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RECOVERY BOILER GENERATING BANK TUBE THINNING

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ABSTRACT

This paper describes recent results of inspections for remaining tube wall thickness, in several 2-drum black liquor recovery boiler generating banks, conducted across North America.

A chemical recovery boiler generating bank is a difficult area to inspect due to limited access to the tubes. These particular tubes typically have not exhibited significant thinning in the past, but several unexpected tube failures in some recovery boilers in recent years has lead to the discovery of widespread tube wastage near the lower drum.

Previous attempts to measure tube thinning in this area have been carried out with limited success.

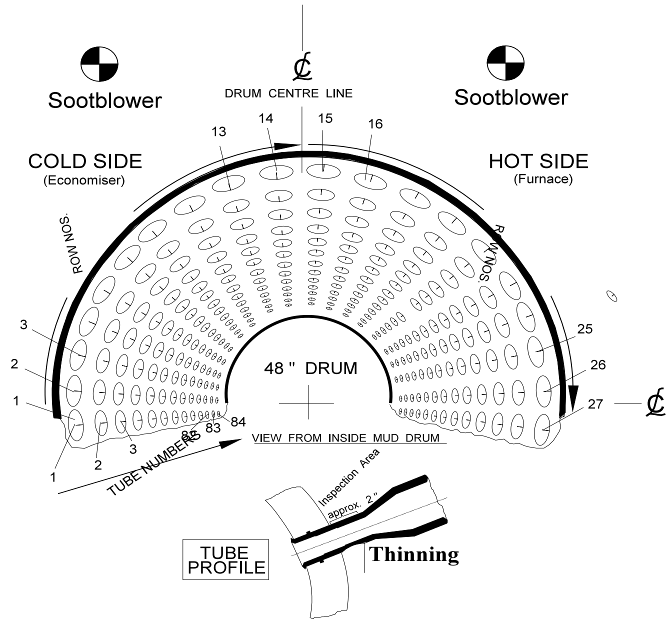
A recent inspection method and new proprietary equipment have been developed and proven to accurately assess the extent of this problem.

Compiled thickness data summaries for several generating bank thickness surveys showing typical thinning patterns and wastage rates for Babcock & Wilcox and Combustion Engineering chemical recovery units are given in tabulated and graphical formats.

INTRODUCTION

Black liquor chemical recovery boilers, such as those used in the kraft pulping process, typically utilize a steam generating bank with a multitude of closely spaced vertical tubes connecting an upper steam drum and a lower mud drum. **Figure 1** shows a typical lower drum tube layout with the usual thinning location.

Wastage of the carbon steel tubes, due to the inherent corrosive environment of the flue gases generated during the combustion of black liquor, is typically well documented for most areas of these boilers. Regular inspections and planned maintenance are scheduled as required before tube thinning leads to premature failures.



Thinning of tubes in the generating bank area was not a major concern 5-10 years ago. In the last 5 years, an increasing number of tube failures in the vicinity of the mud drum have been reported with several operators having to carry out emergency shutdown procedures on 2 or 3 occasions.

Several complete generating banks have been replaced and numerous units have had to plug leaking tubes as well as many suspect tubes.

DISCUSSION

It has been ascertained that the failure of almost all of the tubes in the generating bank is caused by thinning of the tube wall where it leaves the lower (mud) drum, within the first 2 inches. This has been observed in both swaged and non-swaged tubes. There can be from 700 to 3000 tubes in a generating bank, usually spaced approximately five inches apart.

It is difficult to inspect this area with conventional ultrasonic or electromagnetic techniques due to the following conditions:

(1) Only the outer 3-4 rows are accessible from the outside of the generating bank.

(2) The tubes are typically rolled into the drum, leaving internal ridges, generally in the area of interest, which interfere with ultrasonic signals.

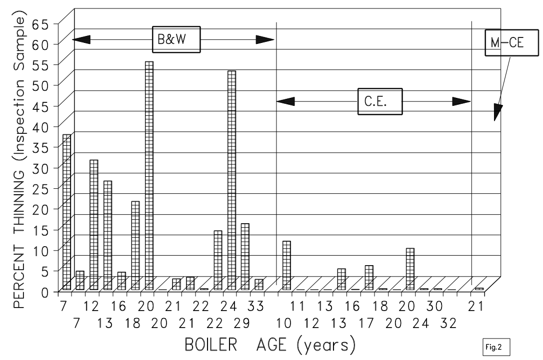
(3) The proximity of the thick walled lower drum and the rolling ridges and variations in inside diameters interfere with electromagnetic techniques.

