A DB RILEY TECHNICAL PUBLICATION

INCREASING GENERATION CAPACITY AND REDUCING EMISSIONS ON WOOD FIRED BOILERS

Case Study: TIMCO, Inc., Center Barnstead, New Hampshire
Boilers 1 and 2

by

Kevin M. Toupin
Staff Engineer
DB Riley, Inc.

Presented at the
Council of Industrial Boiler Owners
Industrial Power Plant Improvement Conference
Concord, Ohio
May 6-7, 1992

RST-94

DEUTSCHE BABCOCK
DB RILEY, INC.

Post Office Box 15040
Worcester, MA 01615-0040
http://www.dbriley.com

INCREASING GENERATION CAPACITY AND REDUCING EMISSIONS ON WOOD FIRED BOILERS

Case Study : TIMCO Inc., Center Barnstead, New Hampshire Boilers 1 and 2

By

Kevin M. Toupin
Staff Engineer
Riley Stoker Corporation

ABSTRACT

Riley Stoker was contracted to work on a wood fired boiler with high CO emissions and steam capacity problems. Utilizing the basics of combustion optimization, Riley Stoker modified the combustion system which resulted in substantially reduced CO emissions and increased the steam flow capacity.

This paper deals with reducing CO emissions and increasing steaming rates on wood fired boilers by optimizing through the basics of combustion. The basics of combustion optimization for wood fired stoker boilers are:

- *Even distribution of both the combustion air and fuel.*
- *Proper turbulence and miring of both air and fuel for the portion of combustion occurring in suspension.*
- *Proper undergrate air temperatures to promote fuel drying and combustion on the grate. Minimize air infiltration. Optimization through the basics of combustion is generally applicable to most wood fired boilers.*

CASE STUDY: HISTORY AND BACKGROUND

TIMCO, Boilers 1 and 2 are located in Center Barnstead, New Hampshire. The boilers are identical and were originally designed to fire oil and pulverized coal. In 1982 the oil and pulverized coal systems were removed, the boilers were relocated to New Hampshire and converted by a local contractor to fire a combination of waste wood and sawdust. Each unit is balanced draft and designed to produce 30,000 lbs/hr of superheated steam at 225 psig and 525 °F.

The wood firing combustion system consists of a water cooled stationary grate, pneumatic fuel distributor, cinder reinjection system, and overfire air system.

PERFORMANCE PROBLEMS

The initial 1982 combustion system retrofit had the following performance problems.

- High CO emissions of 1100 - 4200 ppm (0.9 - 3.4 lbs/10^6 Btu)
- Load was limited to 27,000 lbs/hr steam flow (90% MCR) due to fuel piling

(Refer to Figure 1, page 5, for general Factors Affecting CO Emissions.)

SOLUTION ANALYSIS

Two primary options were evaluated by TIMCO to solve the performance problems:

1. Installation of a oil burner above the grate to essentially burnoff the CO produced from wood firing. The oil burner would also increase the boiler load to the design capability. Since oil firing is not currently used at this site, this modification would require complete oil storage, piping, and firing systems.
2. Optimize the wood combustion process to reduce CO production and increase the steaming output.

Due to the complexity of adding a oil firing system, dual fuel firing, convection pass fouling, and the instability of oil prices TIMCO chose the route of optimizing the wood combustion process.

To optimize the combustion process Riley Stoker recommended the following "Action Plan":

- Evaluate the existing boiler performance through actual testing and establish the problem areas.
- Outline a plan to address each problem area.

Riley Stoker conducted 1-½ weeks of performance and evaluation testing. Based on this testing the following problem areas were found:

1. The fuel distribution on the grate was very poor causing fuel piling.
2. The overfire air system lacked proper penetration and capacity for effective suspension burning and CO burn-out.
3. The undergrate combustion air was unheated; this resulted in the fuel on the grate not drying properly which contributed to the problem of fuel piling. This conclusion was drawn from the observations that once a fuel pile was established the pile did not dry and ignite nor burn off during the course of the test. All burning was located on the periphery of the piles.
4. The boiler bank and economizer hopper cinder reinjection nozzles were located above the combustion zone resulting in poor cinder burnout and increased cinder carryover.
5. The boilers had high amounts of air infiltration from the fuel feed system and the seals between the refractory and waterwall headers.

