

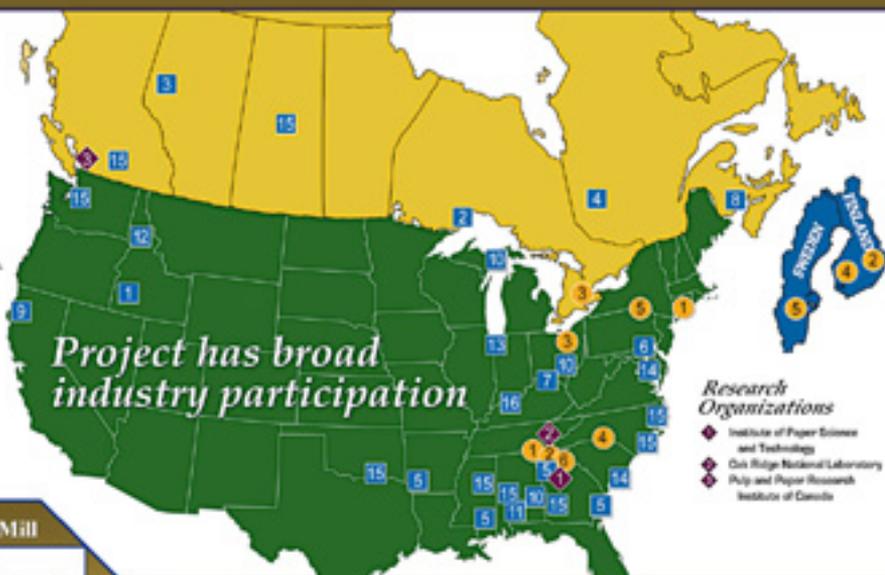
Study of Composite Tube Cracking in Black Liquor Recovery Boilers

Pulp and Paper Companies

- 1 Boise Cascade
- 2 Bowater Inc.
- 3 Daishees Marshall Int.
- 4 Danner National
- 5 Georgia-Pacific Corp.
- 6 PMA Container Co.
- 7 International Paper
- 8 Irving-Poly and Paper Ltd.
- 9 Louisiana Pacific
- 10 Mead Corp.
- 11 Parsons & Whittemore Inc.
- 12 Potlatch Corp.
- 13 Seawall - Stone Container Corp.
- 14 Weyerhaeuser Co.
- 15 Weyerhaeuser Co.
- 16 Willamette Industries

Suppliers

- 1 Abston Power
- 2 AmStar - Abstrom Corp.
- 3 Babcock & Wilcox Co.
- 4 Kvaerner Pulping Inc.
- 5 Sastek Steel Mill
- 6 Worthing Services Inc.



Project has broad industry participation

Research Organizations

- 1 Institute of Paper Science and Technology
- 2 Oak Ridge National Laboratory
- 3 Pulp and Paper Research Institute of Canada

Schematic of Kraft Mill



Chemical Recovery Process

Schematic of Recovery Boiler



Inside Recovery Boiler

Tube Diagram



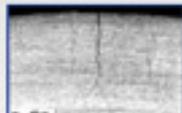
Composite Floor Tube Cracking Causes Concern about Boiler Safety

Typical floor tube cracks:

- originate at SS surface
- have some features of both thermal fatigue and stress corrosion cracking



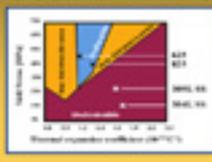
Laboratory corrosion studies have simulated the cracking seen in recovery boiler floor tubes



Neutron and x-ray diffraction have been used to measure the residual stresses in single tubes and in tube panels



Finite element modeling determined properties needed in cladding alloy so that stresses required for crack propagation would not develop



Cracks in Air Port Tubes Have Caused Failures



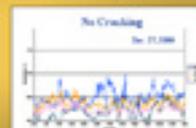
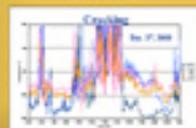
Within the paper industry, there is concern that air port cracks will cause additional recovery boiler tube failures



Cracks in air port tubes:

- sometimes penetrate into the carbon steel
- seem to initiate and grow rapidly

Temperature measurements show air ports with tube cracking experience more frequent and higher magnitude temperature fluctuations



Floor Tube Cracking Recommendations

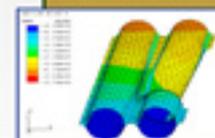
- ◆ Do not allow wash water to contact the boiler floor until the floor temperature drops below 150°C
- ◆ Minimize the thermal fluctuations
- ◆ Substitute 825/CS or 625/CS constructed or Alloy 625 weld overlaid or chromiumized carbon steel tubes for 304L/CS floor tubes

Project Is Very Successful

- ◆ Companies are using recommended materials in new facilities and retrofits
- ◆ Utilized in more than ten locations

Three approaches are being used to find a solution for the air port cracking problem:

- ◆ Identify alternate tube material that would be more crack resistant
- ◆ Find operating conditions that would prevent temperature spikes
- ◆ Determine if air port design or fabrication procedure could be changed to lessen cracking problem



Residual stress measurements and finite element modeling are being used to determine and predict the stresses in air port tubes



Development of Materials for Service in Kraft Recovery Boilers

Because of excessive corrosion encountered in carbon steel wall and floor tubes in the black liquor recovery boilers in Kraft paper mills, coextruded (composite) tubing that consists of a stainless steel layer on a carbon steel core was adopted. However, cracking in the stainless steel layer of this composite tubing has been observed. Since cracking of this tubing is a serious safety issue, a program to identify the cause of, and a solution for, the cracking is under way. Three research organizations, Oak Ridge National Laboratory, the Pulp and Paper Research Institute of Canada, and the Institute of Paper Science and Technology, are participating in this program. The principal tasks on this program include characterization of tube cracking, definition of the tube environment, evaluation of potential cracking mechanisms, measurement and calculation of residual stresses, and identification and testing of alternate materials or processes.

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