PSD-Fl-259

PS Form 3800, April 1995

Re: PSD-FL-259

Mr. C. H. Fancy
Chief, Bureau of Air Regulation
Florida Department of Environmental Regulation
Twin Towers Office Building
2600 Blair Stone Road, MS 48
Tallahassee, Florida 32399-2400

Dear Mr. Fancy:

Our Air Quality Branch has reviewed the Prevention of Significant Deterioration Application for Suwannee Cement Company's proposal to construct a new cement plant in Branford, Florida. The facility is located 83 km southwest of Okefenokee Wilderness and 88 km north of Chassahowitzka Wilderness, both Class I air quality areas administered by the U.S. Fish and Wildlife Service. The technical review comments from our Air Quality Branch are enclosed. Specifically, we recommend that your department require Suwannee to re-evaluate its proposed control technology for nitrogen oxides emissions. Also, we ask that Suwannee be required to evaluate potential impacts from the new emissions to regional haze at the two Class I areas.

Thank you for giving us the opportunity to comment on this permit application. We appreciate your cooperation in notifying us of proposed projects with the potential to impact the air quality and related resources of our Class I air quality areas. If you have questions, please contact Ellen Porter of our Air Quality Branch in Denver at (303) 969-2617.

Sincerely,

Sam D. Hamilton
Regional Director

Enclosures

cc: Doug Neeley, Chief
Air and Radiation Branch
U.S. EPA, Region IV
100 Alabama St., SW
Atlanta, Georgia 30303

Technical Review of Prevention of Significant Deterioration Permit Application For a New Cement Plant Suwannee American Cement Company Branford, Florida PSD-FL-259

by

Air Quality Branch, Fish and Wildlife Service – Denver
December 15, 1998

Suwannee American Cement Company (Suwannee) is proposing to construct a new cement plant in Branford, Suwannee County, Florida. The cement plant will be a dry process preheater/precalciner kiln, producing 2,300 tons per day of clinker, and up to 1,191,360 tons per year of various types and grades of Portland cement. The primary fuels will be coal and petroleum coke. Natural gas will be used as a startup fuel and supplemental fuel. Whole tires and/or tire-derived fuel will be used as a supplemental fuel. The facility is located 83 km southwest of Okefenokee Wilderness and 88 km north of Chassahowitzka Wilderness, both Class I air quality areas administered by the U.S. Fish and Wildlife Service (FWS). This project will result in PSD-significant increases in emissions of nitrogen oxides (NO_x), sulfur dioxide (SO_2), volatile organic compounds (VOC), particulate matter (PM), fine particulate matter less than 10 microns in diameter (PM-10), and carbon monoxide (CO). Emissions (in tons per year – TPY) are summarized below.

POLLUTANT	EMISSIONS INCREASE (TPY)
NO_x	1175
SO2	118
VOC	50
PM	267
PM-10	228
CO	1511

All significant PM and PM-10 emission points will be controlled by baghouses, and kiln SO_2 emissions will be controlled by the alkaline dust captured by the baghouse. NO_x is to be controlled by indirect heating.

Best Available Control Technology (BACT) Analysis

With the exception of NO_x, controls proposed for all emissions appear to represent BACT. The BACT analysis for NO_x is deficient in that it dismisses the application of Selective Non-Catalytic Reduction (SNCR) on the basis of adverse economic and environmental impacts. Suwannee estimates that NO_x removal would cost $1216/ton and states that "costs for NO_x removal using SNCR or any add-on controls are disproportionately high when compared to the costs of controls for NO_x emissions from other cement plants in recent BACT determinations." However, Suwannee does not provide any calculations or documentation to support the

$1216/ton removal cost at the proposed facility, or any comparative costs at other plants, including the Great Star Cement plant in Nevada where SNCR is required by a permit. For other industrial processes, NO_x control is typically $4000/ton; $1216/ton does not seem excessive.

Suwannee states that the availability of SNCR, and therefore its technical feasibility, is questionable because the RACT/BACT/LAER Clearinghouse record for the Great Star Cement plant is over two years old. In fact, construction has not begun on the plant. However, the EPA New Source Review Workshop Manual (Manual) provides guidance on "availability:"

> Two key concepts are important in determining whether an undemonstrated technology is feasible: "availability" and "applicability." As explained in more detail below, a technology is considered "available" if it can be obtained by the applicant through commercial channels or is otherwise available within the common sense meaning of the term. An available technology is "applicable" if it can reasonably be installed and operated on the source type under consideration. A technology that is available and applicable is technically feasible.

Obviously, SNCR is an available technology as it is in use in numerous applications around the world, and is to be applied to the Great Star Cement plant if it is ever built. As for "applicability," the Manual states:

> Commercial availability by itself, however, is not necessarily sufficient basis for concluding a technology to be applicable and therefore technically feasible. Technical feasibility, as determined in Step 2, also means a control option may reasonably be deployed on or "applicable" to the source type under consideration.
>
> Technical judgment on the part of the applicant and the review authority is to be exercised in determining whether a control alternative is applicable to the source type under consideration. In general, a commercially available control option will be presumed applicable if it has been or is soon to be deployed (e.g., is specified in a permit) on the same or a similar source type.

Because SNCR is available and has been "specified in a permit" issued to a similar facility in Nevada, it must be considered technically feasible for Suwannee.

Finally, Suwannee notes that the ammonia used in SNCR presents a risk of environmental degradation. However, ammonia is routinely used in SNCR, SCR, and other industrial process at countless locations everyday and should not constitute a reason for rejection of SNCR merely because of its nature and presence. It is widely recognized that, with proper operation and maintenance procedures, ammonia can be handled and stored safely.

Conclusions & Recommendations

Suwannee should re-evaluate the feasibility of applying SNCR to control NO_x emissions from its proposed cement kiln. Suwannee has incorrectly rejected SNCR by questioning its availability, by failing to document and compare estimated control costs, and by overstating environmental risks associated with the use of ammonia. Suwannee should provide well-documented costs for application of SNCR as well as a comparison to the costs of applying SNCR to the similar Great Star Cement facility.

Air Quality Related Values (AQRV) Analysis

Suwannee did not perform visibility analyses to evaluate potential impacts to regional haze at Okefenokee or Chassahowitzka wildernesses. Suwannee incorrectly concluded that because predicted impacts to the Class I increments were less than significant, no air quality related values (AQRV) analyses were required. However, increment analyses are independent of AQRV analyses; Class I increments were never intended to protect Class I AQRVs. Therefore, Suwannee should perform regional haze analyses, following the recommendations of the Interagency Workgroup on Air Quality Modeling at: http://www.epa.gov/scram001/; "Model Support"; "6th Modeling Conference"; "IWAQM".

Contact: Ellen Porter, Air Quality Branch (303) 969-2617.

MEMORANDUM

TO: Joe Kahn, P.E.

FROM: Lennon Anderson

SUBJECT: Request for Additional Information
Suwannee American Cement Company
Permit No. 1210465-001-AC

DATE: December 28, 1998

If you have not yet sent out a letter requesting additional information on the subject facility, please include the following to assist with the MACT determination:

1. A proposed MACT pursuant to 40 CFR 63.43(d) and (e)

2. A MACT analysis including any new, similar, emission sources contacted (best performing source).

If there are any questions, I can be reached at 954/849-0528; otherwise, I will see you tomorrow.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
1875 Century Boulevard
Atlanta, Georgia 30345

IN REPLY REFER TO:

Re: PSD-FL-259

DEC 22 1998

RECEIVED

JAN 04 1999

BUREAU OF
AIR REGULATION

Mr. C. H. Fancy
Chief, Bureau of Air Regulation
Department of Environmental Regulation
Twin Towers Office Building
2600 Blair Stone Road, MS 48
Tallahassee, Florida 32399-2400

Dear Mr. Fancy:

Our Air Quality Branch has reviewed the Prevention of Significant Deterioration Application for Suwannee Cement Company's proposal to construct a new cement plant in Branford, Florida. The facility is located 83 km southwest of Okefenokee Wilderness and 88 km north of Chassahowitzka Wilderness, both Class I air quality areas administered by the Fish and Wildlife Service. The technical review comments from our Air Quality Branch are enclosed. Specifically, we recommend that your Department require Suwannee to reevaluate its proposed control technology for nitrogen oxides emissions. Also, we ask that Suwannee be required to evaluate potential impacts from the new emissions to regional haze at the two Class I areas.

Thank you for giving us the opportunity to comment on this permit application. We appreciate your cooperation in notifying us of proposed projects with the potential to impact the air quality and related resources of our Class I air quality areas. If you have any questions, please contact Ms. Ellen Porter of our Air Quality Branch in Denver at 303/969-2617.

Sincerely yours,

Judy Jones
for Sam D. Hamilton
Regional Director

Enclosure

cc: J. Kahn, BAR

Technical Review of Prevention of Significant Deterioration Permit Application
For a New Cement Plant
Suwannee American Cement Company
Branford, Florida
PSD-FL-259

by

Air Quality Branch, Fish and Wildlife Service – Denver
December 15, 1998

Suwannee American Cement Company (Suwannee) is proposing to construct a new cement plant in Branford, Suwannee County, Florida. The cement plant will be a dry process preheater/precalciner kiln, producing 2,300 tons per day of clinker, and up to 1,191,360 tons per year of various types and grades of Portland cement. The primary fuels will be coal and petroleum coke. Natural gas will be used as a startup fuel and supplemental fuel. Whole tires and/or tire-derived fuel will be used as a supplemental fuel. The facility is located 83 km southwest of Okefenokee Wilderness and 88 km north of Chassahowitzka Wilderness, both Class I air quality areas administered by the U.S. Fish and Wildlife Service (FWS). This project will result in PSD-significant increases in emissions of nitrogen oxides (NO_X), sulfur dioxide (SO_2), volatile organic compounds (VOC), particulate matter (PM), fine particulate matter less than 10 microns in diameter (PM-10), and carbon monoxide (CO). Emissions (in tons per year – TPY) are summarized below.

POLLUTANT	EMISSIONS INCREASE (TPY)
NO_X	1175
SO2	118
VOC	50
PM	267
PM-10	228
CO	1511

All significant PM and PM-10 emission points will be controlled by baghouses, and kiln SO_2 emissions will be controlled by the alkaline dust captured by the baghouse. NO_x is to be controlled by indirect heating.

Best Available Control Technology (BACT) Analysis

With the exception of NO_x, controls proposed for all emissions appear to represent BACT. The BACT analysis for NO_x is deficient in that it dismisses the application of Selective Non-Catalytic Reduction (SNCR) on the basis of adverse economic and environmental impacts. Suwannee estimates that NO_x removal would cost $1216/ton and states that "costs for NO_x removal using SNCR or any add-on controls are disproportionately high when compared to the costs of controls for NO_x emissions from other cement plants in recent BACT determinations."

However, Suwannee does not provide any calculations or documentation to support the $1216/ton removal cost at the proposed facility, or any comparative costs at other plants, including the Great Star Cement plant in Nevada where SNCR is required by a permit. For other industrial processes, NO_x control is typically $4000/ton; $1216/ton does not seem excessive.

