Thermochemical Recuperation for High Temperature Furnaces

Waste Heat Recovery Technology for Process Heating in the Steel Industry

The potential steel market for the technology could be 75% of the reported 96 Flat Products and 43 Long Products continuous reheat furnaces in the U.S. consisting of recuperated and non-recuperated pusher, walking beam and tunnel furnaces. This technology would also significantly benefit other industries that use high-temperature furnaces, such as glass manufacturing, and aluminum scrap melting operations.

The conventional method for improving the efficiency of steel reheat furnaces is to preheat the ambient combustion air by recovering a fraction of the sensible heat in the flue gases leaving the furnace. This is typically accomplished by the use of metallic recuperators (air heat exchangers). Although recuperation has increased reheating furnace efficiencies, there is a substantial opportunity within the continuous reheat furnace population to reduce fuel consumption, even in furnaces equipped with recuperators.

One approach for utilizing the energy contained in waste heat is called Thermo Chemical Recuperation (TCR). This new technique recovers sensible heat in the exhaust gas from an industrial process, furnace, or an engine. The TCR then uses that heat to transform the hydrocarbon fuel into a reformed fuel with a higher calorific heat content and utilizes this reformed fuel for process heating.

The technology has been demonstrated successfully for a number of applications but has not been evaluated and developed for commercial adoption. Researchers are now evaluating TCR for waste heat recovery. With the varying natural gas prices in the U.S., development of a new cost effective waste heat recovery technique has the potential to improve energy utilization and reduce the carbon footprint of the conventional steel reheating process.

Benefits for Our Industry and Our Nation

The potential benefits of TCR include a net reduction in continuous reheating furnace fuel use since the energy content of the fuel can be increased by over 25% when the original source fuel is natural gas. A proportional reduction in CO_2 emissions can be expected.

Additionally, TCR will reduce NO_x emissions that are generated during conventional recuperation methods, in preheat combustion air temperatures.

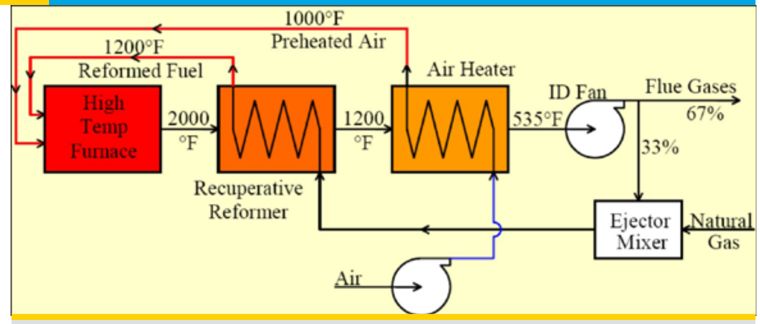

Fig 1. Thermo-Chemical Recuperation concept

Image courtesy of Gas Technology Institute.

Applications in Our Nation's Industry

Because both steam and CO_2 can be utilized in the TCR process, it is advantageous for natural gas-fired systems as these gases are major products of combustion and are therefore readily available in a preheated state.

Project Description

The project goal is to substantiate the technical feasibility of the TCR concept as well as the business viability, including identification of technical, scale-up, and processing concerns.

Barriers

- Until now, the effective utilization of the energy in the flue gases of a steel reheat furnace, to chemically change natural gas, has not been economically favorable.

Pathways

The concept that is currently being evaluated is the close-coupling of a recuperative reformer (RR) and a conventional recuperator within the dimensional envelope of the reheat furnace with a minimum footprint to conserve space. The RR would reform the natural gas using the sensible heat and the chemical energy of the flue gases. This will produce an enriched gas that would be combusted with preheated combustion air as the oxidant.

In the first phase of the project, GTI licensed simulation software that has heat transfer and chemical reaction capability along with computational fluid dynamics modeling. The evaluation focused on energy efficiency improvements and cost benefits.

Technical information developed in phase 1 is being used to design, fabricate, and iteratively test a bench-scale TCR unit at the combustion laboratory of GTI to evaluate performance metrics. The results will then be used for engineering design, construction, and retrofitting a full scale TCR system for prototype field tests on a steel reheat furnace.

Milestones

- Feasibility study to perform technical analysis, identify technical hurdles, and process scale-up issues (Completed)
- Design and test a pre-prototype bench-scale TCR unit to validate scale-up parameters
- Construct full-scale TCR prototype and test

Commercialization

AISI will be responsible for preparing and organizing the commercialization plan. AISI, acting on behalf of its member companies, will license the resulting intellectual property.

It is anticipated that Thermal Transfer Corporation will manufacture the reformer/recuperator components of TCR System for purposes of marketing the technology in steel reheat furnace applications and additionally in non-oxidizing furnaces. GTI will partner with Thermal Transfer Corporation to manufacture and market the reformer module and the convective recuperator module as an integrated system including an instrumentation package and will coordinate with Thermal Transfer in the commercialization planning. Thermal Transfer will market the reformer/recuperator and ancillary equipment, including the instrument package as a TCR System specifically tailored to steel reheat furnace applications, and sell the TCR system through their distributor network to furnace manufacturers.

Project Partners

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