RECOMMENDATIONS AND MODIFICATIONS

Riley recommended the following to address each problem area:

1. Install new Riley pneumatic fuel distributors to evenly spread the fuel

across the grate. The recommended pneumatic distributor utilizes modulating air pressures to create a pulsating blast of air for even front and rear coverage, adjustable distributor plate to control the fuel trajectory, and adjustable air vanes to control the side to side distribution.

2. Redesign the overfire air system to achieve adequate penetration and mixing to effectively complete the suspension burning and CO burnout. The recommended overfire system consisted of four levels, each level having the capacity to introduce eight percent of the total combustion air flow. Each individual level also has a control damper for modulating flows. The nozzles in each level were designed with high velocities of 14500 fpm for penetration and positioned for maximum mixing.

   The redesign uses cold overfire air and did not require replacement of the existing OFA fans.

   Note: The OFA nozzles were sized for the future addition of hot air. Presently, with cold air, the nozzles have inserts to maintain the design nozzle velocities.

3. Preheat the undergrate combustion air. This air was preheated to 300 °F which is the maximum temperature within reason that could be achieved utilizing a conventional steam coil. The objective of the hot air is to increase the drying rate of the fuel landing on the grate and accelerate ignition of the fuel. In addition, the hot air increases the air side pressure drop across the grate which improves the air distribution across the grate.

   The existing forced draft fans did not require replacement due to the low draft loss design of the steam coil.

   Note: A gas/air tubular airheater was also investigated but was not utilized in an effect to control the modification costs.

4. Relocate the boiler bank and economizer cinder reinjection nozzles to a lower elevation in the furnace into the combustion zone. Add sand separators or eliminate the cinder reinjection from the dust collector hoppers. TIMCO chose to eliminate the cinder reinjection from the dust collector.

5. Modify the fuel feeder system and repair the refractory/header seals to reduce air infiltration. The fuel feeder chutes are open to atmosphere. To reduce the air infiltration, the chutes were reduced in size from 30 inches to 20 inches, and a counter-balanced damper was added in the chutes to further reduce the free area. The counter-balanced damper has the capability to swing open to allow passage of oversized fuel pieces. It has been Riley Stoker's past experience that air infiltration contributes to the formation of CO by reducing the flame temperature caused by improper penetration and mixing. Also, reducing air infiltration has the added benefit of increasing boiler efficiency.

(Refer to Figure 2, page 6 for a boiler side view sketch outlining the modifications.)

RESULTS

Riley Stoker conducted 3 weeks of optimization testing after the modifications. The results of these tests combined with the state compliance tests demonstrated that the CO emissions were reduced to 190 - 400 ppm corrected to 3.0% oxygen (0.16-0.33 lbs/10^6 Btu) and the steam capacity increased by 5 to 10 % without any fuel piling. The following is a summary of the before and after modification performance data.

CONCLUSION

Utilizing the basics of combustion optimization, Riley Stoker outlined a plan of action to solve high CO emissions and steam capacity problems on a existing wood fired boiler. The plan of action included diagnostic testing, establishing problem areas, proposing recommendations, and implementing modifications. As a result, the CO emissions were reduced well within the state compliance limits, and the steaming capacity was increased to the original design capacity which was not previously achievable.

	Before Optimization Modifications	After Optimization Modifications
1. Boiler Steam Flow (Avg) Lbs/Hr	27,800	31,000
2. Final Steam Temperature °F	525	531
3. Fuel Piling	yes	no
4. Excess Air %	30-45	30-40
5. Emissions @ 3.0% 0_2 - CO ppm - NOx ppm	 1100-4200 ---	 190-400 96
6. Loss Due to Unburned Combustibles %	2.2	2.0

ACKNOWLEDGMENTS

Behind any successful project there must be commitment and cooperation among the customer, the designer, and field engineers. I would like to thank Mr. David Houle, TIMCO President, Mr. Phil Rog, TIMCO Power Plant Manager, and Mr. Ralph Atchison, Riley Field Engineering for their confidence, commitment, and cooperation.

FACTORS AFFECTING
CARBON MONOXIDE EMISSIONS (CO)

CO emissions are mostly the result of incomplete combustion which can be attributed to the low conversion of carbon to carbon dioxide (CO_2).