Suwannee states that the availability of SNCR, and therefore its technical feasibility, is questionable because the RACT/BACT/LAER Clearinghouse record for the Great Star Cement plant is over two years old. In fact, construction has not begun on the plant. However, the EPA New Source Review Workshop Manual (Manual) provides guidance on "availability:"

> Two key concepts are important in determining whether an undemonstrated technology is feasible: "availability" and "applicability." As explained in more detail below, a technology is considered "available" if it can be obtained by the applicant through commercial channels or is otherwise available within the common sense meaning of the term. An available technology is "applicable" if it can reasonably be installed and operated on the source type under consideration. A technology that is available and applicable is technically feasible.

Obviously, SNCR is an available technology as it is in use in numerous applications around the world, and is to be applied to the Great Star Cement plant if it is ever built. As for "applicability," the Manual states:

> Commercial availability by itself, however, is not necessarily sufficient basis for concluding a technology to be applicable and therefore technically feasible. Technical feasibility, as determined in Step 2, also means a control option may reasonably be deployed on or "applicable" to the source type under consideration.
>
> Technical judgment on the part of the applicant and the review authority is to be exercised in determining whether a control alternative is applicable to the source type under consideration. In general, a commercially available control option will be presumed applicable if it has been or is soon to be deployed (e.g., is specified in a permit) on the same or a similar source type.

Because SNCR is available and has been "specified in a permit" issued to a similar facility in Nevada, it must be considered technically feasible for Suwannee.

Finally, Suwannee notes that the ammonia used in SNCR presents a risk of environmental degradation. However, ammonia is routinely used in SNCR, SCR, and other industrial process at countless locations everyday and should not constitute a reason for rejection of SNCR merely because of its nature and presence. It is widely recognized that, with proper operation and maintenance procedures, ammonia can be handled and stored safely.

Conclusions and Recommendations

Suwannee should re-evaluate the feasibility of applying SNCR to control NO_x emissions from its proposed cement kiln. Suwannee has incorrectly rejected SNCR by questioning its availability, by failing to document and compare estimated control costs, and by overstating environmental risks associated with the use of ammonia. Suwannee should provide well-documented costs for application of SNCR as well as a comparison to the costs of applying SNCR to the similar Great Star Cement facility.

Air Quality Related Values (AQRV) Analysis

Suwannee did not perform visibility analyses to evaluate potential impacts to regional haze at Okefenokee or Chassahowitzka wildernesses. Suwannee incorrectly concluded that because predicted impacts to the Class I increments were less than significant, no air quality related values (AQRV) analyses were required. However, increment analyses are independent of AQRV analyses; Class I increments were never intended to protect Class I AQRVs. Therefore, Suwannee should perform regional haze analyses, following the recommendations of the Interagency Workgroup on Air Quality Modeling at: http://www.epa.gov/scram001/; "Model Support"; "6th Modeling Conference"; "IWAQM".

Contact: Ellen Porter, Air Quality Branch (303) 969-2617.

INTEROFFICE MEMORANDUM

Date: 22-Dec-1998 04:13pm
From: Kukier.Stan
Kukier.Stan@epamail.epa.gov@PMDF@EPIC66
Dept:
Tel No:

To: holladay_c (holladay_c@A1@DER)
To: kahn_j (kahn_j@A1@DER)

Subject: Suwanee American Cement Company - Branford, FL, PSD-FL-259

DRAFT COMMENTS - FOR YOUR INFORMATION ONLY
Joseph,

Based on a preliminary review of the application information submitted thus far, I have the following draft comments:

NOx emissions

1. The applicant should provide a detailed explanation regarding whether or not a kiln NOx emission rate limit of 2.8 lb/ton clinker is feasible at startup. A review of the RBLC listings for two other dry process kilns located in Florida indicate that both Florida Rock Industries and Florida Crushed Stone are presently operating kilns with the reduced NOx emission rate limit (2.8 lb/ton clinker). It appears that final permits for both of the above facilities were issued more than two years ago. Detailed particulate matter, SO2, NOx, CO, and VOC emission rate calculations, including all references and assumptions, should also be provided. Detailed cost effectiveness/economic calculations for each of the add-on control options discussed in Section 3.13 (e.g., low-NOx burners, SCR, and SNCR), including all references and assumptions, should be provided by Suwannee American Cement. Discussions with Florida DEP staff indicate that an SNCR add-on NOx emission control system is available from the kiln vendor. A detailed discussion of the kiln vendor's SNCR system regarding both technical/economic feasibility should be included in Suwannee American Cement's BACT review for cement kiln NOx emissions. The applicant proposes a NOx emission rate limit of 3.8 lb/ton clinker as BACT for the cement kiln.

CO emissions

2. A review of RBLC listings reveals that lower cement kiln CO emission rate limits have recently been determined BACT for several other similar Portland cement plants. A discussion of why a reduced kiln CO emission rate limit would not be proposed as BACT by the applicant, should be included in the submittal. A technical and economic analysis regarding the feasibility of a 1.64 lb/ton clinker (LaFarge Corporation, Sugar Creek, Missouri, Permit No. 0897-019, issued August 20, 1997) kiln CO emission rate limit should be included in Suwannee's submittal. A CO emission rate limit of 2.77 lb/ton clinker has also recently (June 3,1998) been determined BACT for dry process kiln operations at Signal Mountain Cement Company located at Chattanooga, Tennessee. BACT analysis related

information regarding the Signal Mountain Cement Company kiln CO emission rate limit was faxed to Florida DEP on December 18, 1998. The applicant proposes a CO emission rate limit of 3.6 lb/ton clinker as BACT for the cement kiln.

SO2 emissions

3. A technical and economic analysis regarding the feasibility of a reduced cement kiln SO2 emission rate limit (0.27lb/ton clinker) should also be included in the applicant's BACT review. The applicant proposes an SO2 emission rate limit of 0.28 lb/ton clinker for the new cement kiln.

Modeling/Monitoring: (draft comments are attached per Stan Krivo)

If you have any questions, please contact Stan Krivo or myself. If there are any questions regarding the applicability of 40 CFR Part 63, Subpart LLL (Portland Cement Manufacturing Industry), please contact Lee Page at (404)562-9131. I hope these draft comments are helpful.

Stan Kukier
EPA-Region 4

Date: 18 December 1998

To: Stan Kukier

From: Stan Krivo

Subject: Initial Review Air Quality Impact Assessment
Suwannee American Cement Company PSD Application
Branford, FL

The following are comments and questions resulting from my initial review of the air quality impact assessment for the proposed Suwannee American Cement Company facility to be located at an existing limestone quarry near Branford, FL.

1. Secondary Emissions - The PSD application does not address any increase in quarry production due to the operation of the Portland cement facility. Any increase in quarry emissions associated solely with the operation of the cement plant must be included in the cement company's PSD air quality impact assessment.

2. Cement Company Emission Information - The PSD application does not provide specific modeling emission information associated with the cement company's operation. The individual emission sources for each applicable pollutant should be provided along with the location, emission rates, and stack/vent exit variables (e.g., exit temperature, velocity, etc.) for each appropriate level of operation (e.g., 50%, 75% and 100% loads). Where applicable, the emission rates and exit variables should be provided for each fuel source. The basis for each pollutant emission rate should also be provided.

3. Shakedown Period - The applicant requests a 2-year shakedown period with increased NOx emissions. It was indicated that the impact modeling provided used the increased emission rate. This appears to be an unusually long shakedown period.

4. Modeling Data Diskettes - Diskettes containing the modeling input and output files were not included with the PSD application. Because the application contains little specific modeling information, the model input and output files are needed.

5. PSD and NAAQS Modeling - The PSD application does not contain discussions of the modeling procedures, selected model options, source emission information, and receptor information associated with the Area of Significance, PSD increment

, and NAAQS modeling. This information is needed to understand the modeling results presented in the application.

6. Other Emission Sources - The emission sources used for both the NAAQS and PSD compliance modeling were selected based on the 20D rule. This rule, which is not a guideline procedure, does not consider the additive effects of a number sources located in the same general location. Review of the 20D rule eliminated emission sources reveals a few NOx and many PM10 sources that may need to be included in the impact modeling emission inventories.

7. Facility Plot Plan - A plot plan displaying the location and dimensions of the various plant components and the site boundary is needed to determine and understand the input variables used in the modeling.

8. Class I Area Impacts - The results of the Okefenokee National Wilderness Area Class I impact assessments need to be reviewed by the U.S. Fish and Wildlife Service and the Okefenokee Land Manager. The application did not include visual range nor regional haze assessments.

I plan on discussing the above initial review comments with Cleve Holladay of FL DEP. Please let me know if you have any questions or need further information on my initial review of this application.

Date: 18 December 1998

To: Stan Kukier

From: Stan Krivo

Subject: Initial Review Air Quality Impact Assessment
Suwannee American Cement Company PSD Application
Branford, FL

The following are comments and questions resulting from my initial review of the air quality impact assessment for the proposed Suwannee American Cement Company facility to be located at an existing limestone quarry near Branford, FL.

1. Secondary Emissions - The PSD application does not address any increase in quarry production due to the operation of the Portland cement facility. Any increase in quarry emissions associated solely with the operation of the cement plant must be included in the cement company's PSD air quality impact assessment.

2. Cement Company Emission Information - The PSD application does not provide specific modeling emission information associated with the cement company's operation. The individual emission sources for each applicable pollutant should be provided along with the location, emission rates, and stack/vent exit variables (e.g., exit temperature, velocity, etc.) for each appropriate level of operation (e.g., 50%, 75% and 100% loads). Where applicable, the emission rates and exit variables should be provided for each fuel source. The basis for each pollutant emission rate should also be provided.

3. Shakedown Period - The applicant requests a 2-year shakedown period with increased NOx emissions. It was indicated that the impact modeling provided used the increased emission rate. This appears to be an unusually long shakedown period.

4. Modeling Data Diskettes - Diskettes containing the modeling input and output files were not included with the PSD application. Because the application contains little specific modeling information, the model input and output files are needed.

5. PSD and NAAQS Modeling - The PSD application does not contain discussions of the modeling procedures, selected model options, source emission information, and receptor information associated with the Area of Significance, PSD increment , and NAAQS modeling. This information is needed to understand the modeling results presented in the application.

6. Other Emission Sources - The emission sources used for both the NAAQS and PSD compliance modeling were selected based on the 20D rule. This rule, which is not a guideline procedure, does not consider the additive effects of a number sources located in the same general location. Review of the 20D rule eliminated emission sources reveals afew NOx and many PM10 sources that may need to be included in the impact modeling emission inventories.

7. Facility Plot Plan - A plot plan displaying the location and dimensions of the various plant components and the site boundary is needed to determine and understand the input variables used in the modeling.

8. Class I Area Impacts - The results of the Okefenokee National Wilderness Area Class I impact assessments need to be reviewed by the U.S. Fish and Wildlife Service and the Okefenokee Land Manager. The application did not include visual range nor regional haze assessments.

I plan on discussing the above initial review comments with Cleve Holladay of FL DEP. Cmmnt01.dft
Please let me know if you have any questions or need further information on my initial review of this application.

