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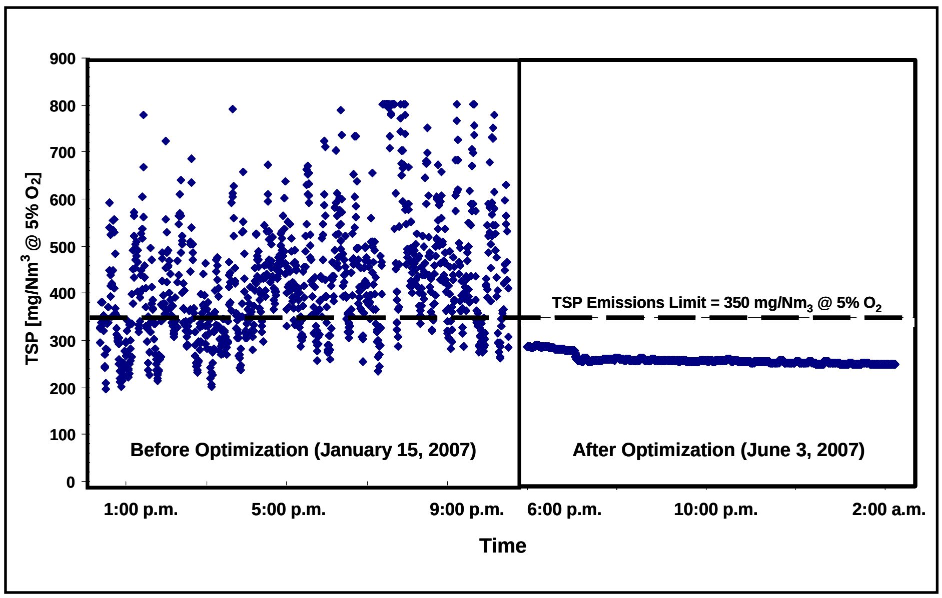
USING COMBUSTION OPTIMIZATION TO SOLVE OPACITY PROBLEMS AT AN OIL-FIRED BOILER

The combustion optimization process is used widely by U.S. power generation companies to find the boiler control settings which result in the lowest NO_x emissions or the best heat rate. Up to now, combustion optimization has typically been applied to coal-fired units, but a recent project carried out by the Energy Research Center at a large oil-fired unit shows that combustion optimization can also be used to reduce stack emissions in oil-fired boilers.

The project was carried out in Mexico at PALM Unit 1, a 350 MW unit with an opposed wall-fired boiler which fires a 3 to 4 percent sulfur heavy fuel oil. Project funding was provided by the Mexican Federal Commission of Electricity (FCE) and CONACYT, the Mexican equivalent of the National Science Foundation. The Lehigh team, led by Dr. Carlos Romero, was supported by engineers from the Mexican Center of Engineering and Industrial Development and FCE's Laboratory for Testing Equipment and Materials. Other members of the Lehigh team included Drs. Harun Bilirgen and Nenad Sarunac, Messrs Zheng Yao and Ricardo Moreno.

PALM Unit 1 had historically experienced high opacity levels which resulted in periodic exceedances of the total suspended particles (TSP) emissions limit. The objectives of the project were to eliminate opacity exceedances (or equivalent TSP exceedances), control NO_x emissions and reduce heat rate.

Romero explains, "Like some oil-fired units in the United States, PALM Unit 1 is not equipped with any means of capturing suspended



Variation of measured values of total suspended solids, both before and after combustion optimization.

particulates. It depends on efficient atomization and the proper combustion conditions to avoid excessive levels of particulate emissions. Our task, on this combustion optimization project, was to determine how the oil atomization, combustion efficiency, suspended particles at the stack, heat rate and NO_x are related to atomization pressure, oil temperature, excess air level, air register settings and flue gas recirculation. Once we had established the relationships between the parameters, we were able to determine which combinations of boiler control settings reduce the likelihood of opacity exceedances, while limiting NO_x emissions and reducing unit heat rate."

Romero continues, "We did this by performing a series of parametric boiler tests in which the important controllable combustion parameters were varied one-by-one. We then used neural networks to develop mathematical relationships between total suspended solids, NO_x and heat rate and the independently controlled boiler operating parameters such as oil temperature, oil atomization pressure, level of excess air and degree of flue gas recirculation. Finally, an optimization algorithm was used to determine the combinations of boiler control settings which result in the lowest heat rate, while maintaining NO_x emissions and TSP levels below the regulatory limits."

Bilirgen adds, "Our test data showed that the two most important parameters are atomization pressure and excess oxygen. The rate of flue gas recirculation is next in importance and the least important are fuel temperature and the air register settings for the combustion air. The mathematical relationships we developed from the test data using neural networks established how the various parameters depend on one another. The optimization calculations then showed what combinations of operating parameters give the best performance and lowest emissions."

Sarunac adds, "We also developed advisory software for use by the plant operators. Through a link to the data acquisition system, the software has access to instantaneous on-line values of the important measured parameters. Using this information along with the optimal control settings determined from the field test data, the software provides continuous information to the operators on recommended and actual settings, deviations between expected and actual emissions and key parameters such as the burner nozzle cleanliness level and oil viscosity."

Romero concludes, "The project was completed in April of 2007 and the plant staff has been operating the unit since then based on the recommendations from the advisory software. The results show that the optimized unit can operate comfortably below the TSP limit. Changes in boiler operating settings which lower TSP also increase NO_x, and, as a result, the reduction in TSP has been accompanied by a small increase in NO_x, but not above the limit for NO_x. The data also show that the new settings yield an optimal level of excess oxygen and result in steam temperatures at the design levels and greatly reduced flow rates of attemperating spray. These last three changes combine to cause a reduced heat rate. We are in the process of analyzing the data to quantify the actual level of heat rate improvement.

We know from speaking with our Mexican partners that the ability to operate PALM Unit 1 while meeting the Mexican TSP limits has made a huge improvement to the plant's operations. We've also been told that, as a result of the success of this project, the Federal Commission of Electricity is planning to perform similar combustion optimizations on the sister unit to PALM Unit 1 and also on one of its coal fired units in Mexico." ■

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