# Recovering more from recovery boilers

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## Introduction

Energy Management in the pulp and paper industry must include optimizing the performance of existing power producing equipment. Improvement in the preformance of recovery boiler results in significant improvements in boiler efficiency, cleanability, capacity increases and smelt reduction efficiency, Results, such as 25, 50 or even 100% increases in capacity, over 10% in efficiency, and all but eliminating outages for gas passes cleaning. have been achieved and demonstrated.

The methodology for achieving these types of spectacular results is to :

1. Carry out site performance tests and understand the present operation of the recovery boiler.

2. Compare the results to the boiler's original design and define limitations.

3. Carry out Engineering studies to determine how to best overcome the limitations.

4. Implement the recommendations of the Engineering study work.

It is also important to understand the existing problems and the history of past operation to be able to recommend comprehensive solutions and upgrades.

A key component to almost all recovery boiler upgrades is to be able to achieve excellent combustion by the furnance liquor introduction and air management system. Changing existing methods to the B&W newly developed highly efficient air management system, is the major step in obtaining recovery boiler improvements.

This paper briefly covers various aspects or recovery boiler upgrades, design considerations, and modifications which will lead to improved performance. While typically the benefits achieved by these upgrade projects are justified by pay back periods of two or less years just on boiler efficiency and steam production increases alone, the larger benefit may well be increased pulping capacity for the whole mill and higher availability for the boiler.

## Engineering Studies :

To understand what is possible and to be able to define the realistic goals for recovery boiler upgrade projects, a thorough Engineering study, which includes boiler performance tests, and an analysis of past and present operation, maintenance and problem areas is a must.

The sequence of work would proceed generally in the following steps :

1 Review the past operation of the boiler-operating records data, load capacity achievable, duration of operation between outages, reasons for outages, number of, locations of and the reasons for tube leaks, existing limitations, boiler availability, modifications to original design, and major problems experienced.

2 Obtain and review original design drawings, expected performance data, design black liquor analysis, and equipment specifications.

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3 Determine the adequacy of existing instrumentation. Install additional instrumentation required for conducting boiler performance tests.

4 Optimize existing boiler operation as much as possible.

5 Carry out performance tests, including obtaining black liquor, smelt, salt cake, green liquor and superheater tube ash deposit samples.

6 Analyze the various samples obtained and the results of the performance tests. Compare to original design—define differences and limitations.

7 Analyze the various existing boiler parameters alongwith the testing results and compare to present day standard limits.

8 Determine the effectiveness of the existing liquor combustion and air distribution system and quantify improvements achievable with the new air management system.

9 Determine what modifications are necessary to overcome the existing limitations and define alternatives which will give the desired results.

10 Calculate the new boiler expected performance for the various options and determine the most cost effective, best alternative.

11 Engineer the chosen modifications and determine the cost, outage and eraction times needed for implementing these changes.

12 Write and submit a report which provides the recommendations, costs of implementation, expected future performance and benefits obtainable.

The work involved in carrying out step 8,9 and 10 above can be very lengthy and time consuming. Sound prior experience with similar work and todays state of the art main frame computer programs are invaluable for achieving good results.

The time period for completing such Engineering studies is usually about three to four months.

## Possible Upgrades

It has been stated that with enough time and money, almost anything is possible and indeed, there have been cases where only the original steam drum has remained and everything else changed, upgraded to new designs to achieve 100 to 200% capacity increases.

All of the types of upgrades listed below have been found to be cost effective, justified and have been carried out in many recovery boilers in actual operation today :

1. Elimination of direct contact evaporator–a long flow economizer will significantly improve boiler efficiency, capacity and achieve low order operation.

2. Air system upgrades - more details provided in the next section of this paper.

3. Furnance enlargement - to obtain more capacity furnance volume, height have been increased by moving walls, excavating and even moving the steam drum.

4. Liquor firing changes-adding oscillators to improve wall coverage and lower furnance utilization as well as to decrease carryover.

5. Changing to "fixed" firing–much higher solids liquor will significantly increase boiler efficiency and capacity.

6. Superheater, boiler bank, economizer spacing changes–much actual operating data is available to better define flue gas temperature limits to specified superheater or boiler tube surface side spacing depending on black liquor and ash deposit characteristics. (Potassium and chlorides are bad actors). Heating surface spacing is modified to conform to the established limits.