DRAFT COMMENTS - FOR YOUR INFORMATION ONLY

Joseph,

Based on a preliminary review of the application information submitted thus far, I have the following draft comments:

NOx emissions

1. The applicant should provide a detailed explanation regarding whether or not a kiln NOx emission rate limit of 2.8 lb/ton clinker is feasible at startup. A review of the RBLC listings for two other dry process kilns located in Florida indicate that both Florida Rock Industries and Florida Crushed Stone are presently operating kilns with the reduced NOx emission rate limit (2.8 lb/ton clinker). It appears that final permits for both of the above facilities were issued more than two years ago. Detailed particulate matter, SO2, NOx, CO, and VOC emission rate calculations, including all references and assumptions, should also be provided. Detailed cost effectiveness/economic calculations for each of the add-on control options discussed in Section 3.13 (e.g., low-NOx burners, SCR, and SNCR), including all references and assumptions, should be provided by Suwannee American Cement. Discussions with Florida DEP staff indicate that an SNCR add-on NOx emission control system is available from the kiln vendor. A detailed discussion of the kiln vendor's SNCR system regarding both technical/economic feasibility should be included in Suwannee American Cement's BACT review for cement kiln NOx emissions. The applicant proposes a NOx emission rate limit of 3.8 lb/ton clinker as BACT for the cement kiln.

CO emissions

2. A review of RBLC listings reveals that lower cement kiln CO emission rate limits have recently been determined BACT for several other similar Portland cement plants. A discussion of why a reduced kiln CO emission rate limit would not be proposed as BACT by the applicant, should be included in the submittal. A technical and economic analysis regarding the feasibility of a 1.64 lb/ton clinker (LaFarge Corporation, Sugar Creek, Missouri, Permit No. 0897-019, issued August 20, 1997) kiln CO emission rate limit should be included in Suwannee's submittal. A CO emission rate limit of 2.77 lb/ton clinker has also recently (June 3,1998) been determined BACT for dry process kiln operations at Signal Mountain Cement Company located at Chattanooga, Tennessee. BACT analysis related information regarding the Signal Mountain Cement Company kiln CO emission rate limit was faxed to Florida DEP on December 18, 1998. The applicant proposes a CO emission rate limit of 3.6 lb/ton clinker as BACT for the cement kiln.

SO2 emissions

3. A technical and economic analysis regarding the feasibility of a reduced cement kiln SO2 emission rate limit (0.27lb/ton clinker) should also be included in the applicant's BACT review. The applicant proposes an SO2 emission rate limit of 0.28 lb/ton clinker for the new cement kiln.

Modeling/Monitoring: (draft comments are attached per Stan Krivo)

If you have any questions, please contact Stan Krivo or myself. If there are any questions regarding the applicability of 40 CFR Part 63, Subpart LLL (Portland Cement Manufacturing Industry), please contact Lee Page at (404)562-9131. I hope these draft comments are helpful.

Stan Kukier
EPA-Region 4

U.S.FISH&WILDLIFE SERVICE
AIR QUALITY BRANCH
P.O. BOX 25287, Denver, CO 80225-0287

FACSIMILE COVER SHEET

Date: December 18, 1998

Telephone: (303) 969-2617
Fax: (303) 969-2822

To: Cleve Holladay

From: Ellen Porter

Subject: Suwannee Cement; signed letter will follow

Number of Pages: 6
(Including this cover sheet)

Office Location: 7333 West Jefferson Ave, Suite 450, Lakewood, CO 80235

Re: PSD-FL-259

Mr. C. H. Fancy
Chief, Bureau of Air Regulation
Florida Department of Environmental Regulation
Twin Towers Office Building
2600 Blair Stone Road, MS 48
Tallahassee, Florida 32399-2400

Dear Mr. Fancy:

Our Air Quality Branch has reviewed the Prevention of Significant Deterioration Application for Suwannee Cement Company's proposal to construct a new cement plant in Branford, Florida. The facility is located 83 km southwest of Okefenokee Wilderness and 88 km north of Chassahowitzka Wilderness, both Class I air quality areas administered by the U.S. Fish and Wildlife Service. The technical review comments from our Air Quality Branch are enclosed. Specifically, we recommend that your department require Suwannee to re-evaluate its proposed control technology for nitrogen oxides emissions. Also, we ask that Suwannee be required to evaluate potential impacts from the new emissions to regional haze at the two Class I areas.

Thank you for giving us the opportunity to comment on this permit application. We appreciate your cooperation in notifying us of proposed projects with the potential to impact the air quality and related resources of our Class I air quality areas. If you have questions, please contact Ellen Porter of our Air Quality Branch in Denver at (303) 969-2617.

Sincerely,

Sam D. Hamilton
Regional Director

Enclosures

cc: Doug Neeley, Chief
Air and Radiation Branch
U.S. EPA, Region IV
100 Alabama St., SW
Atlanta, Georgia 30303

bcc: FWS-REG. 4: AQC
OKEF: Refuge Manager
CHAS: Refuge Manager
AQD-DEN: Ellen Porter
National Park Service - AIR
P.O. Box 25287
Denver, CO 80225

Technical Review of Prevention of Significant Deterioration Permit Application
For a New Cement Plant
Suwannee American Cement Company
Branford, Florida
PSD-FL-259

by

Air Quality Branch, Fish and Wildlife Service – Denver
December 15, 1998

Suwannee American Cement Company (Suwannee) is proposing to construct a new cement plant in Branford, Suwannee County, Florida. The cement plant will be a dry process preheater/precalciner kiln, producing 2,300 tons per day of clinker, and up to 1,191,360 tons per year of various types and grades of Portland cement. The primary fuels will be coal and petroleum coke. Natural gas will be used as a startup fuel and supplemental fuel. Whole tires and/or tire-derived fuel will be used as a supplemental fuel. The facility is located 83 km southwest of Okefenokee Wilderness and 88 km north of Chassahowitzka Wilderness, both Class I air quality areas administered by the U.S. Fish and Wildlife Service (FWS). This project will result in PSD-significant increases in emissions of nitrogen oxides (NO_X), sulfur dioxide (SO_2), volatile organic compounds (VOC), particulate matter (PM), fine particulate matter less than 10 microns in diameter (PM-10), and carbon monoxide (CO). Emissions (in tons per year – TPY) are summarized below.

POLLUTANT	EMISSIONS INCREASE (TPY)
NO_X	1175
SO2	118
VOC	50
PM	267
PM-10	228
CO	1511

All significant PM and PM-10 emission points will be controlled by baghouses, and kiln SO_2 emissions will be controlled by the alkaline dust captured by the baghouse. NO_x is to be controlled by indirect heating.

Best Available Control Technology (BACT) Analysis

With the exception of NO_x, controls proposed for all emissions appear to represent BACT. The BACT analysis for NO_x is deficient in that it dismisses the application of Selective Non-Catalytic Reduction (SNCR) on the basis of adverse economic and environmental impacts. Suwannee estimates that NO_x removal would cost $1216/ton and states that "costs for NO_x removal using SNCR or any add-on controls are disproportionately high when compared to the costs of controls for NO_x emissions from other cement plants in recent BACT determinations." However, Suwannee does not provide any calculations or documentation to support the

$1216/ton removal cost at the proposed facility, or any comparative costs at other plants, including the Great Star Cement plant in Nevada where SNCR is required by a permit. For other industrial processes, NO_x control is typically $4000/ton; $1216/ton does not seem excessive.

Suwannee states that the availability of SNCR, and therefore its technical feasibility, is questionable because the RACT/BACT/LAER Clearinghouse record for the Great Star Cement plant is over two years old. In fact, construction has not begun on the plant. However, the EPA New Source Review Workshop Manual (Manual) provides guidance on "availability:"

> Two key concepts are important in determining whether an undemonstrated technology is feasible: "availability" and "applicability." As explained in more detail below, a technology is considered "available" if it can be obtained by the applicant through commercial channels or is otherwise available within the common sense meaning of the term. An available technology is "applicable" if it can reasonably be installed and operated on the source type under consideration. A technology that is available and applicable is technically feasible.

Obviously, SNCR is an available technology as it is in use in numerous applications around the world, and is to be applied to the Great Star Cement plant if it is ever built. As for "applicability," the Manual states:

> Commercial availability by itself, however, is not necessarily sufficient basis for concluding a technology to be applicable and therefore technically feasible. Technical feasibility, as determined in Step 2, also means a control option may reasonably be deployed on or "applicable" to the source type under consideration.
>
> Technical judgment on the part of the applicant and the review authority is to be exercised in determining whether a control alternative is applicable to the source type under consideration. In general, a commercially available control option will be presumed applicable if it has been or is soon to be deployed (e.g., is specified in a permit) on the same or a similar source type.

Because SNCR is available and has been "specified in a permit" issued to a similar facility in Nevada, it must be considered technically feasible for Suwannee.

Finally, Suwannee notes that the ammonia used in SNCR presents a risk of environmental degradation. However, ammonia is routinely used in SNCR, SCR, and other industrial process at countless locations everyday and should not constitute a reason for rejection of SNCR merely because of its nature and presence. It is widely recognized that, with proper operation and maintenance procedures, ammonia can be handled and stored safely.

Conclusions & Recommendations

Suwannee should re-evaluate the feasibility of applying SNCR to control NO_x emissions from its proposed cement kiln. Suwannee has incorrectly rejected SNCR by questioning its availability, by failing to document and compare estimated control costs, and by overstating environmental risks associated with the use of ammonia. Suwannee should provide well-documented costs for application of SNCR as well as a comparison to the costs of applying SNCR to the similar Great Star Cement facility.

Air Quality Related Values (AQRV) Analysis

Suwannee did not perform visibility analyses to evaluate potential impacts to regional haze at Okefenokee or Chassahowitzka wildernesses. Suwannee incorrectly concluded that because predicted impacts to the Class I increments were less than significant, no air quality related values (AQRV) analyses were required. However, increment analyses are independent of AQRV analyses; Class I increments were never intended to protect Class I AQRVs. Therefore, Suwannee should perform regional haze analyses, following the recommendations of the Interagency Workgroup on Air Quality Modeling at: http://www.epa.gov/scram001/; "Model Support"; "6th Modeling Conference"; "IWAQM".

Contact: Ellen Porter, Air Quality Branch (303) 969-2617.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY - REGION 4
AIR, PESTICIDES & TOXICS MANAGEMENT DIVISION
AIR & RADIATION TECHNOLOGY BRANCH
100 Alabama Street, SW
Atlanta, Georgia 30303
Fax Number: 404/562-9095

FACSIMILE TRANSMISSION SHEET

DATE: 12/18/98	NUMBER OF PAGES (including this sheet): 6
TO: Joseph Kahn	PHONE: 850/921-9519
ADDRESS: FDEP	FAX NUMBER: 850/922-6979
FROM: Stan Kukier	PHONE: 404/562-9140

Please call me if this transmission is received poorly.

SPECIAL INSTRUCTIONS: FYI

re: Dry Process Cement Kiln - Technical BACT related info

Hope this is useful

Stan

Pages 5 + 6 were redundant. This is something like Rinker project where applicant netted out going from wet to dry. al

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET, SW
ATLANTA, GEORGIA 30303-8909

APR 2 2 1998

4APT-ARB

Mr. Robert H. Colby
Director
Chattanooga-Hamilton County Air
  Pollution Control Bureau
3511 Rossville Boulevard
Chattanooga, TN 37407

SUBJ: Draft PSD Permits for Signal Mountain Cement Company, Chattanooga, Tennessee (PSD-TN-154)

Dear Mr. Colby:

Thank you for your letter of March 20, 1998, submitting a preliminary determination and draft Prevention of Significant Deterioration (PSD) permits for the above referenced facility. The draft permits are for an expansion/major modification to the existing portland cement manufacturing facility. The project will consist of the replacement of two existing wet-process kilns with one dry-process kiln and modifications to the raw material handling, processing, and storage equipment. A new finish grinding system will also be added to supplement the existing finish mills.

