Combustion Success Story

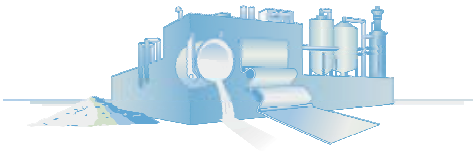
First Super Boiler Field Demonstration

In the U.S. manufacturing sector, steam generation represents the largest use of energy, accounting for over 30% of the total energy consumption. The U.S. manufacturing boiler inventory consists of 33,000 boilers with capacities greater than 10 million Btu/hr. At least 80% of these boilers were purchased over 30 years ago and the technology they employ has only marginally advanced since the late 19th century, resulting in average fuel-to-steam efficiencies around 75%.

Starting in 2000, the U.S. Department of Energy and natural gas industry launched a new R&D program to improve the energy efficiency and reduce the environmental impact of steam boiler systems. As a part of this "Super Boiler" program, the Gas Technology Institute (GTI) and Cleaver-Brooks developed and demonstrated a novel flue gas heat recovery system with specialized controls to maximize energy efficiency and maintain stable performance under industrial conditions.

The Super Boiler uses heat recovery from flue gas to increase energy efficiency and state-of-the-art combustion to reduce emissions. The boiler is capable of a 93-94% fuel to steam efficiency conversion, while releasing less than 9 ppmv of NO_X. The first field demonstration of the Super Boiler is on a 12.2-million-Btu/h (3.5 MWth) unit at Specification Rubber Products, Inc., a manufacturer of rubber gaskets in Alabaster, Alabama. A photograph of the installation is shown in Figure 1.

Figure 1 - Photograph of Boiler and Heat Recovery System at Alabama Field Demonstration Site



Super Boiler Alabama Demonstration in Brief:

- 93-94% fuel to steam efficiencies
- <9 ppmv confirmed NO_X emissions
- 13% annual gas savings
- Running since mid 2006 with excellent results
- Smaller boiler size than conventional units
- The 300hp steam Super Boiler runs 24/5

Project Partners

- Gas Technology Institute
- Cleaver-Brooks, Inc.
- Specification Rubber Products

Technical Accomplishments

The boiler is a specially designed prototype, single-stage, 300 horsepower, two-pass, firetube boiler equipped with an ultra-low-NO_X NatCom burner and extended-surface convective pass tubes to minimize exhaust outlet temperature through high-intensity heat transfer. This unique boiler design exhibits confirmed heat transfer coefficients approximately 5 times higher than those of plain firetubes. The new boiler also uses a novel heat recovery system that employs compact heat exchangers and two nanoporous membrane devices – the transport membrane condenser (TMC) and humidifying air heater (HAH) – to recover a portion of the thermal and latent energy and water that is normally lost up the stack from a boiler. Advanced PLC-based controls are used to maximize steam generation efficiency. The patented TMC uses nanoporous membranes to help turn flue water vapor into liquid water, and the HAH system sends pre-heated humidified air to the boiler to further improve efficiency and aid in NO_X suppression.

In this plant, steam is used primarily to heat vulcanizing presses. Approximately 50 percent of the steam used by the plant is condensed and returned to the boiler room. The plant operates on a 24/5 basis, with the boiler started up on Sunday nights and shut down Friday nights. The boiler generates 120-psig (0.92 MPa) saturated steam from a nominal 12.2-million-Btu/h (3.5 MWth) natural gas input. The system was installed in March-April 2006, shaken down in May-June 2006, and put into long-term on-stream service on July 20, 2006. The boiler has shown 13% less fuel consumption than the previous conventional boiler.

Commercialization Activities

At the Alabama site, researchers faced unique challenges in designing and implementing the PLC-based control system because of site-specific conditions such as fluctuating plant condensate return. The project team is continuing in efforts to optimize the system for the industrial and commercial package boiler markets at sizes from 4 to 40 million Btu/h (1.2 to 12 MWth) across the U.S. In addition, future commercial installations are anticipated to be more compact than the configuration shown on Figure 1, with all heat recovery system components located above the boiler.

A second field demonstration will begin in February 2008 at Clement Pappas & Company in Ontario, California. In this demonstration the boiler itself will employ an advanced two-stage intercooled burner design that reduces NO_X emissions to 5 ppmv or less, while also further improving efficiency gains beyond the previous model. The boiler was built and pre-tested at Cleaver-Brooks' Thomasville, Georgia plant in January-March 2007, and has been installed at the host site for long-term testing. Figure 2 shows a photograph of the boiler installed at the California demonstration site.

A third field demonstration in West Jordan, Utah will feature a retrofit of a "Version 2.0" TMC that will implement lessons learned in previous demonstrations. The new TMC will be retrofitted to a conventional Cleaver-Brooks firetube boiler to obtain long-term operating data with the more compact, optimized design, and will further advance the prospects for commercialization of the technology.

A number of additional field demonstrations are being planned for private, Federal, industrial, and commercial sites covering a range of new boiler sizes. After energy cost savings are successfully demonstrated, Cleaver-Brooks will market a new line of high-efficiency, low-emissions industrial boilers it will name "Super Boiler." In the interim, Cleaver Brooks will offer its "Optimized" line of high pressure firetube boilers (250 – 800 HP) evolving out of the Super Boiler development process. These boilers will deliver 90% fuel-to-steam efficiency when makeup feedwater for the boiler exceeds 25% and the temperature of this water is below 80 °F.

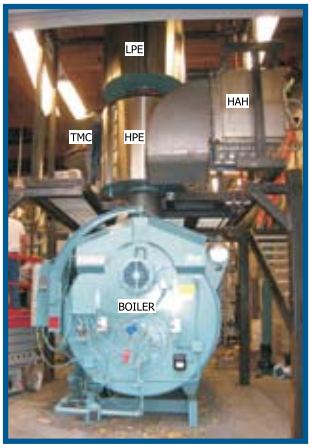


Figure 2 - Photograph of Boiler and Heat Recovery System at California Field Demonstration Site

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