Materials for Industrial Heat Recovery Systems

Materials Improvements Result in Enhanced Heat Recovery, Better Reliability, and Prolonged Life

Heat recovery is an essential energy-saving part of almost every process system, and the proper selection of materials for these systems is complex, yet crucial for satisfactory performance. Enhancing heat recovery in industrial systems was a direct and very efficient way to substantially improve energy utilization and lessen environmental impact. To gain enhanced heat recovery and improved reliability of such systems, challenging materials problems in the areas of strength and environmental degradation were overcome. These challenging and complex materials problems required an integrated approach that included experimental characterization, field evaluation, and modeling efforts involving industry, research organizations, materials suppliers, and component manufacturers. This project addressed materials improvements for enhanced heat recovery, reliability, and competitiveness in two industries: aluminum and forest products. The focus of the efforts was on melting furnaces and recovery boilers. There were several common features for these applications—including flue gas temperatures, requirements for high duty cycles, and service in oxidizing and reducing environments—that resulted in similar materials requirements for these applications.

Improved materials for heat exchangers were required for various industries.

Benefits for Our Nation and Our Industry

The alternate materials and process changes identified in this project led to a number of benefits. The estimated energy benefits due to improved operational efficiency will exceed 12 trillion Btu/year by 2020. The improved durability of the materials led to longer operational life, fewer shutdowns, and improved yield and productivity.

Applications in Our Nation's Industry

Alternate materials and changes in operating conditions were used in recuperators in the aluminum industry, in black liquor recovery boiler air port tubes, black liquor recover boiler mid-furnace walls, and superheater tubes. Results were also applicable in various heat recovery operations in the chemicals, petroleum, and steel industries.

Project Description

The goals of this project were to identify corrosion mechanisms, perform prototype tests of alternate materials, and identify operational changes that modify the environment experienced by heat recovery system components. This enabled industrial heat recovery systems to operate in a more energy-efficient, productive, and reliable manner.

Barriers

Barriers addressed:

- Lack of knowledge and understanding of the materials' failure mechanisms and relationship to processing; and
- Insufficient knowledge of fluctuations in the operational parameters of equipment and impact on materials.

Pathways

The objectives of this project were achieved through the following: (1) characterizing degradation, and identifying and understanding failure mechanisms; (2) measuring temperature and environmental fluctuations during the process; (3) performing computational fluid dynamics (CFD) modeling to understand the magnitude and extent of fluid flow and temperature fluctuations; (4) identifying alternate materials capable of improved performance; (5) studying residual stress effects and the effect of environmental fluctuations on material behavior through measurements and finite element modeling; and (6) developing laboratory simulation test systems and in-plant testing.

Results

- Acquired and completed examination of degraded parts
- Characterized the chemical, thermal, and mechanical environment to which components were exposed
- Completed CFD modeling, thermodynamic modeling, and finite element modeling
- Selected alternate commercially available materials or developed new materials/coatings
- Evaluated alternate materials, coatings, and surface treatments in simulated and industrial plant environments
- Recommend the optimum alternative materials, repair conditions, and operational changes

Commercialization

Commercial adoption of the material recommendations and operating procedure recommendations were achieved through the active participation of equipment designers/ suppliers and end-user industries. Alternate materials were exposed in heat recovery system conditions in partners' locations and process changes were evaluated allowing companies to obtain first-hand information on the technology and to directly participate in the commercialization of the technology.

Project Partners

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Domtar Inc.
Montreal, PQ, and Ashdown, AR

E3M Inc.
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Institute of Paper Science and Technology,
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Oak Ridge National Laboratory
Oak Ridge, TN

Process Simulations Ltd.
Vancouver, BC

Pulp and Paper Research Institute of Canada
Vancouver, BC

SECAT Inc.
Lexington, KY

A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

U.S. Department of Energy
Energy Efficiency and Renewable Energy
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

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