Based on our review of the draft permits and supporting information, we have the following comments.

1. The project is subject to PSD permitting requirements due to a significant increase in CO emissions. The best available control technology (BACT) for CO emissions from the new kiln is the use of proper design and operation to achieve a CO emission limit of 248 lb/hr. Since this CO emission limit is based on an emission rate of 2.77 lb/ton clinker and the BACT emission limits for this source category are typically reported in units of "lb CO/ton clinker," we suggest that the permit for Signal Mountain Cement Company also include the CO limit of 2.77 lb/ton clinker.

2. Although each draft permit includes a condition indicating that all of the emission limits are BACT, the only emission limit which was determined by going through the BACT review process, as required by the PSD regulations, is the limit for CO. We recommend that this condition be

removed from each draft permit, since it is misleading. Since the project will result in either a net decrease or an insignificant increase in emissions of other pollutants (i.e., particulate matter, NO_x, SO_2, and volatile organic compounds), a BACT analysis was not required for those pollutants and was not included in the PSD permit application.

3. Each permit includes a condition indicating that the limitations of the permit may be modified, based on the required stack tests (or based on the final design of emission control equipment), "provided the adjusted limits do not exceed emission netting requirements..." For clarity, we recommend a modification in this clause. Instead, the following language may be preferable - "provided the adjusted limits do not result in a net emissions increase greater than the PSD significance levels..." Also, since the project will result in a significant increase in CO emissions and the emission limit for CO is based on the applicant's BACT analysis, the permit should not allow the CO emission limit to be increased.

4. Although the application for the kiln bypass and cement kiln dust (CKD) handling facility indicates that baghouses 15, 16, and 17 control emissions from these units, the permit only limits particulate matter emissions from baghouses 16 and 17. Please check to ensure that all emission points affected by the project are covered in the permits.

The requirements of 40 CFR Part 60, Subpart F (Standards of Performance for Portland Cement Plants) are applicable to the facility. Also, on March 24, 1998, 40 CFR Part 63, Subpart LLL - National Emission Standards for Hazardous Air Pollutants; Proposed Standards for Hazardous Air Pollutants Emissions for the Portland Cement Manufacturing Industry was published in the Federal Register. When finalized, this regulation will apply to each new and existing portland cement plant.

Thank you for the opportunity to review and comment on draft permits and supporting information. If you have any questions, please contact Keith Goff of my staff at (404)562-9137.

Sincerely yours,

Douglas Neeley

R. Douglas Neeley
Chief
Air and Radiation Technology Branch
Air, Pesticides, and Toxics Management Division

RECEIVED 12/18/98
DISTRICT DIRECTORS MEETING

ECONOMIC INFORMATION

SELECTED FLORIDA COUNTIES WITH FIRST MAGNITUDE* SPRINGS

Suwannee County: Ichetucknee Springs

Unemployment Rate:	9.0%
Tourism & Recreation Tax Revenues:	$38.08 per capita
Percent of 10th Grade Students Passing the State Student Assessment Test:	78.5%

Citrus County: Homosassa Springs

Unemployment Rate:	8.5%
Tourism & Recreation Tax Revenues:	$59.74 per person
Percent of 10th Grade Students Passing the State Student Assessment Test:	96.5%

Hernando County: Weeki Wachee Springs

Unemployment Rate:	8.2%
Tourism & Recreation Tax Revenues:	$44.99 per person
Percent of 10th Grade Students Passing the State Student Assessment Test:	81.0%

Marion County: Silver Springs

Unemployment Rate:	8.6%
Tourism & Recreation Tax Revenues:	$73.45 per person
Percent of 10th Grade Students Passing the State Student Assessment Test:	81.5%

Wakulla County: Wakulla Springs

Unemployment Rate:	6.0%
Tourism & Recreation Tax Revenues:	$48.43 per person
Percent of 10th Grade Students Passing the State Student Assessment Test:	85.5%

*First magnitude springs discharge more than 64 million gallons of water per day.

SUMMARY

These other counties all have better economic indicators than Suwannee County:

- Lower unemployment rates
- Higher revenues, per person, from tourism and recreation
- Higher passing rates on the State Student Achievement Test

This information shows that industrial development, environmental protection, and tourism and recreation are all necessary for good economic development. The attached pages show large industrial and utility facilities located within 20 miles of these other springs.

Reference: Florida County Comparisons, 1992. Florida Department of Commerce
Florida Department of Environmental Protection. Title V Facility Inventory, 1997.

CERTAIN SPRINGS in FLORIDA
and
NEARBY INDUSTRIAL FACILITIES
(within 20 miles)

Silver Springs
Marion County

Lead furnace, charcoal manufacturing, gas compressors, other industrial

Distance from spring

Owner/Company	Process Description	Stack Ht (ft)	km	miles
GRIMES AEROSPACE COMPANY	SMALL METAL PARTS MANUFACTURING		5.62	3.5
GRIMES AEROSPACE COMPANY	STEAM BOILER		5.62	3.5
DAYCO PRODUCTS INC	#1 RUBBER COMPOUND MIXER W/BAGHOUSE	12	7.32	4.6
DAYCO PRODUCTS INC	HOSE CURE PREPARATION PROCESS W/BAGHOUSE	24	7.32	4.6
DAYCO PRODUCTS INC	LEAD EXTRUDER #3 AND 10 TON LEARD POT FURNACE	17	7.32	4.6
PREMDOR AKA JOHNSON DOOR PRODUCTS	DRYING OVEN	26	9.60	6.0
PREMDOR AKA JOHNSON DOOR PRODUCTS	BAKING OVEN	25	9.60	6.0
ROYAL OAK ENTERPRISES	NICHOLS HERRESHOFF RETORT CARBONIZER	40	10.17	6.3
ROYAL OAK ENTERPRISES	BRIQUETE PRES ROOM & DRYER	10	10.17	6.3
LOCKHEED MARTIN ELECTRONICS	PLATING ROOM	29	15.20	9.4
LOCKHEED MARTIN ELECTRONICS	ETCHER/STRIPPER ROOM	26	15.20	9.4
LOCKHEED MARTIN ELECTRONICS	TWO PLASMA ETCH MACHINES	25	15.20	9.4
LOCKHEED MARTIN ELECTRONICS	HOT WATER BOILER	20	15.20	9.4
LOCKHEED MARTIN ELECTRONICS	AIR STRIPPER #3 & 4	25	15.20	9.4
MARK III INDUSTRIES	UV REACTOR ROOM: 3 COATING SPRAY BOOTHS WITH LINE CONVEYORS	20	20.11	12.5
MARK III INDUSTRIES	18 IDENTICAL PAINT SPRAY BOOTHS (#1-#18);	30	20.11	12.5
FLORIDA GAS TRANSMISSION CO.	COMPRESSOR ENGINE NO. 1	28	22.93	14.3
FLORIDA GAS TRANSMISSION CO.	COMPRESSOR ENGINE #2	28	22.93	14.3
FLORIDA GAS TRANSMISSION CO.	COMPRESSOR ENGINE #3	28	22.93	14.3
FLORIDA GAS TRANSMISSION CO.	COMPRESSOR ENGINE #4	28	22.93	14.3
FLORIDA GAS TRANSMISSION CO.	RECIPROCATING I.C. ENGINE #5, 2400 BHP, NATURAL GAS FIRED	40	22.93	14.3

Wakulla Springs
Wakulla County

Power plant, other industrial

Distance from spring

Owner/Company	Process Description	Stack Ht (ft)	km	miles
PRIMEX TECHNOLOGIES, INC.	NORTH SWEETIE BARREL (VENTURI SCRUBBER & 2ND STAGE PACKED CO	6	10.02	6.2
PRIMEX TECHNOLOGIES, INC.	NORTHEAST SWEETIE BARREL (VENTURI SCRUBBER & 2ND STAGE PACKE	6	10.02	6.2
PRIMEX TECHNOLOGIES, INC.	BOILER #1, CLEAVER-BROOKS	35	10.02	6.2
PRIMEX TECHNOLOGIES, INC.	BOILER #2, CLEAVER-BROOKS	35	10.02	6.2
TALLAHASSEE CITY PURDOM GENERATING STA.	BOILER PURDOM #5 FUEL OIL #6 & NAT GAS	125	13.31	8.3
TALLAHASSEE CITY PURDOM GENERATING STA.	BOILER PURDOM #6 FUEL OIL #6 & NAT GAS R	125	13.31	8.3
TALLAHASSEE CITY PURDOM GENERATING STA.	BOILER PURDOM #7 FUEL OIL #6 & NAT GAS	180	13.31	8.3
TALLAHASSEE CITY PURDOM GENERATING STA.	COMBUSTION TURBINE PURDOM UNIT #1-CT PEAKING UNIT	38	13.31	8.3
TALLAHASSEE CITY PURDOM GENERATING STA.	COMBUSTION TURBINE PURDOM UNIT #2-CT PEAKING UNIT	38	13.31	8.3
TALLAHASSEE CITY PURDOM GENERATING STA.	AUXILLARY BOILER	30	13.31	8.3
TALLAHASSEE CITY HOPKINS GENERATING STAT	BOILER HOPKINS #1 NAT GAS & FUEL OIL #6	200	25.68	16.0
TALLAHASSEE CITY HOPKINS GENERATING STAT	TURBINE HOPKINS UNIT #1	29	25.68	16.0
TALLAHASSEE CITY HOPKINS GENERATING STAT	COMBUSTION TURBINE HOPKINS #2 GT PEAKING UNIT	30	25.68	16.0
TALLAHASSEE CITY HOPKINS GENERATING STAT	UNIT #2	250	25.68	16.0
U.S. MARINE	STACK ID H- 18"X24" WOODSHOP/BAGHOUSE	12	31.34	19.5
U.S. MARINE	STACK ID - 2, 6" STACKS SPENCER VACUUMS	12	31.34	19.5

CERTAIN SPRINGS In FLORIDA
and
NEARBY INDUSTRIAL FACILITIES
(within 20 miles)

Homosassa Springs
Citrus County

2 Cement plants, 2 power plants, lime plant, other industrial

Owner/Company	Process Description	Stack Ht (ft)	Distance from spring km	miles
METAL INDUSTRIES, INC	PROPANE FIRED DRYING OVEN USED AFTER CLEANING & PRETREATMENT	25	11.15	6.9
FLORIDA POWER	STEAM UNIT #1 - 400MW	499	20.68	12.9
FLORIDA POWER	UNIT #2, 500 MW COAL FIRED STEAM GENERATOR WITH ESP	503	20.68	12.9
FLORIDA POWER	CRYSTAL RIVER UNIT #5 ******POWER PLANT SITING******	600	20.68	12.9
FLORIDA POWER	CRYSTAL RIVER UNIT #4 ******POWER PLANT SITING******	600	20.68	12.9
FLORIDA POWER	THREE 820 KW DIESEL GENERATORS.	15	20.68	12.9
SOUTHDOWN, INC.	CEMENT KILN NO. 1 BAGHOUSE(E-55);REVISED OIL CONCENTRATIONS	150	20.79	12.9
SOUTHDOWN, INC.	CEMENT KILN NO. 2 BAGHOUSE(E-19); REVISED OIL CONCENTRATIONS	105	20.79	12.9
CHEMICAL LIME INC. (SEE COMMENT)	LIME HYDRATOR	20	28.42	17.7
FLORIDA CRUSHED STONE CO., INC.	KILN, CLINKER COOLER, RAW MILL, AND DRYER W/BAGHOUSE	300	28.56	17.7
CENTRAL POWER & LIME, INC.	POWER PLANT	320	28.56	17.7

