Evaluation of Boiler Modifications at SHERCO Unit 2

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by

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Introduction

For several years, the Northern States Power Company (NSP) Sherburne County (SHERCO) Unit 2 has experienced decreased boiler performance. There were two main problems in the boiler: (1) decreased economizer performance, including excessive outlet water temperature, tube failures, and pluggage, and (2) low main steam temperature and a temperature mismatch with the reheat temperature.

In 1996, Northern States Power Company looked at ways to correct these problems. They sought bids from three boiler manufacturers for equipment and/or operating changes to remedy the problems. All bids had basically the same solution - redesign the economizer and increase the superheater surface area. However, the proposal details were different for each vendor.

In order to evaluate the various proposals, NSP contracted with Performance Engineering, Inc. (PEI) to construct a PEPSE boiler model of SHERCO Unit 2 and perform various operating studies using the model. Some surprising results were obtained. Although all vendor proposals offered similar solutions, the extent of the changes were diverse, and the resulting proposed performance changes on the boiler were quite different. The low-cost proposal did not meet the NSP plant operating requirements for the boiler.

This paper discusses the PEPSE boiler model of SHERCO Unit 2 and the analyses of the various vendor proposals. Because of the proprietary nature of the vendor proposals, quantitative details of the results will not be given. This paper will contain mostly a narrative description of the model and the analyses of the vendor proposals.

Unit Description

SHERCO Unit 2 has a subcritical , forced circulation boiler with single reheat and a balanced draft divided furnace. The unit, designed and built by Combustion Engineering, is located in Becker, Minnesota on the banks of the Mississippi River. At Maximum Continuous Rating (MCR) and at 5% overpressure operation, the unit produces approximately 750 MW at a main steam flow of 5×10^6 lb/hr. Design main steam temperature is 1007 °F, and design hot reheat temperature is 1005 °F. Design main steam pressure and hot reheat pressure are 2640 psig and 589 psig, respectively. Thunder Basin and Big Sky coals are currently fired in the Unit 2 boiler in a 70/30 blend. This is a departure from the original design coal.

Problems at SHERCO Unit 2

Several problems existed in the Unit 2 boiler:

1. Economizer Pluggage - The economizer is a continuous staggered fin tube arrangement and is prone to pluggage. This caused local areas of high velocity and resultant erosion damage.

2. Economizer tube failures - Because of the frequent pluggage, mechanical cleaning was employed, which contributed to tube cracking at the inlet header.

3. Economizer hanger failures - Due to fuel changes, gas temperatures throughout the boiler were elevated. These higher than design temperatures, coupled with temperature reductions during load swings, caused higher than normal economizer hanger tube failures.

4. Low main steam temperature (and steam temperature imbalance between superheater and reheater) - The main steam temperature was low and lagged the reheat temperature by as much as 20 °F.

5. High economizer outlet gas temperature - Fuel changes from the original coal caused current boiler temperatures to be elevated throughout the boiler. This caused higher than design economizer exit gas temperatures, resulting in decreased boiler efficiency due to high losses.

Changes in fuel caused the higher boiler flue gas temperatures. These higher flue temperatures did not translate into a higher main steam temperature, but caused excessive flue temperatures in the back end of the boiler, causing the economizer hanger degradation, increased economizer outlet water temperatures, increased economizer outlet gas temperatures, and decreased boiler efficiency.

Solutions

To correct these boiler problems, NSP personnel solicited proposals from various boiler manufacturers. Three manufacturers responded to the bid invitation, and all three vendors proposed roughly the same solution - increase the convective superheater area, and modify the economizer by removing the fins (bare tube design) and opening the gas path through the economizer. Their specific proposals and assumptions were different, however.

The vendors' solutions provided some thermodynamic challenges. Boilers are complex heat exchange devices, and their inherent counterflow nature makes any change to the heat transfer surface a complicated calculation. For example, increasing the superheater area would cause the main steam temperature to increase, but what is its effect on other temperatures, specifically the reheat temperature? Also, reducing the economizer surface area to lower the economizer water outlet temperature has effects on the furnace heat absorption.

Opening up the economizer flow path and converting to a bare tube design will reduce or eliminate the economizer plugging problem. This cannot be verified thermodynamically.

Each vendor provided a specific guaranteed solution based on their own in-house calculations. The basis for these calculations and guarantees were unknown.

PEPSE Model

NSP personnel decided that an independent evaluation of the vendor proposals would be in their best interest. Their chosen evaluation tool was to be a PEPSE model of the boiler.

Performance Engineering, Inc. was chosen to build a PEPSE boiler model of SHERCO Unit 2 and perform analyses using the model. These analyses would be used as a check of each vendor's proposal.

The first step was to build a model based on the original boiler design. This model appears in Figure 1. Developing this "design" model first allows verification of the model against some known or guaranteed performance. The model did match the design conditions.

PEPSE Analyses

For each vendor proposal, the PEPSE model shown in Figure 1 was modified to reflect the proposed boiler modification. Both the geometrical configuration of the schematic and the geometric input to various sections were modified for the proposed section changes.

