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Boiler performance and cost analysis of fuels and fuel blends using the *Fuel Quality Advisor*

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ABSTRACT

Fuel quality is one of the most critical variables in determining the heat rate, efficiency, and performance of power plants. The drive to leverage fuel switching and/or blending to meet more stringent SO_2 and NO_x emission requirements has, in many cases, led to both a reduction in power station efficiency and a poorer net plant heat rate (NPHR). In addition, fuel switching and/or blending can lead to a significant reduction in operating margins and increase the risk of unit derates. To maintain boiler efficiency and performance, there is a strong incentive to manage or mitigate this risk. A first step in evaluating fuel options is using the spreadsheet-based *Fuel Quality Advisor*. The *Advisor* incorporates fuel quality information, furnace operating conditions, as well as some basic furnace design information to estimate the maximum boiler load potential, fuel cost/MWh, deposition tendency, mercury compliance, ash resistivity, corrosion potential, and backpass erosion potential.

The basics of the *Fuel Quality Advisor* have been presented earlier; this paper presents results from a major US utility who used the *Advisor* to evaluate over 70 fuels and fuel blends for 10 of their larger coal-fired boilers. Combining the estimated performance from the *Fuel Quality Advisor* with actual operating experience using the new fuels or fuel blends has permitted the *Advisor* to be tailored to each specific unit — thus increasing the reliability of the estimations. This paper discusses the use of the *Fuel Quality Advisor* by the utility as well as several of the resulting estimations and comparisons to actual operations.

1 . Introduction

Ash deposition is a major issue in the utility industry especially, with the switch from design coals to less expensive coals and the use of opportunity fuel blends. Devir [1] states that "slagging costs the global utility industry several billion dollars annually in reduced power generation and equipment maintenance." In addition, an EPRI study on the U. S. utility industry estimated that fuel quality and deposition accounted for well over $1.2 billion annually in lost revenues [2,3]. A joint EPRI/DOE publication on guidelines for solving ash deposition problems [4] offers an excellent discussion on deposition occurrences and provides some general economic impacts. Given the nature of today's power markets, the precise cost of poor fuel quality is station specific and depends on market conditions and utility-specific economic drivers.

As the quality of fuel to a boiler changes due to factors such as coal pricing, mine closures, environmental regulations, and market structure, boilers and boiler operators are plagued by poor or marginal operating performance. While general improvements to boiler performance have been made, the need to address fundamental fuel quality issues and how they affect deposition, corrosion, emissions, handling, and combustion is still relevant. Coal quality differences at the burner, as a result of coal yard practices and/or the inability to blend coals, may result in unforeseen boiler derates or outages. The need to burn a coal or a blend of coals not originally meeting the design specifications for a boiler may also contribute to derates and outages due to deposition and corrosion [3].

As part of an EPRI study [2], a questionnaire was sent to personnel intimately involved with boiler coal quality issues from 30 different member utilities soliciting their insights into their most important coal quality concerns. The results are shown in Fig. 1. It is interesting to note that each of the 24 performance categories received at least one mention as a coal quality concern. This demonstrates the wide range of issues that are affected by fuel quality at a power plant.

As shown in Fig. 1, slagging dominates as the most important coal quality issue facing the utility respondents, followed by fouling and fuel blending. This is not surprising since changes in fuel quality affect furnace deposition and lead to ash-related problems in many areas of the boiler.

To address this issue, a screening method has been developed to provide guidance to utility personnel on fuel selection and optimal blending. This screening tool, the *Fuel Quality Advisor*, is based on a combination of fuel quality, specific boiler parameters, operating conditions, and literature correlations. It is meant to be used as a quick method to evaluate multiple fuels and fuel blends and rule out further testing of those that are predicted to be the most troublesome at the specific

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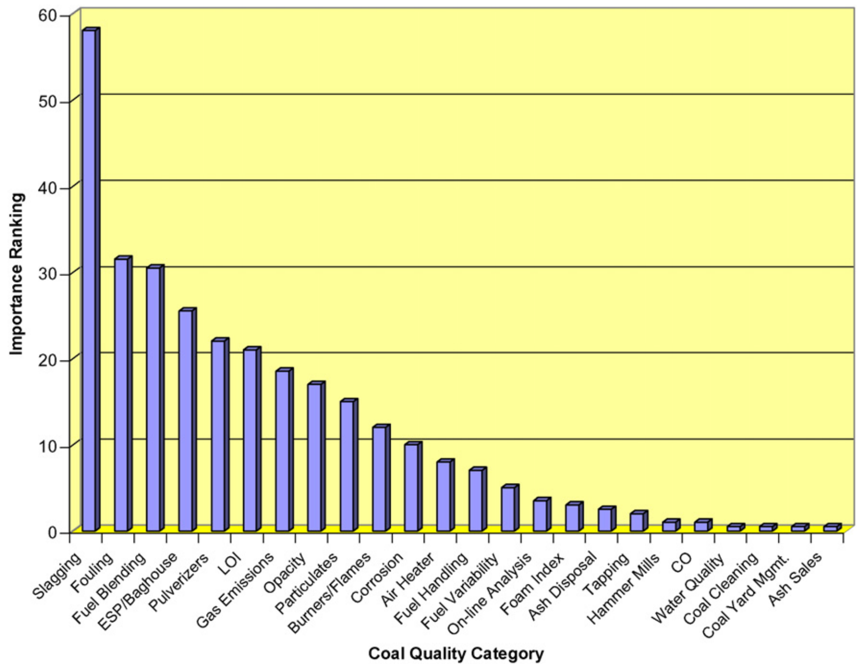

