HOT FLOW LIME KILN MODELING

1) REQUIRED INFORMATION FROM MILL

a) *Kiln Geometry and Material Properties. We require dimensioned drawings of the kiln including:*

- Barrel with lining structure (shell, brick, etc). Density and thermal conductivity of each material. Chain configuration. Barrel tilt and rotation direction/speed.
- Average mud depth
- Dam
- Hood including location and size of all airports, leakage openings, coolers, etc.
- Detailed burner drawings including position in kiln and off-axis tilt.
- DNCG/NCG lance size/location

b) *Operating Parameters*

- Fuel flow rate, temperature, density, elemental chemical composition, heating value
- DNCG/NCG flow rate, temperature, density, elemental chemical composition, heating value
- Primary Air (burner air) flow rate and temperature
- Secondary (hood/cooler) air flow rate and temperature
- Leakage air flow rate and temperature (can be estimated by specifying induced draft and leakage openings)
- Lime feed rate
- Average residence time
- Initial mud composition (solid content, $CaCO_3$, inert material, …)
- Lime properties (density, specific heat)

Information in 1a) and 1b) can be gathered in conjunction with the mill or can be taken from previous kiln surveys. In any case PSL spends as much time as it takes to ensure that accurate data is supplied to the model.

2) ADDITION INFORMATION REQUESTED FROM MILL

- Exit emissions (CO, O_2, NOx, TRS,…)
- Shell temperature distribution
- Degree of mud calcination
- Mud exit temperature

3) INFORMATION PROVIDED BY PSL'S ANALYSIS

a) *For each unique set of operating parameters (termed a 'case') the model provides the following:*

- Detailed (at >100,000 points in the kiln) air/combustion gas velocities; distributions of temperature, chemical species (O_2, H_2, N_2, CO, CO_2, NO_x, CH_4, H_20, …)
- Exit emission (CO, O_2, NOx, TRS,…) distributions and averages
- Heat flux, to/from wall/gas/product
- Shell temperature distribution at each layer
- Calcination profile
- Heat release profile

- Three dimensional flame shape
- Air/Fuel flow animations showing primary/secondary air/fuel mixing, DNCG/NCG combustion and interaction with normal kiln operation
- Fuel solids particulate tracking. Amount and state of material combusted to gas phase, amount/state/location of material landing on walls/product.

b) By analyzing the above information for various cases we can deduce the effect of hood shape, hood ports, leakage air, primary/secondary air ratio, burner type/angle/settings, fuel type/load, excess air, NCG/DNCG injection, and other operating parameters on:

- Fuel/air mixing and combustion.
- Flame shape
- Shell temperature distribution
- Heat release profile
- Calcination
- Unburned fuel solids landing on walls/product
- Emissions

All information compiled in the analysis is provided to the client in a written report. A companion CD includes a copy of the report in Microsoft Word 97 format and a series of process 'animations' showing air/fuel flow/mixing, DNCG/NCG burning, and fuel solids particulate tracking in QuickTime movie format. All model input/output data files are provided on the CD upon request

4) PROCESS TRAINING

PSL has developed a set of advanced process simulation software that is used in conjunction with the data compiled from the modeling. This system allows users to interactively change operating conditions and view the results in an intuitive, user-friendly, three-dimensional virtual environment. Operators can be better trained in substantially less time than through traditional methods. When control system data matches or is close to modeled results, the system can provide real-time visual and analytical feedback of process operations.

5) CONTROL AND SIMULATION

Any or all of the information compiled in 3) can be used to improve process control logic. The complete set of information is stored and can be used concurrently or later date to help develop control algorithms. As a basis, PSL can compile this information in whatever format is required by the control algorithms, such as regression curves, neural network coefficients, or other interpolation methodologies. If necessary, additional cases can be computed at some future time to help tune the control algorithms. This is done without the re-incurring the costs of 4a) above. PSL will work with or can subcontract process control specialists to develop the necessary data sets.