(4) Most tubes have scaling and pitting to various degrees.

(5) The thinning of the tubes is not evenly distributed throughout the bank, but generally occurs in groups.

A recent development using an immersion ultrasonic technique and new proprietary equipment has yielded accurate, repeatable data. This recently developed equipment has been tested in approximately 29 recovery boilers across Canada and the United States in both Babcock & Wilcox, and Combustion Engineering units.

Figure 2: % THINNING vs. BOILER AGE



RESULTS

Inspections of 29 recovery boilers (15 B&W, 13 C.E. and 1 Mitsubishi-C.E.) for wastage of the generating bank tubes near the lower (mud) drum area have found that over half have some wastage in this area. Most of the data is for first-time inspections, but a few have now had 2 -3 inspections. A pattern of thinning is apparent in most tubes that seems to be related to sootblowing. Most boilers exhibit the wastage near the tubes close to the sootblower lanes, but not necessarily in the lanes themselves. In C.E. boilers, the wastage is usually found on the economizer side of the generating bank, while in B&W boilers the wastage can be found on the furnace and/or economizer side.

Individual tubes show thinning generally in one quadrant of the tube circumference, however corrosion has also been observed in two or three quadrants. Where thinning is widespread, and there are symmetrical sootblowers coming from each side of the boiler, the thin quadrant can generally be located in the same relative location on one side of the boiler and have a mirror image on the other side of the boiler.

Figure 2 is a bar chart which shows a comparison of tube thinning with boiler age. The boiler manufacturers are grouped separately to show if there is a correlation between design and age. The height of each bar represents the percent thinning of the actual sample tested, not the percent of the total tubes in the generating bank.

Figure 3 is a bar chart which shows a summary of boilers inspected, again grouped according to manufacturer. Boiler designations A through O are B&W, P through 2 are C.E. and boiler 3 is a Mitsubishi-CE. Again, the height of each bar represents the percent thinning of the actual sample tested.

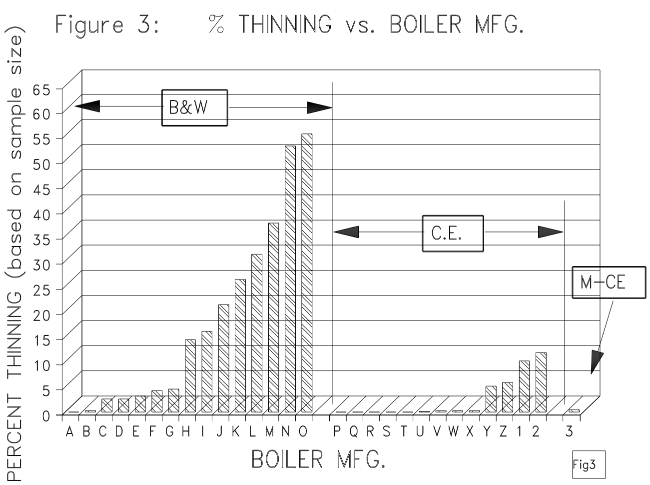


Figure 4 is a line graph which shows the relationship between observed tube thinning and test sample size. This was prepared to ascertain whether a minimum sample size could be established that would give a degree of confidence in finding the majority of any thin tubes which may be present.

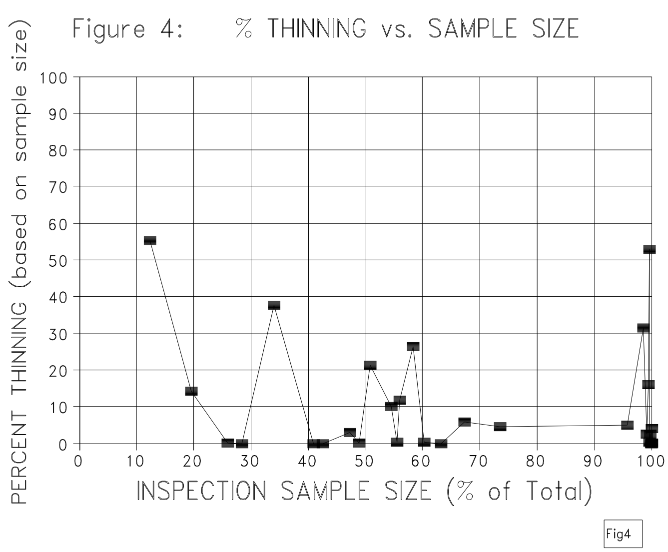


Figure 5 shows typical tube thinning rates for boilers that have had multiple inspections. The wastage rates show an average of 0.05mm (2.0 mils) to 0.24mm (9.3 mils) per year thinning. This is an overall average for all tubes inspected in the generating bank. In some cases, the wastage rate has been shown to be significantly higher when only the thinnest tubes are compared, instead of overall average tube thickness.

