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Lime Kiln Optimization at Irving Pulp & Paper

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Introduction

The rotary lime kiln at Irving Pulp and Paper in St. John, New Brunswick is an essential part of the plant's operation. Its purpose is to convert mud ($CaCO_3$) to lime (CaO) for reuse in the process. Kilns face many operational challenges including greenhouse gas emissions, fouling, high energy costs and inefficient operations. Many of these problems are caused by poor temperature control resulting from long process dynamics and variations in raw material quality.

This paper presents the work done at Irving Pulp and Paper to stabilize the process. The firing end temperature (FET) is predicted 2 hours in advance to provide operators with a guidance tool for making process changes. The model was placed online using ProSensus's first version of ProMV Online. Flame stability and residual calcium carbonate prediction are also discussed.

Method

Available Data

A partial least squares model is built using both flame images and process variables to predict the firing end temperature several hours into the future. The kiln is equipped with a cutting edge, air cooled, digital camera that has seamless recording capacity. An example of a flame image is shown in Figure 1.

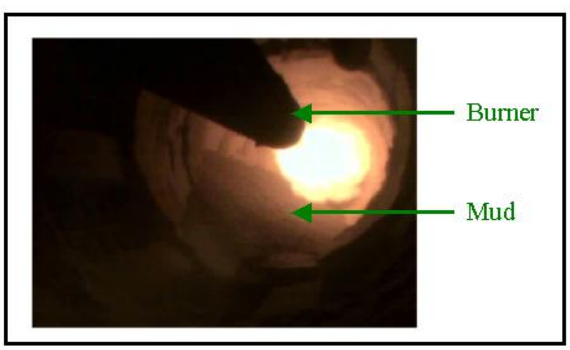

Figure 1: Typical Flame image

Process measurements that were used include the manipulated variables (fuel flow, air flow and mud flow) as well as the important response variables (firing end temperature, residual $CaCO_3$). Features are extracted from the images and combined with process data to create a model to predict FET 2 hours into the future.

Multivariate Image Analysis

Multivariate image analysis methods [2], namely masking in the score space, were used to extract features from the images.

Designed Experiment

The data was collected using a designed experiment (DOE) where changes in the manipulated variables were suggested. As a result of the DOE, only 4 days of images had to be analyzed as opposed to many months had the DOE not been performed.

Accounting for process dynamics

Since there are long dynamics in the process, this had to be accounted for to create an accurate model. The calculated dynamics were applied to both process data and images in order to obtain a reasonable model.

Results and Discussion

Flame Stability

A potential use of the images is to study flame stability and flame length. A stable flame will reduce fouling in the kiln and prevent long, costly shutdowns. From the features extracted from the images, it is possible that flame length could be inferred.

FET prediction

Once the flame image features and manipulated variables were filtered for the dynamics, PLS models were built using these data. Figure 3 shows the resulting prediction of firing end temperature, 2 hours in advance. This is a very good model, considering it is predicting 2 hours in advance.

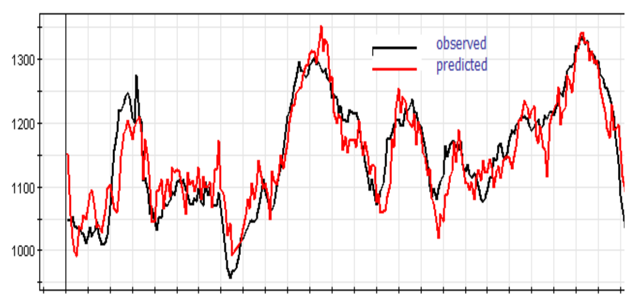

Figure 3: FET prediction, 2 hours in advance

Residual CaCO3, another important quality parameter, is strongly correlated with firing end temperature, thus there is no need for two models. The relationship is shown in Figure 4. This quality indicator is currently a manual, error-prone measurement, thus having a prediction from the PLS FET model is of great interest.

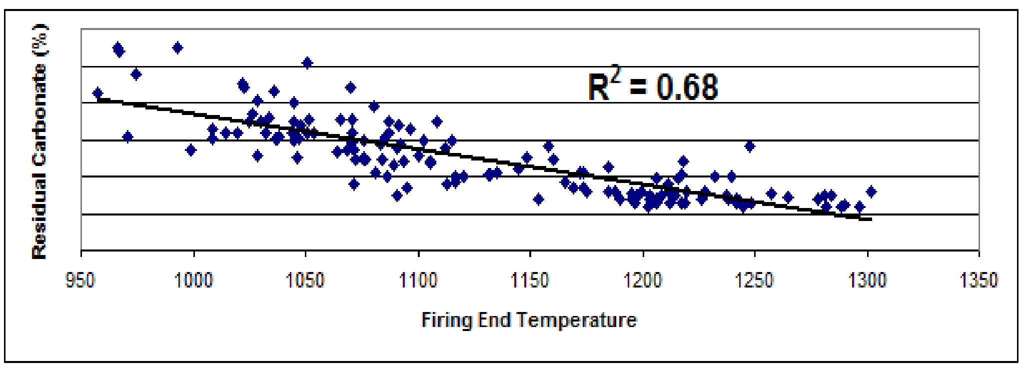

Figure 4: relationship between FET and Residual CaCO3

Online Implementation

While online implementation was hampered by major process changes (change in fuel type) and image stability due to dusting, the FET model was successfully placed online using ProMV Online. The purpose is for it to be an advisory model for the operators. In the past, one of the reasons for temperature fluctuations was as a result of too many changes made by operators. The goal is that if the operators see that the FET is predicted to be reasonable in 2 hours there would be no need to make a process change, preventing unnecessary fluctuations. Likewise, if there is a large temperature change being predicted, the operators could make a change to one of the manipulated variables.

References

1. Cardin, Marlene. (2009). *Inferential Models for Combustion Processes,* Ma.Sc Thesis, Department of Chemical Engineering, McMaster University, Canada.
2. Bharati, M. (2002). *Multivariate Image Analysis and Regression for Industrial Process Monitoring and Product Quality Control*. PhD Thesis, Department of Chemical Engineering,McMaster University, Canada.
3. Marlin, T. E. (2000). *Process Control - Designing Processes and Control Systems for Dynamic Performance, 2nd Edition*. McGraw Hill.

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