

Application Report

AR-145

Auto-Recupe burners heat up efficiency, cool down energy costs for Inland Steel motor lamination steel annealing line

Inland Steel Company of East Chicago, Indiana, is the sixth largest steel producer in the United States, with annual net sales of more than \$2.5 billion. Inland mines the iron ore and makes the iron used to produce carbon and high-strength, low-alloy steels for distribution to worldwide markets. In 1995, the company shipped more than five million tons of value-added steel — including cold rolled, hot rolled, coated, motor lamination, special bar quality and alloy bar — to automotive, appliance, furniture, electric motor and other manufacturers, as well as to metals service centers.

lighting ballasts. Important quality factors for these markets include the magnetic properties of the steel, such as core loss and permeability.

The Normalizer, originally built in 1957, performs a continuous heat treating process — high temperature annealing — which is critical to the quality and performance of the lamination steel. Inland's upgrade involved rebuilding the line's annealing furnace, including its refractory insulation and burner system. The original burners, typical of their era, were "straight through" types, which means that combustion occurs on one side of the furnace and exhausts out the other side. With age, and for better efficiency, the burners needed to be replaced.

According to Jerry Yothment, Inland's Section Manager for Modeling and System Control, increased burner efficiency was one of the main goals in sourcing a new burner system for the annealing furnace, but there were other objectives as well. "We wanted more up-to-date technology," he explains. "While we required high burner efficiency, we needed a system that would be reliable, easy to maintain and complied with emissions requirements of the area. After evaluating burners from several manufacturers, we determined that Eclipse Combustion's Auto-Recupe radiant tube burner system would be the best choice."



High temperature annealing is critical to the quality and performance of cold rolled motor lamination steel, used to manufacture transformers, electric motors and lighting ballasts.

More than a year ago, Inland made the decision to upgrade its #1 Continuous Normalizer Line, which processes Cold Rolled Motor Lamination steel used in the manufacture of transformers, electric motors and

An Overview of the Normalizing Process

Inland's #1 Normalizing line runs continuously, except for scheduled maintenance. In the process, the steel coils are loaded onto the line and unwound, attaching the tail of the last coil to the head of the next. The steel is transported through the 270-foot-long furnace, which is fueled by natural gas and reaches temperatures that range from 1500° F to 1800° F.



Inland's continuous heat treating line processes the steel within the chambers of this 270-foot-long furnace. Depending on the alloy, temperatures range from 1500° to 1800° F. After annealing, a chilled atmosphere of nitrogen and hydrogen cools the steel to about 400° F.

The steel's first pass is through the top level of the furnace — the heating area where the burners are located. Here the steel is heated to the required annealing temperature. After heat treating, the steel is conveyed through cooling chambers where it is cooled in a chilled furnace atmosphere composed of nitrogen and hydrogen. The cooling process requires two complete passes, each one running the entire length of the furnace. "Turn down" rolls are used within the furnace to reorient the direction of the steel and transport it to the different levels. When the steel emerges from the furnace, it has been cooled to about 400° F.

Simple Design Fired By State-of-the-Art Technology

Eclipse Combustion technical sales representatives worked closely with Inland Steel process engineers to coordinate the design and installation of a state-of-the-art burner system that fulfilled Inland's requirements. The computer-controlled system incorporates a total of 193 Eclipse Auto-Recupe Burners, Model 3019R, each with a diameter of 7.5 inches and an effective length of 84 inches. The single-ended radiant (SER) tube burners have metallic tubes that can withstand temperatures of up to 1850° F. In order to boost efficiency even higher, heat fins were added to the burner recuperators.

The Auto-Recupe provides an unprecedented level of energy conservation by virtue of its innovative operating principle. Each Auto-Recupe has a nozzle mixing burner and a recuperator mounted coaxially inside the single-ended radiant tube. Combustion air coming into the burner is preheated in the recuperative section by waste exhaust heat, reaching temperatures ranging from 850° F to 1100° F. This preheating results in energy cost savings of 37 to 62 percent over radiant tubes with sealed ambient air burners. When Auto-Recupes are used to replace atmospheric burners, the savings can run even higher.

The Auto-Recupe's simple design offers the most energy-efficient method available for radiant tube firing. Since the recuperator is mounted inside the furnace wall, heat loss is minimal. The internal tube surfaces are scrubbed with a spinning flame, which serves to provide uniform heat distribution and increase heat transfer efficiency. With exhaust and air passing the heat transfer tube in opposite directions, a highly efficient counter-flow pattern is created. In addition, NO_x and CO emissions are extremely low. Installation is simplified because no

additional hot air ductwork is required, and the unit's rear access design allows routine burner or flame maintenance to be performed without disturbing the air connection or the flame tube alignment.

