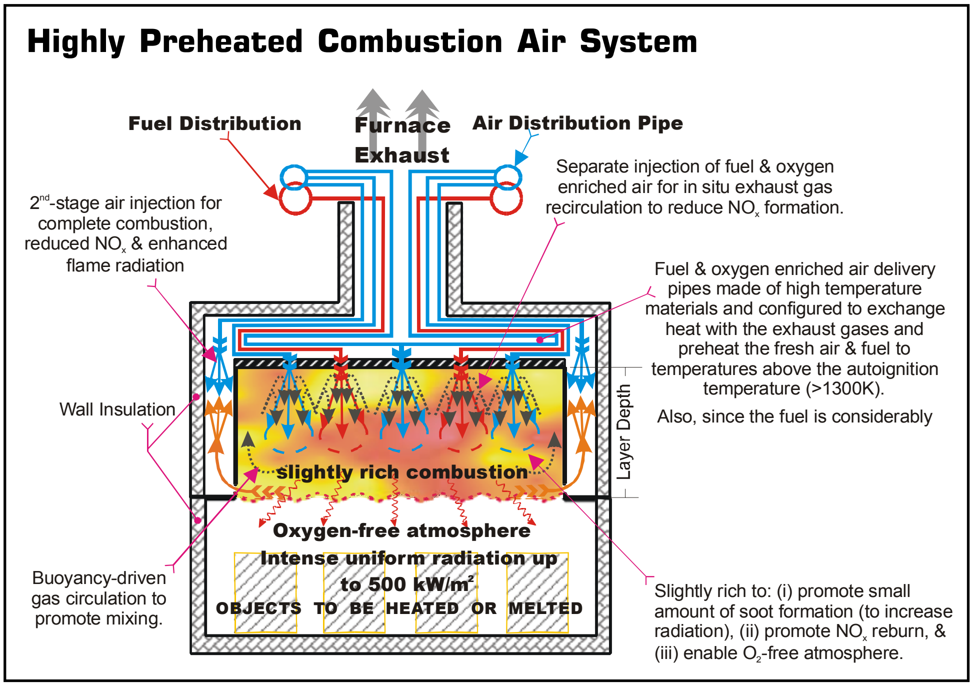
Industrial Technologies Program

Development of a Highly Preheated Combustion Air System with/without Oxygen Enrichment

Novel Furnace Design Promises Improved Energy Efficiency

The increase in energy costs, concern about greenhouse gases and energy security has increased the importance of energy efficiency in production. This is particularly important for globally-competitive and energy-intensive industries like aluminum, chemicals, glass, metal casting, pulp and paper, and steel. In the U.S. alone, the industrial sector consumes about 35 quads of primary energy. More than half of this energy is used as production process heat by energy-intensive industries. However, over 40 percent of this energy (~ 7 quads, valued at approximately $35 billion) is lost as a result of process and equipment inefficiencies. This project develops furnace technology to significantly reduce energy consumption and emissions while improving productivity. Here, wasted flue gas enthalpy is captured to highly preheat the incoming O2 or O2-enriched air and fuel. While simple in concept, this is often not done because it increases NOx production and contributes to heat flux non-uniformities within the furnace. A novel solution is proposed where exhaust gas recirculation and intense flame radiation are employed to reduce the flame temperatures and thus



A conceptual diagram of the proposed furnace configuration

Benefits

- *50-percent reduction in energy losses*
- *Increased furnace efficiency*
- *Reduced pollutant production—one fifth less NOx and one sixth less CO_2 per unit product*

Applications

The process will improve energy efficiency of furnaces used in industries with particularly high energy expenditures, such as aluminum, chemicals, forest products, iron and steel, glass, and metal casting.

Project Partners

State of Michigan Department of Consumer & Industry Services
Lansing, MI

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thermal NO. Nearly homogeneous burning is made to occur in distributed reaction zones under slightly rich conditions that enable increasing the flame radiation and also promote NO reburn. A second-stage O2/air injection completes the combustion and efficiently transfers the heat to the incoming fresh fuel and air. Near unity flame emissivities are obtained at a temperature not exceeding 1900K. The resulting uniform heat flux enables an increase in the furnace productivity or a decrease in size and cost. This concept is equally applicable to many of the nation's most energy-intensive industries and in water-tube boilers used in power production.

Project Description

Goal: The overall objective of the project is to optimize the proposed design of the natural gas furnace and demonstrate its efficiency and pollutant prevention capabilities in a small test furnace, as well as developing optical detector technology to control the furnace output. The focus of this project will be to reduce stack losses through recuperation of wasted flue-gas enthalpy, which will be used to preheat incoming oxygen-enriched combustion air and fuel. The proposed system provides nearly uniform radiation heat transfer to the objects in the furnace while maintaining strict constraints on NOx, CO, unburned hydrocarbons, and particulate emissions. It also enables heat flux levels nearly twice that of current limits, providing for increased furnace productivity or decreased size and cost. Ancillary benefits include i) an oxygen-free atmosphere within the furnace, ii) capability to burn lowheating value gases in the hot layer, as well as VOCs produced by other processors, iii) capability to attain extremely high temperatures, and iv) little required maintenance.

Milestones

1) *Furnace Design*—a small-scale furnace for testing design concepts (Year 1)
2) *Furnace Construction* (Years 1 and 2)
3) *Furnace Instrumentation and Measurements* (Years 2 and 3)
4) *Development of Detectors for Furnace Control* (Years 2 and 3)
5) *Development of Measurement Iterations* (Years 2 and 3)
6) *Industry Advisory Group/Outreach Activities* (Years 1 through 3)
7) *Project Reporting* (Years 1 through 3)

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