7. Furnance construction changes–Modifications to pin stud patterns and sizes as well as lower furnance replacements with composite tubing improve boiler reliability and safety.

8. Controls & instrumentation Upgrades to achieve improved boiler controllability and performance

9. ESP system installations to improve safety of operation.

10. Numerous soot blower steam source, blowing pattern and blowing sequence changes to achieve improved heating surface cleanability alongwith prolonged operating periods without necessity for cleaning shut downs.

The above by no means covers all of the enhancements or modern equipment available for achieving improved recovery boiler operation, capacity and efficiency. Imaging cameras that enable greatly enhanced observation and control over the bed; improved high temperature profiles and staying below established limits and heating surface heat transfer, cleanliness factor monitoring systems for most effective soot blowing are a few more of the recent developments.

The technology exists today to achieve most, if not all, of the various pulp and paper mill operator improvement goals for their recovery boilers and in most cases, very cost effective.

## Advanced Air Management System

As a result of a lot of computer and laboratory modeling work carried out by B&W during the last few years, it has been determined that mechanical carryover of unburned black liquor particles in the furnace is not a product of the fuel, nor is it necessarily a product of the way the boiler is operated, but is controllable by the combustion system. The key to achieving an excellent combustion system is to correctly inject the liquor and air into the proper zones of the lower furnance.

As a standard, B&W has for over the past 50 years of recovery boiler designs incorporated a three level air system and splash plate - type black liquor nozzles in combination. While these systems in most cases operated adequately, the combined effects of air introduction and fuel delivery were not fully understood until recently.

The new B&W advanced air management system provides for the injection of air at three separate elevations as jets of specific separation, penetration, and direction is paramount. This procedure was verified in an exhaustive large-scale laboratory fluid-flow research program and subsequently confirmed with actual operation of the modified boilers. Each elevation serves different functions, and while the primary air obviously assures high reduction (95%) and smelt run off the secondary air caters specifically to shape and control of the top of the bed providing for intense mixing with the combustibles above and in the porous bed surface This results in very effective combustion control by lowering combustion to an elevation just above the bed. To accomplish this, the secondary air must be injected as powerful, high momentum jets through few and very large, opposed but interlaced ports, provided with individual dampers. These ports can be located on front and rear walls, but sidewall mounted ports are preferred.

The tertiary air system serves a rather different objective as it is now known that by a properly dimensioned and interlaced arrangements, the very large eddies can be eliminated, which normally occupy and render ineffective up to half the furnance volume under the nose.

The consequence of this air system design is a factor of 3-4 reduction in peak gas velocities and in combination with correctly designed secondary air, the combustion process is completed in the lower furnance and a significant reduction of chemical/solid particle carryover is achieved. Some reduction in furnance exit gas temperature also results but only in the order of 20-50° F. The tertiary air can only be injected from the front and rear walls to be effective.

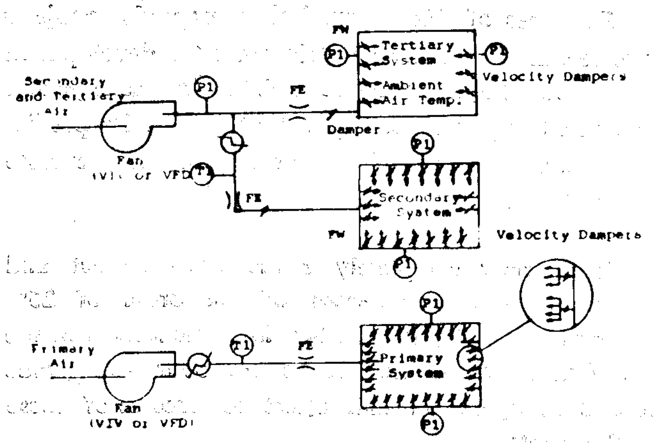
With this air management in place, a highly desirable non-stratified ,upper furnance gas flow and temperature environment can be secured, which then may lend itself to conventional design practices for dealing with slagging and fouling.

Implementation of this air flow system is so effective that in many cases just installing the air flow system alone will result in about 25 or more percent capacity increases as well as significant improvements in boiler efficiency.

Fig. 1 shows a schematic of this system.

ADVANCED AIR MANAGEMENT ( TWO FAN SYSTEM )

FIGURE 1




## Conversion Examples

The following provides some examples of operating results from recovery boilers that have been converted.