Analyses were performed to determine if each vendor proposed change could actually produce the desired results. In addition to the geometrical changes, other changes were also included. These included boundary conditions, fuel flows, and burner tilt.

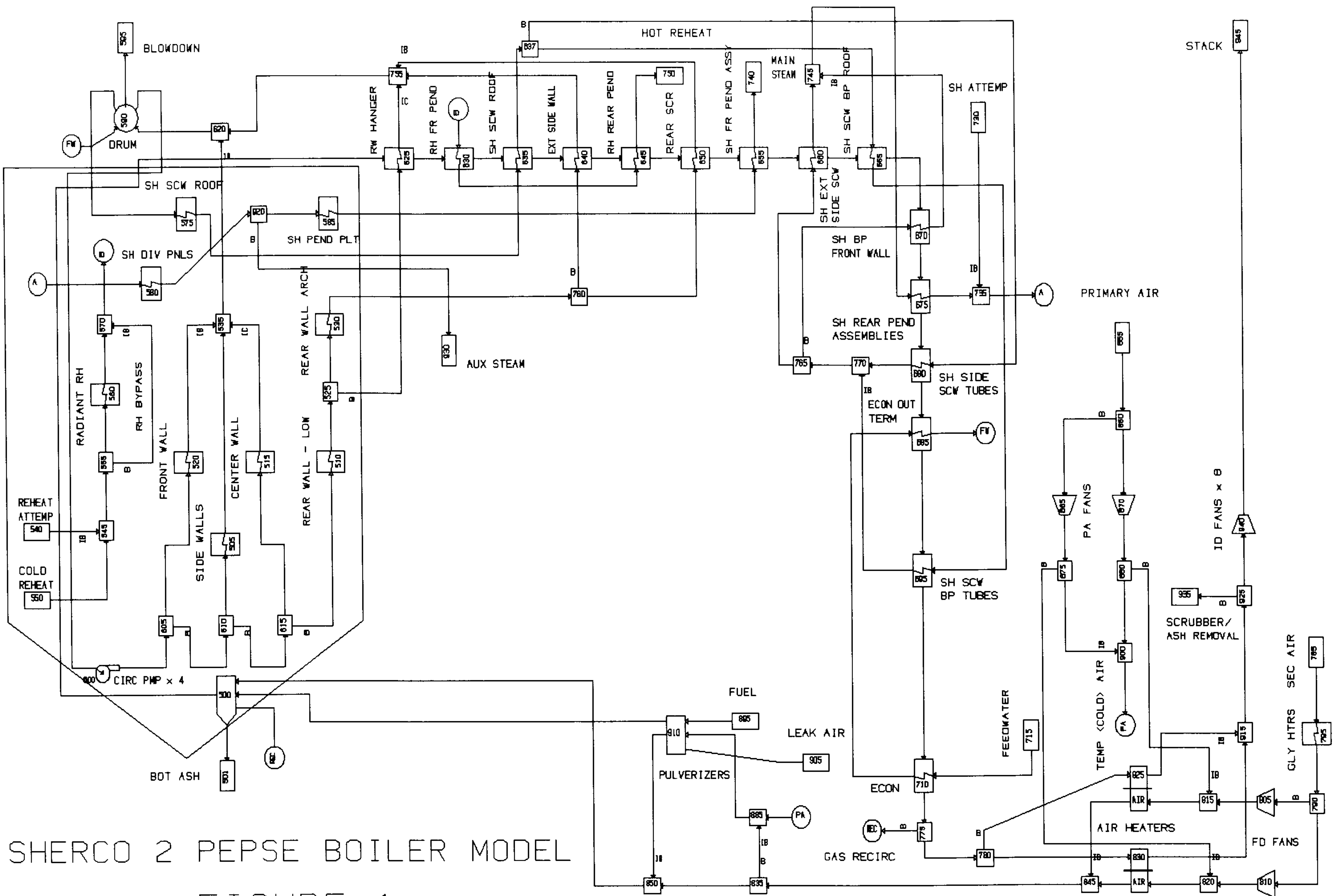
After a careful and thorough evaluation of the proposals using the PEPSE model, the low-cost vendor's proposal was found to be flawed. The desired boiler conditions were not met using their proposed design under all operating conditions.

Discussion

The low-cost bid did not meet NSP's performance requirements set forth in the bid request. Rather than discard this proposal, the low-cost vendor, NSP personnel, and PEI personnel met to determine the reasons for non-compliance. This meeting, subsequent discussions, and a re-analysis on the part of the vendor brought resolution to the problems.

Verification of vendor proposals can save utilities millions of dollars on proposed design changes. A heat balance program like PEPSE can be a valuable tool in this verification process. It provides fast and accurate results to complex calculational problems.

PEPSE is a registered trademark of Scientech, Inc



SHERCO 2 PEPSE BOILER MODEL

FIGURE 1