Ceramic Heat Exchangers
Applied To An Aluminum Reverberatory

Efficient use of Energy
Table of Contents

Case History • HX-97-1 ........................................... 1
Specifications ....................................................... 1
Scope ............................................................... 1
Results ............................................................. 1
Comments .......................................................... 2
CASE HISTORY • HX-97-1
Since 1970, Heat Transfer International has designed and supplied industrial furnaces that utilize metal heat exchangers. In the early 1980s, development was started on an all-ceramic shell-and-tube heat exchanger for use in melting furnaces, incinerators and similar processes where acidic, high temperature, or particulate-laden flue gas prohibits the use of metals.

One of the country’s largest aluminum producers purchased ceramic exchangers for two reverberatories. The first went on line in late summer 1985 and the second the following October. The former, described herein, contains tubes made by the three major silicon carbide manufacturers and zoned according to anticipated service severity. The ceramic selection was based on a field test program conducted in this customer’s plant for 18 months.

The exchanger was installed directly above the main flue, and the combustion air ductwork, combustion air fan, soot blowing platforms, etc., are all well above the furnace.

SPECIFICATIONS
- 60,000 lb secondary aluminum melting furnace
- 12 million Btu/hr high fire rate with ambient combustion air
- 2,500 to 3,500 lbs/hr continuous tapping
- Primarily 5,000 series aluminum alloy
- Zoned furnace with 45,000 lbs in main chamber, 15,000 lbs in holding chamber
- One burner in holding chamber, two burners in melting chamber
- Scrap varies from 50 to 70 percent of charge
- Melting chamber designed for firing of ingots on a dry hearth and scrap melting in the bath
- Chlorinated fluxing 20 minutes out of every hour
- 1,400°F average bath temperature
- 1,750°F average furnace temperature, with excursions to 2,200°F
- 1984 average melt/hold fuel consumption was 2,850 Btu/lb.

SCOPE
Redesigned the control system to accommodate an all-ceramic, high temperature heat exchanger and maintain optimum air/fuel ratio throughout the combustion air temperature range (ambient to 1,200°F).

Supplied a furnace pressure control system to hold a slightly-positive (+.02 w.c.) furnace pressure regardless of changes in furnace pressure that are caused by varying mass flow or by opening of doors.

Supplied new high momentum burners positioned to fire directly into the bath or charge.

Supplied an all-ceramic exchanger capable of providing combustion air up to 1,200°F and still take flue gas temperatures up to 2,400°F.

The exchanger was designed to allow maintenance without furnace shutdown and soot blowing without process interruption.

The ceramics were selected to withstand both temperature cycling and acid attack during fluxing.

Supplied all the high and low temperature ductwork. This ductwork was arranged and valved in a manner to permit the operators to run the system at full-load capacity with or without the exchanger in service.

Each burner has its own fuel, air, and flame safeguard system and can be operated independently.

Combustion air temperature is measured at each burner, and the air/fuel ratio, by weight, is held automatically despite changes in the combustion air temperature.

The holding burner was not modified to use preheated combustion air.

RESULTS
The company designed and shop-fabricated the system as described above, and provided start-up engineering.

The customer installed the equipment. Since start-up, the customer has kept weekly data sheets and confirmed in writing the following:
- The furnace melts aluminum at a faster rate than previously because of higher flame temperatures and new burners.
- By directing the flame into the charge, there has been a reduction in average furnace temperature. In fact, at times the bath temperature is actually above the furnace flue gas temperature.
- The controls are operating smoothly.
- The two main burners are at high fire 40 to 50 percent of the time. The balance of the time the burners are just holding at low fire.
• Furnace production could be increased and thereby reduce Btu per pound of melt even more, but the limiting factor is the continuous casting equipment.

• Today the average fuel consumption is 2,040 Btu/lb. melt, so fuel costs have been reduced 24 percent.

• There have been substantial reductions in furnace refractory maintenance because of the lower average furnace temperature.

COMMENTS

The customer had an identical furnace in operation which accepts the same charge mixture of scrap and ingot and supplies similar continuous casting process. This duplicate furnace was modified by the addition of a furnace control system and high momentum burners. The ceramic recuperator was installed in 1991. Fuel consumption in the second furnace without the recuperator is 2,700 Btu/lb. melt, of which 460 Btu are from the holding zone and 2,240 Btu from the main chamber.

The installation with the recuperator operates with 1,580 Btu/lb. melt in the melting chamber and 460 Btu/lb. melt in the holding chamber. Again, the 1,580 Btu/lb. melt would be less than 1000 if the tapping rate could be increased.

Heat Transfer International has also installed these all-ceramic heat exchangers on industrial incinerators and batch style aluminum melting furnaces. Units have been in service since 1982 using material that has been tested in the laboratory and field since 1975. Those in service are on furnaces as small as 500,000 Btu/hr. (total furnace heat release) up to 42 million Btu/hr.

All-metal recuperators are available when acid or high temperature is not a problem. Hybrid metal/ceramic combinations are used when only high temperature, clean flue gas is the major consideration. All-ceramic construction is used when acids and/or particulate attack is prevalent, regardless of temperature, and when the flue gas temperature is between 1,800°F and 2,800°F. Heat Transfer international is able to supply not only the exchanger but also controls, materials, and engineering needed to modernize the entire furnace.

Heat Transfer International has patents and patents-pending on three all-ceramic, air-to-air, shell-and-tube heat exchangers for low (1" to 16" w.c.), medium (1/2 psig to 5 psig), and high (50 psig to 200 psig) differential pressures. All the exchangers can operate with flue gas temperatures up to 2,600 °F and indirectly preheat clean air up to 2,200 °F. Leakage from the air side to the flue gas side is minimal and can be controlled.

Low pressure machines are used to pre-heat combustion air in the incinerators and light metal remelt furnaces. Medium pressure devices are ideal for the chemical processing and carbon black industries. High pressure machines can supply clean, hot air to drive gas turbine generator sets.