Weeki Wachee Springs
Hernando County

2 Cement plants, municipal waste-fired power plant, coal-fired power plant, other industrial

Owner/Company	Process Description	Stack Ht (ft)	Distance from spring km	miles
CHEMICAL LIME INC. (SEE COMMENT)	LIME HYDRATOR	20	15.07	9.4
FLORIDA CRUSHED STONE CO., INC.	KILN, CLINKER COOLER, RAW MILL, AND DRYER W/BAGHOUSE	300	15.69	9.8
CENTRAL POWER & LIME, INC.	POWER PLANT	320	15.69	9.8
PASCO COUNTY (OWNER)	#1 MUNICIPAL WASTE COMBUSTOR, (HAS PSD)	275	16.80	10.4
PASCO COUNTY (OWNER)	#2 MUNICIPAL WASTE COMBUSTOR,(HAS PSD)	275	16.80	10.4
PASCO COUNTY (OWNER)	#3 MUNICIPAL WASTE COMBUSTOR, (HAS PSD)	275	16.80	10.4
SOUTHDOWN, INC.	CEMENT KILN NO. 1 BAGHOUSE(E-55);REVISED OIL CONCENTRATIONS	150	16.93	10.5
SOUTHDOWN, INC.	CEMENT KILN NO. 2 BAGHOUSE(E-19); REVISED OIL CONCENTRATIONS	105	16.93	10.5
CITRUS SERVICE, INC.	600 HP CLEAVER BROOKS, MOD. CB420, NO. 6 OIL, NO CONTROLS	34	18.40	11.4
CITRUS SERVICE, INC.	CITRUS PEEL DRYER W/WASTE HEAT EVAPORATOR	60	18.40	11.4
CITRUS SERVICE, INC.	JOHNSON 150 HP PROCESS STEAM BOILER (BOILER NO. 2)		18.40	11.4

Florida Department of Environmental Protection

Meeting Sign-In Sheet

Re: SUWANEE AMERICAN CEMENT

Date: 12-17-98

Name	Representing	Telephone
CINDY PHILLIPS	FDEP - AIR TOXICS PERMITTING	850-921-9534
Lennon Anderson	" " "	850 921-9588
Steve Cullen	Suwannee American Cement	352 377-5822
MARK MUELLER	KRUPP POLYSIUS CORP.	770-980-5029
John Koogler	KA/Suwannee Am	352/377-5822
MARK TERRY	KRUPP POLYSIUS	770 980 5013
FRANK DARABI	DARABI & Assoc Suwan Amer Cem	352/276-6533
Al Linero	FDEP - Bureau of Air Regulation	850/921-9523
JOE KAHN	DEP - BAR/NSR	850-921-9519
C H Fancy	" " "	9219503

MARK S. TERRY
VICE PRESIDENT ENGINEERING

KRUPP POLYSIUS CORP.
180 INTERSTATE NORTH
ATLANTA, GEORGIA 30339-2194

TEL. 770 980-5013
FAX 770 980-5026
E-mail: mterry@polysius.com

Directors of District Management Meeting
December 18, 1998
8:30

CARR BUILDING, ROOM 154

Progress of SLERP Process Mapping - District Directors

"Public" vs. "private" easement determinations - Phil Coram, Gary Heiser

Data quality and lab. certification / role of district labs - Bill Coppenger

Proposed cement manufacturing plant - Howard Rhodes, Frank Darabi

Intergovernmental Issues - Deb Parrish
- Gov's Task Force on Cumulative and Secondary Impacts
- Int. Trade / Seaport Expansions / Freight Task Force
- Transportation and Land Use Study Committee
- State Comprehensive Plan Review Process

Data access issues

EMRTF penalty dollars - Jacki McGorty

Happy Holidays

…MBUSTION, … TRANSFER AND …

… and B G Jenkins, Fuel and Combustion …

… combustion optimisation in, and NOx emission characte…

… FOR THE SPANISH TRANSLATION, PLEASE REFER TO THE SPECIAL SECTION AT THE …

Abstract

Guesswork, simple calculations combined with the extrapolation of experience, and system modelling can all be used to design combustion systems for rotary kilns. While the sole use of guesswork is rare, simple calculations and extrapolation are still the standard method, despite the availability of proven modelling techniques. This paper provides a brief background to combustion, heat transfer and NOx formation in rotary kilns and demonstrates how these modelling techniques, a detailed knowledge of the interaction of the combustion process with the process itself, and consideration of NOx formation chemistry, can be successfully applied to rotary kilns particularly with regard to the conversion of kilns from solid fuels to gas firing, product quality improvements, and waste and multiple fuel firing. Any one modelling technique can give only part of the answer and several methods have to be used to provide reliable answers for real industrial problems. A number of major benefits can be realised through this approach, including reduced costs and increased profits for the kiln operator with reduced environmental impact. Much future emphasis will be directed towards NOx reduction whilst maintaining and improving predictability and product quality.

Introduction

Rotary kilns are used for the processing and production of many materials in industry. Typical examples are cement clinker, lime, alumina, calcination of petroleum coke, and many other ore beneficiation processes. Clearly, there are similarities between all rotary kilns; they are all cylindrical, rotate at between 0.5 and 2 rpm and are generally fired by a single flame. However, here the similarity ends. Kiln configurations are process dependent, the required process temperatures vary widely, and secondary air temperatures are highly variable, as is the type of firing system employed. In addition, a wide range of fuel types are typically fired.

As previously mentioned, rotary kilns are used across a broad range of process industries, but by far the largest user is the cement industry, which operates approximately 2000 cement rotary kilns worldwide. Consequently, this paper is principally concerned with the cement rotary kiln but the general approach to resolving combustion problems and improving process efficiency, and the consideration of the complex interaction between the combustion process and the process itself, is applicable across the range of processes employing the rotary kiln technology.

Optimisation of both the energy consumption and process efficiency of cement kilns involves both fossil fuel and electrical energy, and this paper is principally concerned with the former. Optimisation encompasses minimising fuel consumption, unburnts, NOx, SO_2 and cement linker grinding energy.

Cement clinker with small crystals and sharp boundaries assists easy grinding and gives the cement a high early strength. Crystal growth is strongly influenced by the heat transfer from the flame, favourable conditions being the rapid heating from calcining temperature to sintering temperature, and the sudden quench in the cooler to freeze the crystal structure. These conditions are produced by a flame with a high heat flux close to the burner nozzle. Flames with very flat heat flux profiles provide slow rates of heating and large crystals. The resultant clinker is hard to grind and produces cement with poor early strength. To compensate and meet market requirements, the raw mix is sometimes adjusted, the kiln burnt harder, and the cement ground finer, thus increasing the energy consumption both in the kiln and in the grinding mill. The difference in energy consumption in the kiln and grinding mill between clinker produced by an optimised flame and a poor flame can be as much as 10%. With energy being a major cost in cement manufacture (between 40-50% of production costs) a poor flame heat flux profile therefore imposes a high economic cost as well as a significant increase in atmospheric emissions.

The importance of the flame on the cement clinker manufacturing process was first recognised by Martin[1] in the late 1920s. A method of optimising the flame for an individual kiln was first developed by Moles and Jenkins[2] in the early 1970s. Early applications of this technique, dubbed Flame Control by Moles, were very successful[3]. These early techniques used empirical formula together with physical modelling. The advent of the PC in the early 1980s permitted heat transfer modelling to be included. Today, with the availability of much more powerful PCs, computational fluid dynamic modelling is also utilised.

This paper is concerned with the application of both physical and computer modelling techniques to the optimisation of combustion and heat transfer in commercial cement plants. The increasing use of these techniques leads to improved product quality, reduced fuel consumption and emissions, more stable kiln operation and improved refractory life. A section is also included on NOx and techniques to control NOx emissions.

Combustion & heat transfer modelling

Combustion and heat transfer are very complex subjects which are even today not readily amenable to rigorous mathematical analysis. Prediction of the performance of burners and combustion equipment and associated plant is therefore extremely difficult. There are essentially three choices for designing combustion and heat transfer systems:

- Guesswork.
- Simple calculations combined with the extrapolation of experience.
- Modelling of the system.

Fortunately the use of simple guesswork is probably quite rare but the majority of kiln burner systems are still designed using simple calculations with the extrapolation of experience. Since the secondary air provides most of the combustion air in cement kilns, its temperature, velocity and flow distribution has a significant effect on the performance of the burner. There are unique differences between kilns (even those of the same size and nominal design) in respect of cooler and hood, and hence secondary air temperature, velocity and flow distribution. This vital fact is largely ignored by most kiln builders and burner suppliers. It is little wonder therefore that kiln performance is often unsatisfactory, resulting in unstable operation, poor clinker quality, high fuel consumption and CO emissions, and poor refractory life.

Combustion in cement kilns

Combustion is defined as the oxidation of fuel to release heat. The objective of the combustion engineer and plant operator is to obtain a steady heat release at the required rate. The chemistry of the oxidation of hydrocarbon fuels is very complex but none of the reactions can take place until the oxygen in the air is brought into contact with the fuel. As a result, all combustion processes take place in the following stages:

- Mixing.
- Ignition.
- Chemical reaction.
- Dispersal of products.

The overall rate of combustion is dependent on the slowest of the above stages. In most industrial combustion systems, the mixing is slow whilst the other steps are very fast. The rate and completeness of the combustion process is therefore controlled by the rate and completeness of fuel/air mixing. Insufficient mixing produces unburnt CO in the flue gases, wasting fuel. For good combustion, it is necessary to ensure that adequate air is supplied and that the burner mixes the fuel and air streams effectively and efficiently, hence the combustion is controlled by the rate and completeness of the fuel/air mixing i.e. if it is mixed, it is burnt.

For kiln burners, fuel/air mixing occurs as a result of jet entrainment. Figure 1 shows a schematic of a fuel jet issuing from a burner nozzle in a rotary kiln. Momentum exchange occurs between the boundary of the jet (which is normally fuel and primary transport air) and its surroundings, causing the surrounding secondary air to be locally accelerated to the jet velocity. The accelerated air is then pulled into the jet, expanding it. This process is momentum controlled and continues until the velocity of the jet is the same as that of its surroundings. The greater the momentum of the jet, the more rapidly the surrounding secondary air is entrained into the fuel.

If the jet has momentum in excess of that required for the complete entrainment of the secondary air, recirculation will occur. A moderate degree of recirculation is a positive indication that fuel/air mixing is complete, whilst its absence is a clear indication that not all of the secondary air has been entrained into the fuel jet up to the point at which the fuel jet impinges on the kiln refractory wall. In the latter case, the production of significant levels of carbon monoxide is normal, and hot reducing gases will then be in direct contact with the coating and refractory, tending to 'wash' away the coating and causing subsequent brick failure. The recirculating gases from a high momentum flame, however, provide a 'cushion' of cooler neutral gases which prevents this direct impingement of the flame on the coating and refractory.

Since the secondary air must be entrained into the primary air and fuel jet, the secondary air flow patterns and temperature have a huge effect on the fuel/air mixing. The aerodynamics are determined by the design of the cooler and secondary air inlet system (hood) and as a result, the design of these items significantly affects the combustion in the kiln. Any effective modelling of the combustion process must take these factors fully into account.