— In a 900 ton B & W boiler, a total of 18 five inch round tertiary air (T/A) ports were installed, interlaced between front and rear wall. This change decreased the superheater temperature decay from 7°F to 2°F per day. Since that initial modification, work has been done to the secondary air (S/A) ports to improve the air administration at that level. Coupled with several alterations to the Control system,which resulted in better $O_2$ control and sootblowing strategy, the temperature decay has reduced to 0.2°F per day.

— At another boiler, rated at 1.8 MM lbs dry solids per day but operated at 2.3MM, plugging occured at a rate that required water wash every 40 days. The mill accepted the wash cycle but wanted a load increase to 2.7 MM. An air system, using cold tertiary air located on the sidewalls and four wall secondary air with the addition of high secondaries located in front and rear walls, was installed. Because of the added air capability, CO was reduced resulting in a very significant increase in steam production, but plugging now occured at four week intervals. We then redesigned the T/A system to front and rear wall and rearranged the S/A to the sidewalls only, and eliminated high secondaries. The unit is now running longer than 40 days between waterwash while burning 2.8MM, with attempts to fire upto 3.0 MM. Reduction is 95% and all levels conform to the statutory requirements.

— On a 1500 ton CE unit, waterwash was required every 72 days. By installing a new air system and changing the method or fuel introduction, the unit now operates with such improved availability that the mill now fires at overloads. In this case, the liquor judged to be " severe fouling " due to its exceptionally high potassium content. The achievements were reached by reducing peak furnance exit temperatures and peak velocities while eliminating recirculation under the nose, thus minimizing carryover and velocity stratifications.

— A 600 ton unit rated at 1.8 MM lbs of solids per day was rebuilt in late 1987, and by mid summer of 1988 the precipitator was replaced. The rebuilt unit, using the same furnance geometry i.e. height, width and depth, was upgraded to 2.4 MM lbs per day solids. This unit has operated very well at this 33% increase while meeting all performance and emission criteria. High velocity temperature ( HVT ) traversing, as well as Pyrosonic thermal mapping, indicate only a 25°F side to side temperature difference entering the superheater screen. Testing at 2.6 MM lbs solids per day indicated the temperature differential to be 30°F, clearly demonstrating the effectiveness of the new air system in providing uniform temperature and velocity profiles leaving the furnance. In all cases, solid particle carryover was judged to be either non existent or minor.

— On a recently restarted unit originally rated at 2.8 MM lbs of solids per day, the unit, after 44 days of operation, was judged to be at the same cleanliness level as after only four days of operation prior to modification.

**Benefits Achievable :**

As can be seen from the previous examples cited, the benefits of upgrading recovery boilers are significant, making these projects very cost effective.

Because of the fuel characteristics dictating large furnaces and drums for existing recovery boilers other considerations for capacity increases such as circulation and drum steam-water separating ability, are usually not a limiting factor for the upgrades. However, such factors as larger feedwater requirements to handle the extra steam side pressure drop, safety valve capacity, etc. must be considered and handled for these upgrade projects.

Any recovery boiler that is over 8 years old is an excellent prospect for an upgrade, because it will not have the benefit of the new air flow system, which will be able, very cost effectively to :

- increase boiler efficiency
- increase boiler steam production capability
- increase boiler black liquor solids handling capability
- increase smelt reduction efficiency
- prolong time periods between outages necessary for gas passage cleaning

The benefits obtained for increasing steam capacity and smelt reduction efficiency for the same fuel input and eliminating outages, necessary for cleanings, are substantial enough to make all such Projects cost effective.

## Conclusions

Successes of Recovery boiler upgrade projects have become much more certain since the development of the new, highly effective B & W air management system and computer programs that accurately predict boiler performance with various heating surface modifications.

It is now completely realistic to expect and to obtain capacity increases in the order of 25% for the same fuel input with the implementation of the B & W air flow system. There are over 40 upgrade projects in operation that attest to success of these developments.

Recovery boilers are excellent prospects for upgrades, capacity and efficiency increases as well as availability, safety and reliability improvements, because only now, after considerable effort into research and development, are many of the basic necessities for enhanced operation and performance better understood. By installing the advanced air management system and modifying heating surface arrangements to operate below established flue gas temperature limits, not only will higher steam production and black liquor utilization be possible, but the resulting operation can be more trouble free, reliable and of longer duration.