Research, Development, and Field Testing of Thermochemical Recuperation for High Temperature Furnace

DE-FG36-08GO18130

American Iron and Steel Institute/Gas Technology Institute

09/30/2008 – 12/31/2013

Joseph Vehec, American Iron and Steel Institute

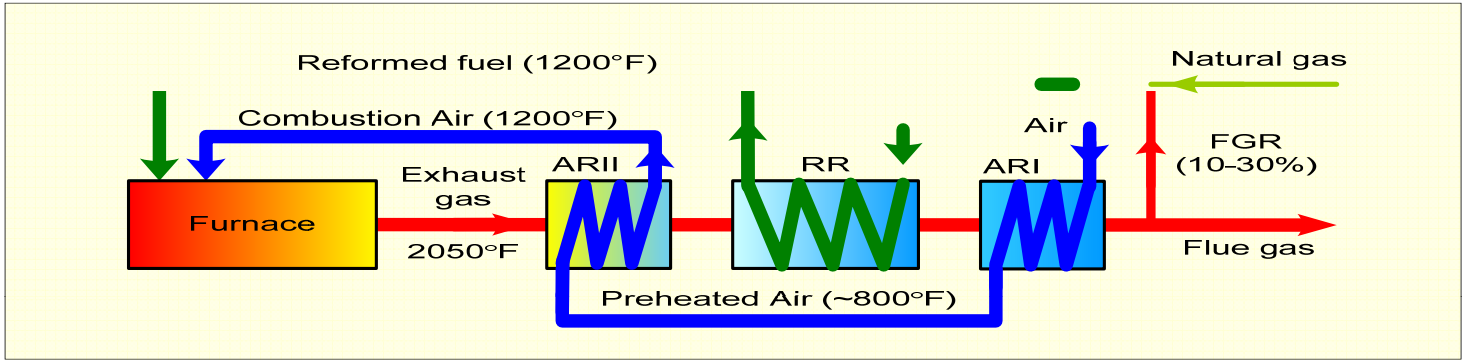
U.S. DOE Advanced Manufacturing Office Peer Review Meeting
Washington, D.C.
May 6-7, 2014

The New Steel

American Iron and Steel Institute

Project Objective

- Substantiate technical feasibility of Thermochemical Recuperation (TCR) concept and economic viability including identification of technical scale up and manufacturability concerns
  - Increase furnace thermal efficiency to 61%
  - Reduce Natural Gas usage ~ 21%
  - Reduce Carbon footprint ~ 21%
  - Reduce NO_X > 21% (due to flue gas recirculation)



Technical Approach

- Current Industry Practice: Recouping of sensible heat from waste gas to combustion air
- TCR Approach: Recouping both sensible heat from waste gas and endothermically converts fuel to higher calorific value
  - Current optimum TCR System is equivalent to preheating combustion air to 1700°F
- Innovation: TCR System consists of a non-catalytic reformer and air pre-heater in one integrated system

Technical Approach

- Project team included a leading R&D organization; three major steel companies; a major burner manufacturer; and a major recuperator manufacturer
  - Gas Technology Institute [GTI]
  - ArcelorMittal USA
  - Republic Steel
  - United States Steel Corporation
  - Bloom Engineering
  - Thermal Transfer Corporation
  - Steel Manufacturers Association
  - Union Gas Limited

Transition and Deployment

- Domestic Steel Industry competition drives reductions in costs and new regulatory requirements drives Greenhouse Gas reductions
- Initial end users - Steel Reheat Furnaces
- Future end users
  - Electric Arc Furnaces; indirect heating systems; hybrid heat recovery-and-hydrogen production
- Commercialization Approach:
  - A revised Commercialization and Market Acceptance Plan (CMP) provides details regarding natural gas price sensitivity to return on investment (ROI) success; market population, etc.

Measure of Success

- Based on an EIA projected natural gas price of $5.91 per MMbtu, the table below represents a typical range of economic paybacks for three Reference Reheat Furnace (RRF) cases
  - Note that for Case III to have a satisfactory payback the natural gas price will need to exceed $6.03 per MMBtu
- Reference Reheat Furnace (RRF)

Description	Case I	Case II	Case III
	Retrofitting an Air Recuperator on RRF without recuperation	Retrofitting a Three-unit TCR System on RRF without recuperation	Retrofitting a three-unit TCR System on RRF with existing recuperation
CAPEX	$4.3 million	$18.3 million	$14 million
Fuel Savings	$6.0 million	$9.4 million	$3.3 million
Simple ROI	8.6 months	23.4 months	50.2 months
NPV *	$19.1 million per year	$18.8 million per year	($0.25) million per year

*NPV at a 7% discount rate over six years of cash flow

Project Management & Budget

- Phase I - Feasibility Study *(October 2009)*
  - Economic evaluation for reheat furnaces
  - Established design parameters
- Phase II - R&D *(March 2012)*
  - Transition concept to a prototype for field testing
- Extended Testing *(July 2013)*
- Phase III - Prototype Field trial *(terminated December 2013)*
  - Design, fabrication and field testing of prototype at a steel company site


TCR Lab Set Up

Total Project Budget			
	Phase 2.5	**Phase 3**	**Total**
DOE Investment	1,910,649	2,675,573	4,586,222
Cost Share	818,849	1,146,675	1,965,524
Project Total	2,729,498	3,822,248	6,551,746

Results and Accomplishments

- Project work ended with Phase II - Extended Testing (Task 2.5)
- A 21% fuel reduction was validated for the reference reheat furnace (RRF) specification provided by a steel company partner
- A CAPEX was developed for both a non recuperated RRF and a recuperated RRF
- The CMP contains a sensitivity analysis of ROIs based on the above with respect to a range of natural gas prices