For any given kiln, the flame length and heat transfer are determined by the fuel/air mixing rate and the quantity of excess air. Increasing either the

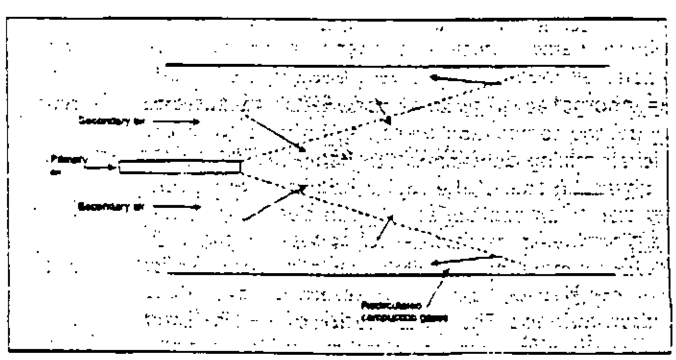

Figure 1. Entrainment and recirculation in a confined jet.

fuel/air mixing rates or excess air gives a shorter flame. The fuel/air mixing rate is dependent on the ratio of the momentum between the combined primary air and fuel jet and the momentum of the secondary air. Thus, the higher the velocity and mass flow of the primary air, the more rapid the fuel/air mixing.

Kiln operators will invariably run the kiln to provide the best product possible. If the fuel/air mixing is poor, the kiln has to be operated at a higher excess air to shorten the flame to give adequate heat transfer. Operating at a relatively high excess air is detrimental to the kiln thermal efficiency (Figure 2). This shows the relationship between the oxygen level and the measured daily heat consumption for a semi dry process cement kiln. Increasing the oxygen level in the kiln from 1% to 5% causes an increase in the heat consumption of more than 10%.

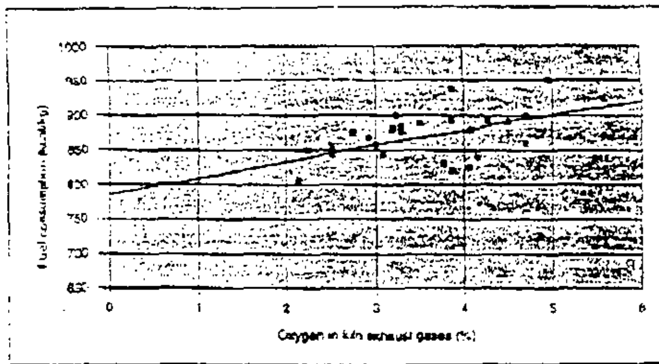

Figure 2. The effect of excess air on kiln fuel consumption modelling of combustion and heat transfer in cement kilns.

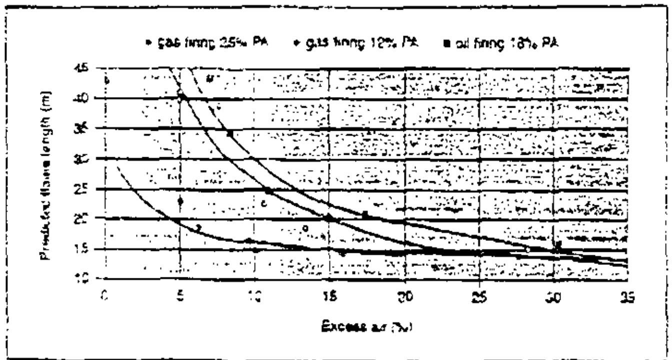

Figure 3. The predicted effect of excess air on flame length for various primary airflows

To obtain the best potential performance from any kiln, it is absolutely essential that the flame is optimised to give the best product crystal structure at low excess air. This requires that the aerodynamic characteristics of the kiln are taken fully into account when designing the burner.

Effective modelling requires that the important parameters of the process being studied are identified and represented in the model. Since it is not possible to scale nature completely, physical modelling can only give part of the answer. Mathematical modelling is similarly limited both by computing power available and the ability to describe the combustion and heat transfer process mathematically. As a result, each modelling technique represents a partial understanding of the process. The objective is to provide predictive techniques which work for real flames in real kilns and contribute to improved kiln performance. To achieve this objective normally requires the use of several modelling techniques simultaneously.

Physical modelling of flames

Despite the growth in computer modelling, physical modelling is still the most effective method for determining flame length and shape in rotary kilns. Acid/alkali modelling was developed by Sir William Hawthorne[4] at MIT as long ago as 1938 and is used to model the combustion process in rotary kilns where fuel/air mixing determines the flame characteristics. A physical model of the cooler, hood and kiln is constructed to an appropriate scale in clear acrylic plastic. The fuel is represented by dilute caustic soda solution containing phenolphthalein indicator, whilst the combustion air is represented by dilute hydrochloric acid. The concentration of the alkali and the stoichiometric ratio of alkali to acid is chosen to represent the correct air/fuel air requirement for the particular fuel. The flow of acid is adjusted to simulate different excess air levels, hence determining the relationship between flame length and excess air. The phenolphthalein becomes colourless at the boundary where the mixing is complete, thus the model flame envelope is defined by the coloured region. The aerodynamics of the full size system are reproduced on the physical model thus allowing an accurate simulation of the fuel/air mixing characteristics and hence flame length under representative conditions.

These model results have to be corrected since the model is run under isothermal conditions; whilst in the kiln, considerable changes in temperature usually occur as combustion takes place. This results in a reduction in the gas density and an increase in volume giving a longer flame in the kiln than in the model. For most practical purposes the model flame length has only to be corrected for the density changes. When the corrections are applied to the model results, a series of curves of predicted flame length against excess air are produced (Figure 3).

Heat transfer modelling

The combustion process, and its integration into energy transfer equipment design, is the most complex of all process engineering problems, requiring the simultaneous solution of heat, mass and momentum transfer. For effective modelling of combustion and heat transfer in a rotary kiln many factors must be taken into account. Rotary kiln flames are turbulent jet diffusion flames which are fortunately relatively well understood owing to the work of Thring and Newby[5], Craya and Curtet[6], and Becker[7]. Their analysis of momentum transfer in free and confined jets has yielded theories to predict the macro-turbulent entrainment characteristics for both cold and hot systems. Mathematical modelling is used for a wide range of combustion and heat transfer processes including the burnout of oil, coal and coke particles, heat transfer and the residence time and concentrations of feed and product in the process.

For heat transfer modelling, the kiln is divided into axial slices, typically 100 mm thick, and the mixing rates, combustion heat release, and radiative effects of the gases and particles calculated within each slice to determine the radiant heat transfer to the product and walls. Convective heat transfer effects are also calculated within each slice. By stepping the calculation through the system, a realistic estimate of the burnout, gas temperature, heat transfer and product temperatures can be obtained. The flame itself and the combustion products absorb, and emit, thermal radiation. Both gases and particulate material present in the flame contribute to the absorbing propensity of the flame. Within the flame, the chemical effects of the combustion process are secondary, since the reaction time constants are orders of magnitude faster than the diffusional mixing constants. Thus, the combustion process can be reduced, with a 'mixed is burnt' assumption controlling the rate of heat release. The mathematical model used by FCTI for calculating the heat transfer from flames in rotary cement kilns takes these factors fully into account[8].

Computational fluid dynamic modelling

FCTI uses commercially available CFD software packages (Phoenics, CFDS Flow-3D, Fluent) as design tools for an increasing number of flow and combustion problems, particularly problems involving materials in suspension, such as feed in a rotary kiln precalciner and the incineration of sewage sludge in a vortex combustor. In simple terms, the calculation commences by sub-dividing the solution domain into cells, thus forming the computational grid. When the grid has been constructed, the fluid properties and boundary conditions are specified. Having specified the grid, the fluid properties and the boundary conditions, discretised versions of the Navier-Stokes partial-differential equations that govern the dynamics of fluid flow, are generated internally and solved by the applicable CFD solvers. More complex systems including two phase and combustion flows are also mathematically simulated.

NOx assessments

The NOx formation in kiln flames is generally by both thermal and fuel routes (for coal, oil and petroleum coke which contain fuel nitrogen). Owing to the very high flame temperatures which occur, usually above 2000 °C, thermal NOx is generally the dominant mechanism and typically accounts for circa 70% of the total NOx emission dependent on secondary air preheat temperature. In gas fired kilns, fuel NOx is absent so all the NOx is thermal NOx. However, it should be noted that the absence of fuel NOx in gas fired kilns does not necessarily lead to a reduction in NOx emissions, since gas flame temperatures are often higher than of coal or oil. Apart from temperature, the in-flame oxygen concentration and the residence time in the high temperature zones influence the final thermal NOx emissions.

The formation of NOx is complex and still not a well understood process, consequently modelling these of the NOx formation process is still very difficult. A number of the currently available models are capable of predicting the trends of NOx formation with change in flame conditions and fuel type, but accuracy is poor and sometimes little better than orders of magnitude. Currently, the most reliable methods of predicting NOx emissions from full scale flames is by empirical scale up from test flames.

FCTI has achieved good results using the data from the test work undertaken by The International Flame Research Foundation for the Cemflam 1 consortium[9] and the main results of this work are described below. In addition, for prediction of NOx in rotary kilns, FCTI utilises a customised and modified version of the Facsimile kinetic package produced by AEA Technology. The programme used by FCTI utilises the package to solve full combustion and NOx chemistry superimposed on a platform of a thermal and mixing field determined from FCTI's physical, heat transfer and CFD complementary modelling. These complementary modelling techniques allow acceptable NOx predictions to be made in any combusting environment. To date results have been encouraging, with predictions of NOx emissions from an existing coal fired 'dead burned' dolomite kiln being within 10% of measured values and predictions for a petroleum coke fired pre-cal-

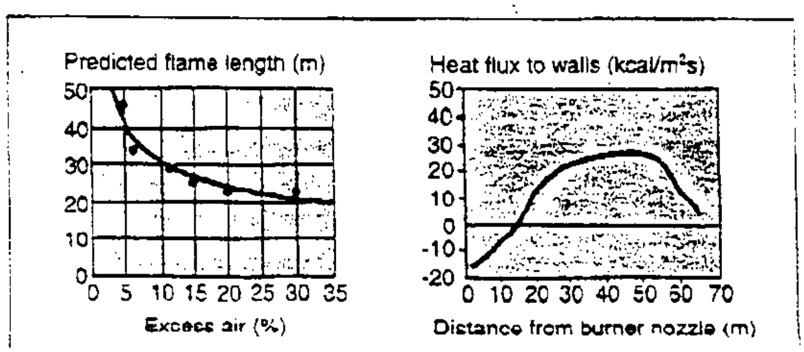

Figure 4. Flame lengths and heat flux profiles for existing combustion conditions (original burner 11% PA (cold). Left, effects of excess air on flame length, right, wall heat transfer prediction.

either being marginally high. Further validation of this programme over a broad range of combustion processes is currently in being undertaken by FCTI.

Validation of modelling

Although it is possible to produce a predictive method, it is difficult to ensure that its predictions are correct i.e., in agreement with experimental observations. Consequently, considerable effort has been made by FCTI to 'validate' these computer models. The method involves making detailed comparisons between predictions and experiments; to interpret whatever discrepancies are discovered in terms of computational inaccuracies, inadequacies of assumptions, and imprecisions of measurement; and then to implement improvements which result finally in the reduction of the discrepancies to acceptably-small values. To date, FCTI's computer models have been sufficiently validated for designers and operators of equipment to use reliably.