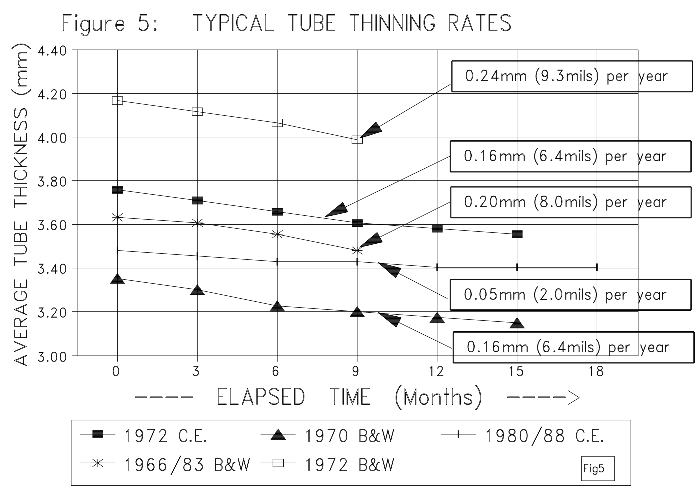


Figure 6 at the end of this paper shows a typical generating bank with widespread thinning. It is a B&W boiler, approximately 12 years old. The circles represent each tube in the generating bank. The darker the circle, the thinner the tube and the white area in each area points to the thin spot (original reports are colour-coded and are much more revealing). Solid black circles are previously plugged tubes. Note the thin tubes are in bands in Rows 6&7 on the cold (economizer) side and Rows 17-25 on the hot (furnace) side. As the tubes become progressively thinner, it has been observed that the thin spots on each tube tend to occur along or near the sootblower lanes.

CONCLUSIONS

(1) The survey of chemical recovery boiler generating bank tubes are showing some premature tube thinning in over half of the boilers inspected to-date. One example reveals that 53% of the total tubes have thinned less than or equal to the minimum allowable wall thickness.

(2) The corrosion mechanism is generally related to sootblower location as shown by the thinning patterns observed.

(3) The wastage rates vary for different boilers with overall average rates from 0.05mm (2.0 mils) to 0.24mm (9.3 mils) per year.

(4) The B&W boilers seem to have a more severe thinning problem than the C.E. units tested to-date.

(5) There does not appear to be a correlation between boiler age and thinning. Boilers as new as 7 years and as old as 29 years both show significant thinning. (Note: some data has been collected on boiler rebuilds as new as 4 years which are starting to show signs of thinning).

Literature cited

The source of all data for this paper has been taken from actual inspections carried out by Stasuk Testing & Inspection Ltd., Burnaby, B.C. Canada. Data was collected using Stasuk's proprietary equipment.