Factors which typically affect the production of CO on wood fired boilers are:

1. Poor Combustion

   - fuel distribution (fuel piling)
   - air distribution
   - air turbulence, mixing, and penetration of the overfire air system for suspension burning

2. Excess air concentration

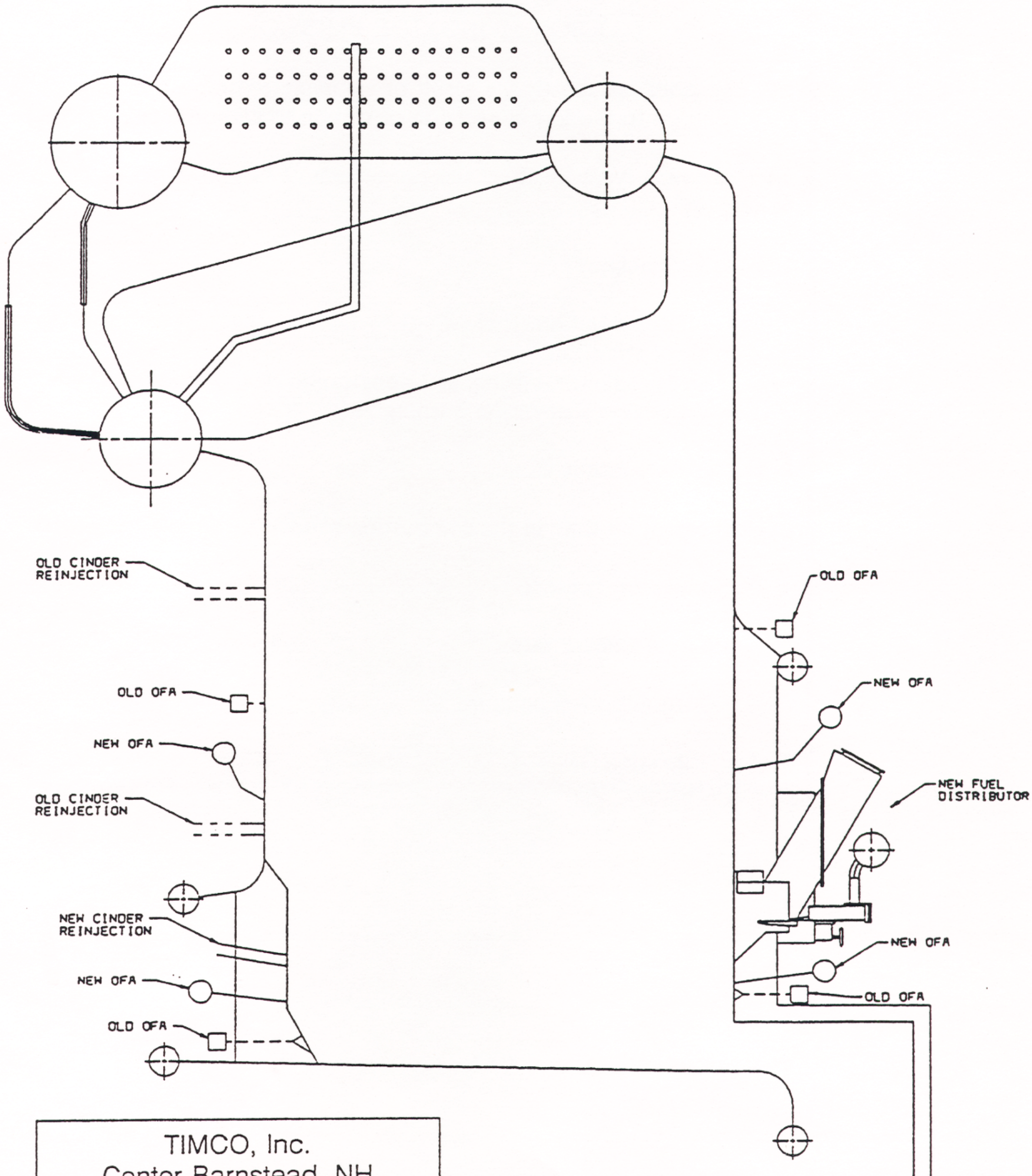
3. Fuel retention time in the combustion zone

4. Fuel moisture content

5. Grate heat release rate

6. Combustion air temperature

7. Air infiltration



TIMCO, Inc.
Center Barnstead, NH
Boilers 1 and 2

FIGURE 2.0