Application of modelling techniques to real kilns

Modelling can be used to solve problems with existing kilns, optimise the performance of existing kilns, assess the effect of fuel or other process changes in advance of the changes being made or optimise the design of new plant. FCT uses modelling for all these purposes. Typically more than one modelling technique is used for a particular application because each technique provides only part of the answer required. Within the kiln itself, acid/alkali modelling is used to simulate the combustion whilst the zone method of heat transfer is used to predict heat transfer from the flame to the product. For flash calciners, both techniques can be used together with CFD modelling of the particle trajectories and residence times.

The major benefits are reduced costs and increased profits for the kiln operator with reduced environmental impact. The former is attributable to reduced fuel consumption, improved refractory life, and shorter downtime, with potentially greater sales resulting from longer production runs and improved product quality. The reduced emissions are the result of reduced flue gas volumes and less unburnt fuel. A few examples are now described.

Kiln conversions to gas firing

FCTI first applied these techniques to lime kilns over ten years ago during the conversion of a lime kiln in Cheddar Gorge, UK, to gas firing. The first cement application came a year later with the conversion of Cockburn Cement's kilns in Western Australia to gas firing. Cockburn Cement operates three cement kilns and two rotary lime kilns. Four of the kilns at Cockburn Cement had originally been oil-fired and then converted to coal using a very difficult local coal. The coal firing systems were designed using Moles and Jenkin's Flame Control Techniques in 1981. The initial conversion to gas firing was undertaken using the traditional technique of simple calculations combined with the extrapolation of experience. Whilst these burners were satisfactory in the two smaller cement kilns, they presented serious problems with regard to product quality on the largest cement kiln and on one of the lime kilns. FCT was called in and asked to assist with identifying and resolving these problems and designing a burner for the second lime kiln. Acid/alkali modelling of the combustion and mathematical modelling of the heat transfer was undertaken for both kilns and new burners designed and successfully installed.

Product quality improvements

Adelaide Brighton Cement operated a gas fired preheater kiln rated at 2000 tpd using a high velocity gas burner without primary air. The plant management used the Ono method for assessing burning conditions in the kiln and this indicated a slow rate of heating of the charge. The kiln flame was modelled using the acid/alkali technique which confirmed a long slow mixing flame (Figure 4). Heat transfer modelling confirmed a flat heat flux profile consistent with large crystals and high proportion of glass phase.

Improving the heat flux profile by better fuel air mixing is a matter of increasing the burner jet momentum relative to the secondary air momentum. With the maximum gas velocity already in use this could only be achieved by adding some primary air to the burner, hence increasing the overall mass flux of the burner jet. To achieve the most suitable flame length and heat flux profile the flowrate and velocity of this primary air has to be optimised. This is essentially a trial and error technique with the equivalent of various primary air flows and velocities tried on the acid/alkali model. This is a time consuming business but much quicker than a similar trial and error exercise on the full size kiln! Once conditions are optimised, the heat transfer model is used to assess the heat flux profile. The modelling confirmed that improving the mixing by using some primary air would produce considerable benefits in terms of flame length excess air and heat flux profile (Figure 5). A suitable burner was designed and installed.

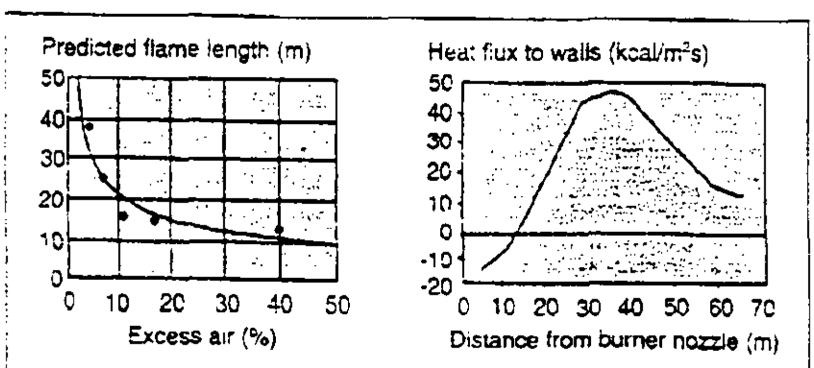

Figure 5. Flame lengths and heat flux profiles for optimised combustion conditions (optimised burner 7% PA (hot), left, effects of excess air on flame length; right, wall heat transfer prediction

Following commissioning of the new burner, there were several significant improvements in kiln operation including improved stability, better coating and improved clinker quality. CO emissions and specific energy consumption were reduced and the clinker was also easier to grind.

Precalciner conversion modelling

Later this kiln was converted to a precalciner kiln and the new kiln process conditions modelled. Operation in precalciner mode requires lower primary air flowrates and velocities than preheater mode for optimum performance. Modelling also played an important role in the design of the calciner with acid/alkali modelling used to determine the optimum position for the burners. In more recent times CFD modelling has been used to study the particle trajectories, concentrations and residence times in flash calciners[10] and to optimise these by suitable adjustments to the feed inlet position and velocity. These techniques result in improved output for existing units.

Waste fuels and multiple fuels

The modelling techniques outlined above can cope with multiple fuel firing. Hence waste derived fuels can be effectively utilised with minimum disruption to both the kiln and environment by the use of modelling to ensure that the fuel/air mixing is excellent. This allows unburnts to be minimised whilst optimising the heat flux profile produced by the combination of waste and main fuel firing.

NOx formation in rotary kilns

The formation of NOx in flames is generally by both thermal and fuel routes (for coal, oil and petroleum coke and other fuels containing fuel bound nitrogen). The total NOx emission is always made up of contributions from both sources. The dominant source, however, is dependent on the amount of nitrogen contained in the fuel and the flame temperature with the latter being highly dependent on secondary air preheat temperature and the thermal requirement of the material being processed. Secondary air temperatures can vary from ambient in the case of petroleum coke calcination to in excess of 1100 °C for the production of cement clinker. Dependent on the process, reactions can be exothermic or endothermic or the process may merely require the material in the kiln to be heated to a pre-specified temperature. If NOx emissions are an issue for a particular process, the dominant source of NOx in the flue gases must be identified if the appropriate NOx reduction technology is to be employed to facilitate its reduction without compromising the process thermal requirements. In the cement industry specifically, with the kiln fired with solid or liquid fuels, very high flame temperatures occur, i.e. above 2200 °C, and thermal NOx is generally the dominant mechanism accounting for between 60 and 70 % of the total NOx appearing in the flue gases.

In gas-fired plant, by contrast, fuel NOx is absent so all the NOx is thermal NOx. However, it should be noted that the absence of fuel NOx in gas fired plant does not necessarily lead to a reduction in NOx emissions, since flame temperatures are often higher.

NOx formation mechanisms

Thermal NOx is formed by the combination of atmospheric nitrogen and oxygen at very high temperatures. The high temperatures are required because of the high activation energy of the reaction, due particularly to the energy required to break the bond in the nitrogen molecule. The reaction is therefore highly temperature dependent. The reaction takes place between oxygen radicals, nitrogen radicals and molecular nitrogen and oxygen in the Zeldovich reaction couple. Apart from temperature, the in-flame oxygen concentration and the residence time in the high temperature zones influence the final thermal NOx emissions.

Most fuels, other than gas, contain nitrogen bound as organic compounds in the fuel structure. When the fuel is burnt, this organic nitrogen becomes converted into a range of cyanide and amine species which are subsequently oxidised to NOx, depending on the local oxygen availability, but this mechanism is less dependent on temperature.

A third mechanism of NOx formation has been identified by some workers which involves the fixation of nitrogen by hydrocarbon compounds in fuel rich areas of the flame. This mechanism is known as prompt NOx. The formation mechanisms of prompt NOx, thermal NOx and fuel NOx are described in more detail below.

Thermal NOx

The common approach for explaining the formation of thermal NOx is to base the theory on two basic Zeldovich reactions:

$$O + N_2 \frac{k1f}{k1b} = NO + N$$

$$N + O_2 \frac{k2f}{k2b} = NO + O$$

K1f is strongly dependent on the local temperature. N_2 and O_2 are traditionally set to the equilibrium conditions at the prevailing temperature but in coal flames the temperatures are probably too low for this equilibrium assumption to be valid for N_2 and it is virtually impossible to measure O using currently available techniques.

The above is a limited and greatly simplified approach to the theory of thermal NOx formation and is included to allow an appreciation of the complexity of the theory and the difficulty of making theoretical predictions of thermal NOx emissions. Figure 6 shows the extreme temperature dependence of thermal NOx formation.

Fuel NOx

Fuel NOx is generally associated with coal or petroleum coke combustion which contain nitrogen chemically bound within their structures, and to a lesser extent with oil. Most studies on fuel derived NOx have been performed on coal and the main focus of this section is related to fuel NOx derived from coal combustion. The mechanisms by which NOx is formed from the chemically bound nitrogen in coal is extremely complex, even the structure of the nitrogen in the coal is subject to considerable conjecture. The nitrogen is believed to be in the form of pyridine, pyrrol and amine type structures (Figure 7). The actual structure in any coal or oil is believed to be strongly dependent on coal type or the origin of the oil. The predominant forms of nitrogen in most coals are the pyrrolic and pyridine forms and that the former tends to decrease with increasing coal rank. However, at present, the importance of the structure of the nitrogen in the coal on the final NOx emissions is not well established.

When coal is burnt in suspension, as in rotary kilns, it is heated very rapidly to high temperatures and pyrolysis occurs, producing solid and gaseous products. The nitrogen present will divide between these with typically 20% of the nitrogen in the char and 80% in the gaseous phase, the latter both as the light fractions and tars. For any coal, the distribution of nitrogen between the gaseous phase and char is heavily dependent on the conditions in the flame such as heating rate, peak temperature, and residence time at high temperature.

A simplified NOx formation path is shown in Figure 8. Most of the gaseous nitrogen pyrolyses either directly or indirectly to HCN. This complex process is not instantaneous but dependent on the conditions in the flame. The HCN then oxidises to NO (Figure 9) with this reaction being both temperature and time dependent (Figure 10).

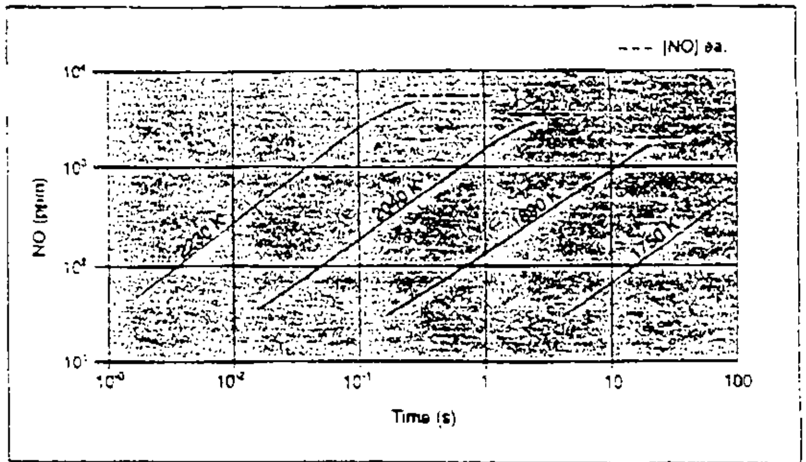

Figure 6. Dependence of thermal NOx formation rate on temperature.