A C M E   C O R P O R A T I O N   o f   A M E R I C A

Sunny Beach, Florida

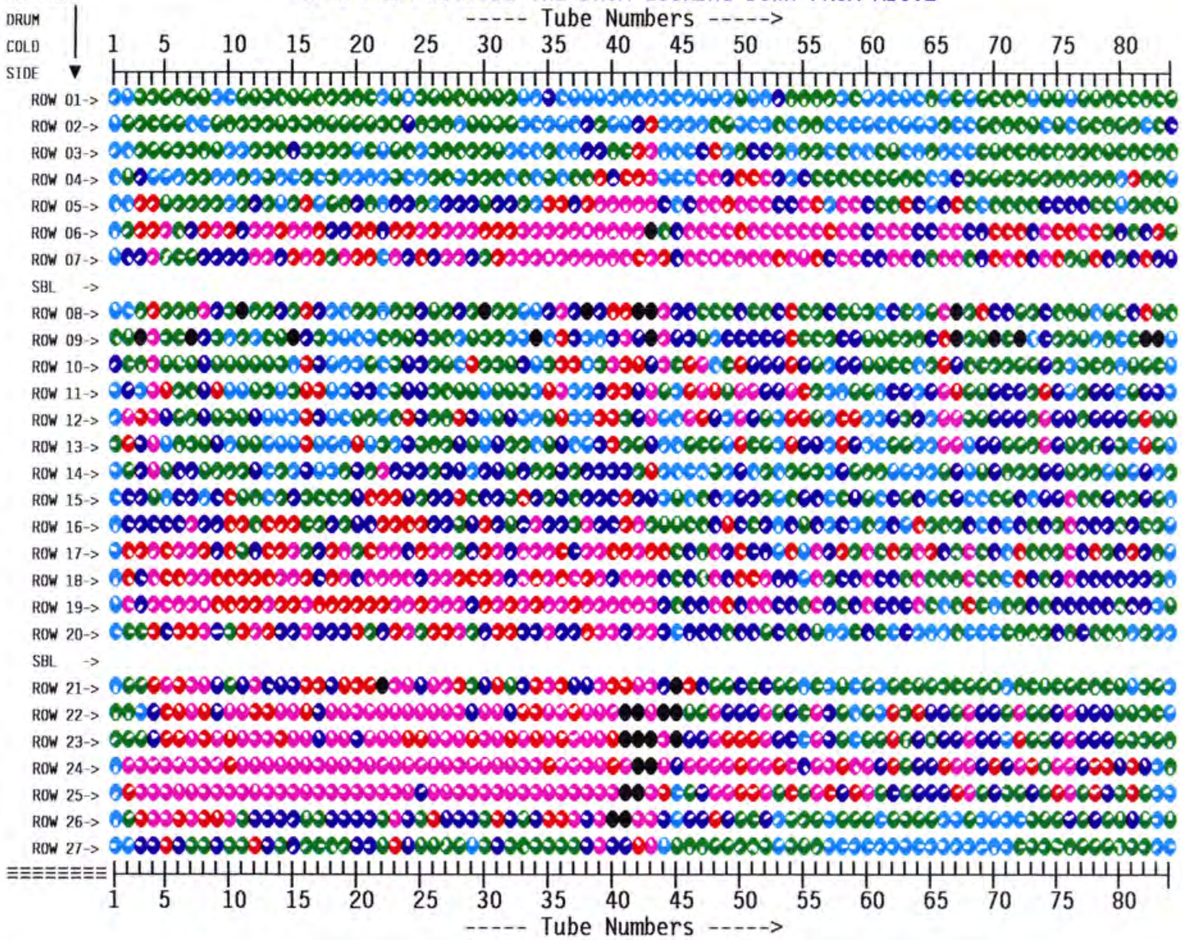
No.X RECOVERY BOILER — Carbon Steel Thickness

GENERATOR (Mud Drum) TUBES

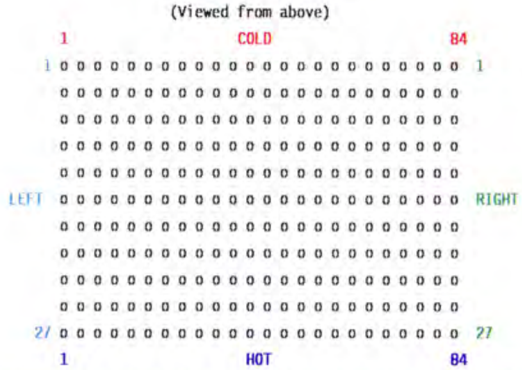
JUNE 1990

LEGEND: Thickness Colours (mils) ● LESS THAN 78 ● ● 78 THRU 92 ● ● 93 THRU 107 ● ● 108 THRU 123 ● ● GREATER THAN 123 ●

VIEW FROM OUTSIDE THE DRUM LOOKING DOWN FROM ABOVE



MUD DRUM TUBE LAYOUT
(Viewed from above)



NOMENCLATURE
(Tube symbols)

- O = No reading
- ⊗ = Not accessible
- O = Same all around
- ● = Tube plugged
- = Thin area at 1 o'clock
- = Thin area at 7 o'clock
- = Thin area at 2 o'clock
- = Thin area at 8 o'clock
- = Thin area at 3 o'clock
- = Thin area at 9 o'clock
- = Thin area at 4 o'clock
- = Thin area at 10 o'clock
- = Thin area at 5 o'clock
- = Thin area at 11 o'clock
- = Thin area at 6 o'clock
- = Thin area at 12 o'clock