Fig. 1. Coal quality concerns in power industry from EPRI study [2].

site. The *Fuel Quality Advisor* is spreadsheet based and is used to evaluate various areas where fuel quality might affect boiler performance. Currently the *Advisor* incorporates the following evaluation parameters:

- Slagging
- Fouling
- Mercury capture
- Mass/Energy balance
- Viscosity estimations
- Precipitator performance
- Mill limitations/Maximum load
- Coal delivery cost/MW-hr

Details of the basic *Fuel Quality Advisor* are provided in the Appendix A and in a previous report [5,15]; only an overview is presented here.

2 . Methods

To develop the *Fuel Quality Advisor*, the literature was reviewed for combustion performance correlations based on fuel composition and other boiler/operating parameters specifically for the areas of interest noted above [6–13]. Using these correlations, estimates were made regarding boiler performance. These estimation techniques have been developed to provide insights into predicted boiler performance at a reduced cost when compared to full-scale testing. However, because these parameters are based on multiple coals, all boiler types, and various firing and operating conditions, they are not exact for any one specific unit. The risk is high in blindly accepting these results. Fig. 2 compares the confidence/risk of using different fuel evaluation techniques as a function of cost. As shown, the risk is very high in using only literature parameters (ASTM), but the cost is very low. On the other extreme are full-scale demonstrations—the risk is very low since the test was performed in the actual boiler, but the cost is considerably higher.

The goal of the *Fuel Quality Advisor* is to provide the greatest amount of confidence in the estimated performance results at the lowest costs. When there are many potential fuels and/or blends available for a specific boiler, the *Fuel Quality Advisor* can be successfully used to eliminate those fuels that consistently show poor performance based on multiple parameters. For example, twenty fuels or fuel blends can be evaluated in a matter of minutes and only those that are estimated to have adequate or high performance tendencies based on the results of the *Fuel Quality Advisor* runs can be evaluated further.

The *Fuel Quality Advisor* is made up of several spreadsheets containing detailed calculations. A summary of the overall predicted boiler performance and fuel cost is shown in Fig. 3. As noted, there are twenty potential fuels for this boiler; and the figure presents the predicted results of a 70/30 blend of Fuel 3 and Fuel 6. In addition to the estimated performance summary, the *Advisor* overview sheet shows the tonnage of each fuel needed to meet the full load condition, the cost of that fuel, whether there are mill limitations with the fuel, a NO_x emissions factor, and sulfur, mercury and ash loadings to the boiler. This sheet provides the use with a quick overview of estimated performance and cost information for the fuel(s) being evaluated.

The inputs to the *Advisor* begin with an initial spreadsheet containing the major fuel analyses affecting combustion performance and permits up to twenty different fuels or additives to be mathematically blended. For example, in Fig. 4 is shown the analyses of twenty different fuels (including eastern bituminous, Powder River basin, Illinois basin and petroleum coke) of which only Fuel 3 and Fuel 6 are being evaluated at the 70/30 ratio as summarized in Fig. 3. Note that the far right column contains the composition of the fuel blend which is used as the fuel to estimate all boiler performance parameters.

In addition to the fuel analyses, several of the deposition and other combustion parameters require specific boiler and operating information such as boiler dimensions, boiler heat rate, capacity factor, steam flow, heat transfer surface areas, fuel and air flow rates, air preheat temperatures, fuel delivery costs, mill throughputs, and particulate collection specifics. This information is important because it makes the parameter predictions more specific to the unit being evaluated. In certain cases, some of the necessary information may not be known. In these cases, approximations are used and sensitivity studies can be done to evaluate the magnitude of the effect of unknown parameters on the estimations.

A unique feature of the *Fuel Quality Advisor* is that weighting factors are also assigned to each of the calculated parameters. These weighting factors allow the utility to increase the importance of those parameters which most closely mirror actual boiler experience. Over time, as slagging or fouling propensities in the boiler are compared to the estimated performance from each of the slagging/fouling parameters in the *Fuel Quality Advisor*, those parameters that do not agree with the actual performance can be eliminated, thus making the predictor even more representative of