According to Inland, the design and installation of the Auto-Recupe burner system into the rebuilt furnace went well. Yothment notes: "We required a considerable amount of technical information and support before and during the design phase, as well as during installation and start-up. We were pleased with the Eclipse field service support, especially during start-up, which was very smooth — in fact, a highlight of our project. In my opinion, Eclipse went beyond the call at start-up to ensure our success."

One Year Later: Efficiency Exceeds Expectations

To date, the Auto-Recupe system has met every one of Inland's objectives. One of the key factors in the decision to specify the Eclipse burner system was that Eclipse not only demonstrated the Auto-Recupe's efficiency, but was also able to quantify how the system would help to reduce Inland's energy costs in the Normalizer application.

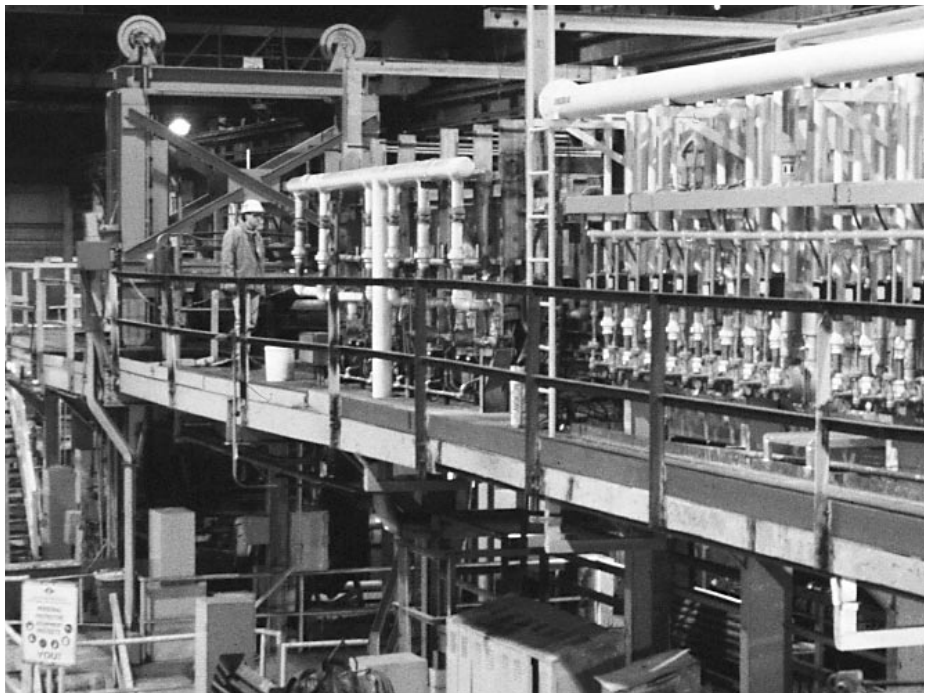
Eclipse technical sales representative, Al Benz relates: "I knew from past experience that our Auto-Recupe system delivers excellent cost savings. The system was designed for energy conservation, whether in gas and electric furnaces, convection ovens, aluminum holding furnaces, and in virtually every batch or continuous process that requires clean heat. But, from the customer's point of view, there is nothing more convincing than a dollars and cents analysis directly related to their application."

With the system up and running for a year now, Yothment states that the Normalizer furnace rebuild project as a whole — and the Eclipse Auto-Recupe burner system — have been successful in helping Inland achieve

its original business goals. He notes: "Before the project, our average monthly MMBTU/Ton* was 1.7. After the project, this figure dropped to 1.2. We attribute such a high level of improvement to the quality of the refractory insulation, the effectiveness of the furnace sealing, and the efficiency of the Auto-Recupe burners. The overall level of efficiency we have achieved has exceeded our expectations, which is a benefit both to Inland and to our customers."

As for Inland's future plans to team with Eclipse, Yothment says they are already under way. "We are currently in the process of upgrading our #5 Galvanizing line. For this job, we also selected Eclipse burners, in part because of our positive experience with the Normalizing line," he concludes.

* MMBTU/Ton is a standard measure in the steel industry denoting millions of BTUs per ton of steel processed.



Inland Steel's computer-controlled process includes an annealing oven equipped with 193 Eclipse Auto-Recupe burners, each having a diameter of 7.5 inches and an effective length of 84 inches. Since the furnace upgrade, Inland has experienced improved energy efficiency and compliant emissions.