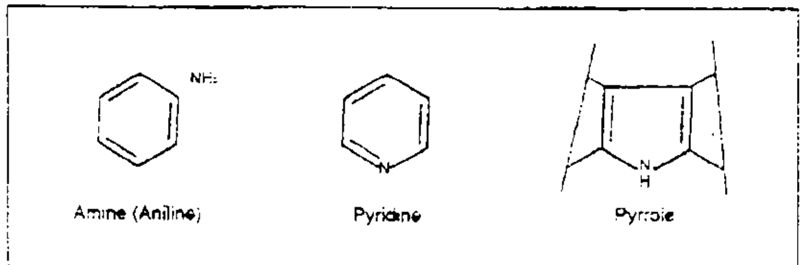

Figure 7. Characteristic forms of nitrogen in coal.

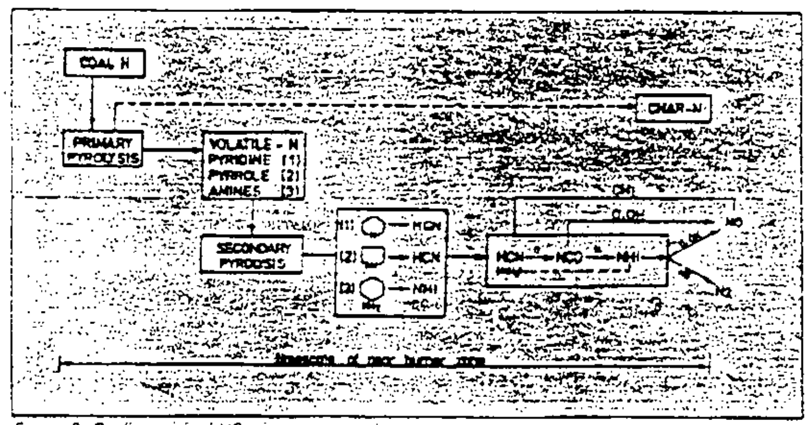

Figure 8. Outline of fuel NOx formation path.

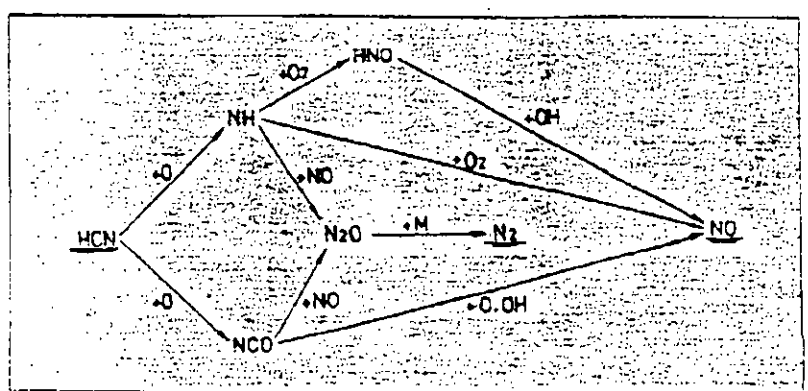

Figure 9. Mechanism for conversion of HCN to NO in flames

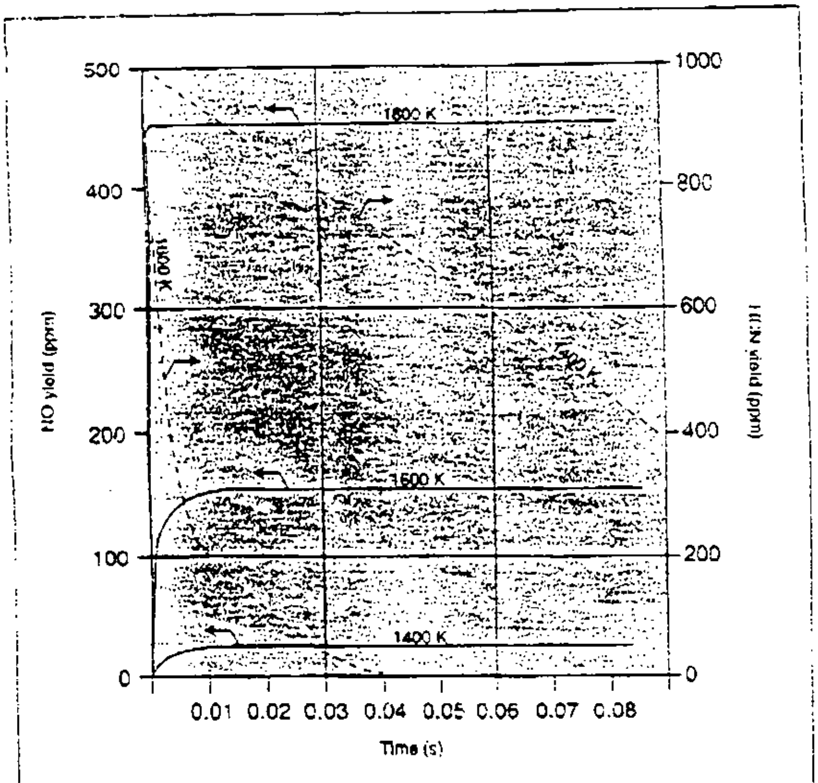

Figure 10. Effect of temperature on the rate of conversion of HCN to NO in flames.

Prompt NO

In low temperature, fuel rich flame zones, NO is found to form more rapidly than predicted from considerations of the thermal NO mechanism. The difference is due to the so called 'Prompt NO' formation mechanism. Prompt NO is formed by the rapid fixation of atmospheric nitrogen by hydrocarbon fragments. The following reactions are formed:

$CH + N_2 = HCN + N$

$C + N_2 = CN + N$

NO is subsequently formed from the oxidation of the nitrogen atom:

$N + O = NO$

HCN and CN also react to form NO by reactions important in the fuel nitrogen conversion mechanism.

Prompt NO is formed in all combustion systems but its contribution to the total NOx emission is combustion system and fuel dependent. In cement kilns, its contribution to the total NOx is negligible.

To control NOx emissions it is important to identify the dominant source during the combustion process. If thermal NOx is dominant, reduction in flame temperature is required or reduced residence time at high temperature in the flame gases. However, this may compromise process requirements. If fuel NOx is dominant, manipulation of the fuel air mixing, creating fuel rich zones (restricting oxygen availability during volatiles combustion) where fuel bound nitrogen can react to molecular nitrogen as opposed to NOx, offers significant potential. Work performed within the aforementioned Cemflam research programme at the IFRF[a] demonstrated a very important feature of rotary kiln flames. Dependent on burner type, primary air momentum and primary air percentage, a distinct ignition delay is generally observed before the flame is initiated. During this pre-ignition period, secondary air is being entrained into the primary air/fuel jet. The greater the ignition delay distance, the greater the amount of air entrained into the fuel jet prior to ignition. This results in higher flame temperatures resulting in increased thermal NOx formation and a more oxygen rich flame environment with consequential more effective conversion of fuel bound nitrogen to NOx. Experimental results confirming this effect is shown in Figure 11, where NOx levels are plotted against calculated amount of air entrained into the fuel jet at the point of ignition. FCTI are actively exploiting this phenomenon in the design of low NOx rotary kiln burners.

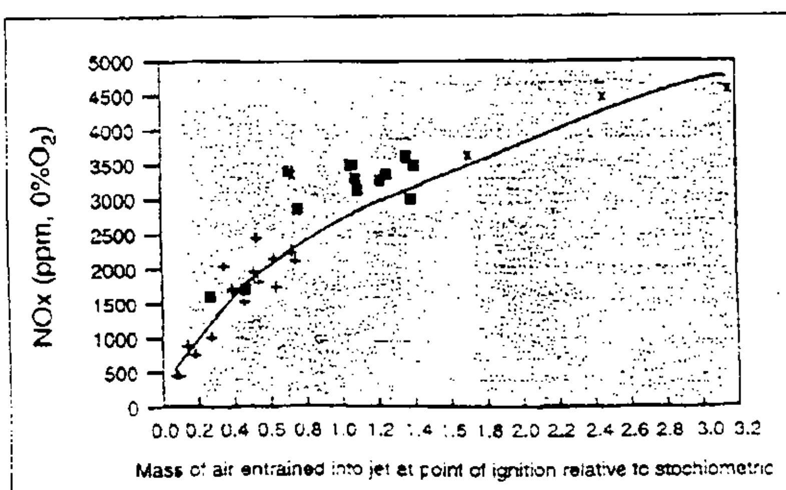

Figure 11. NOx emissions as a function of the amount of air entrained into the fuel jet at the point of ignition relative to stoichiometric (800 °C air preheat).

Future direction

With over two hundred examples of the aforementioned modelling techniques successfully applied to a wide range of real plants over the past 15 years, the authors have considerable confidence in the use of these techniques. Much of the future emphasis of FCTI's work will be directed towards NOx reduction whilst maintaining and improving predictability and product quality.

Conclusion

- The success of the modelling process is more dependent on the engineer's skill at interpreting the plant data and determining the relevant modelling techniques to use, than the elegance of the techniques themselves.
- Only engineers adequately trained in modelling generally, and computer modelling of combustion in particular, can be used to 'operate' these models.
- One technique used alone rarely offers sufficient information to provide a reliable solution. Engineers using modelling must therefore be skilled in the use of all the methods so that they do not favour the use of one technique above the others in possibly unsuitable circumstances.
- The users and designers of combustion equipment have tasks to perform of such magnitude that failure is not to be contemplated. No one should be willing to employ predictive means which have not been validated and in which they do not have complete faith.
- A thorough understanding of the various NOx formation mechanisms in combination with a detailed knowledge of the combustion process and the thermal and chemical interactions with the material being processed in a rotary kiln is necessary to design an effective low NOx combustion system.

References

1 MARTIN, G., *Chemical engineering and thermodynamics applied to the cement rotary kiln*, The Technical Press, London 1932.

2 MOLES, F.D., *The elements of flame control in rotary kilns*, Rock Proc. Conf. 1986.

3 MULLINGER P.J., *Energy Saving at South Ferriby Cement Works*, 2nd AFCM Technical Symposium, Manila, Philippines, 1981.

4 HAWTHORN, W.R., *Mixing of gas and air in flames*, PhD Thesis, MIT, Mass, 1938.

5 THRING, M.W. AND NEWBY, M.P., *Combustion length of enclosed turbulent flames*, 4th International Symposium on Combustion, 1953, pp789-796.

6 CRAYA, A. and CURTET, R., 'On the spreading of a confined jet', *Comptes-Rendus Acad. des Sciences* 241, 1955, pp 611-622.

7 BECKER, H.A., *ScD Thesis*, MIT, Mass 1961.

8 MOLES, F.D. AND JENKINS, B.G., 'Modelling of heat transfer from a large enclosed flame in a rotary kiln', *Trans. I. Chem E.*, Vol. 59, 1981, pp17-25.

9 VAN DEN KAMP, W.L., AND SMART J.P., The effect of burner design and operation and fuel type on the properties of the cement kiln flame, *IFRF Doc F97/y/1*, 1992.

10 BERTRAND, C., *The use of mathematical modelling in the optimisation of flash calciner design*, 2nd International Kiln Association Conference, London 1991.

Enquiry no: 2