Suggested Actions

Questions to ask if your furnace can be adapted to load preheating (not all can be):

1. Would combustion air preheating or some other savings measure be cost-effective?
2. How large a preheating chamber is needed?
3. Do you have enough space for a preheater that size?
4. You might have to restrict exhaust gas paths so they will come in contact with the load. Will this interfere with exhaust gas flow and cause too much backpressure in the furnace chamber?
5. How will incoming parts move through the preheating chamber? If conveying equipment is needed, can it withstand exhaust gas temperatures?

Questions to ask before adding a separate load preheat section or chamber:

1. How would flue gases move to the heating chamber? Will a fan or blower be needed to overcome pressure drops in ducts?
2. Does heat demand equal heat supply during most of the heating cycle time?
3. How would the hot load be transferred to the main furnace? Would the heat loss be considerable?
4. What type of controls are required to maintain the desired temperature in the preheat chamber? Will an auxiliary heating system be needed?

Resources

See also the *ASM Handbook*, Volumes 1 (1990) and 2 (1991); Materials Park, OH: ASM International.

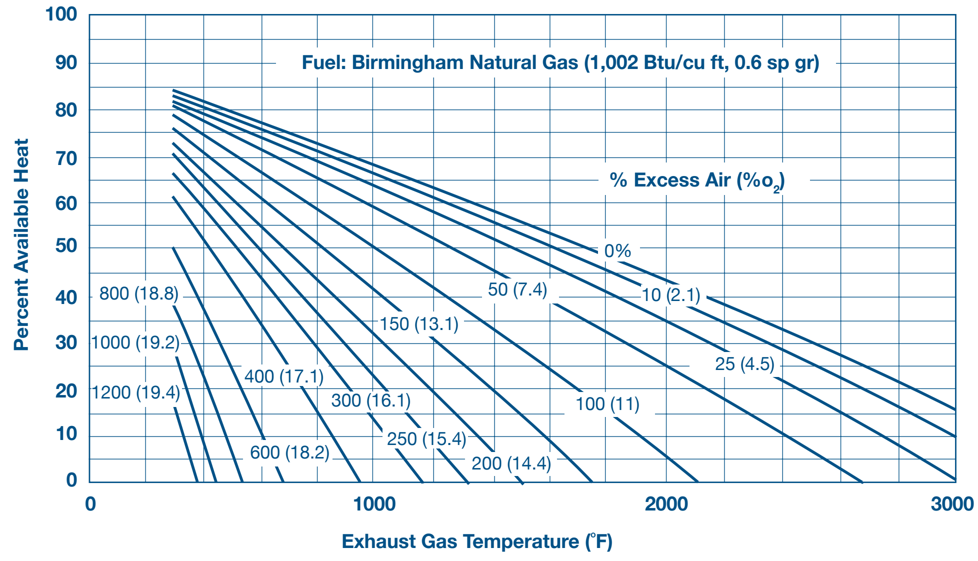
U.S. Department of Energy— For additional information on process heating system efficiency, to obtain DOE's publications and Process Heating Assessment and Survey Tool (PHAST) software, or to learn more about training, visit the BestPractices Web site at www.eere.energy.gov/industry/bestpractices.

Load Preheating Using Flue Gases from a Fuel-Fired Heating System

The thermal efficiency of a heating system can be improved significantly by using heat contained in furnace flue gases to preheat the furnace load (material coming into the furnace). If exhaust gases leaving a fuel-fired furnace can be brought into contact with a relatively cool incoming load, heat will be transferred directly to the load. Since there is no intermediate step, like air or gas preheating, in the heat recovery process, this can be the best approach to capturing waste heat. Load preheating is best suited for continuous processes, but it can sometimes also be used successfully with intermittently operated or batch furnaces. Load preheating can be achieved in a variety of ways, including these:

- Use of an *unfired load preheat section*, in which furnace flue gases are brought in contact with the incoming load in an extended part of the furnace.
- Use of an *external box*, in which high-temperature furnace flue gases are used to dry and/or preheat the charge before loading in a furnace.
- Use of a *counter-current* flow design in a furnace or a kiln, in which the burner gases flow in the opposite direction of the load being heated.

Figure 1. Available Heat Chart



The amount of energy savings obtained by using load preheating is *higher* than the amount of actual heat transferred to the load. The "net" heat delivered to the load has to account for the efficiency of the furnace. Since the furnace efficiency is always less than 100%, the resulting energy savings exceed the energy picked up by the load. Load preheating can result in higher production from the same furnace.

Example

An aluminum die cast melting furnace has an average production rate of 1,000 lb/hr. As metal is drawn from the furnace at 1,400°F, the molten bath is periodically replenished with ingots at room temperature. The furnace exhaust temperature is 2,200°F. Wall conduction and opening radiation losses average 100,000 Btu/hr. The burners operate at 20% excess air. The graphs and tables in the reference below (and other sources) show that the molten metal requires 470 Btu/lb heat, for a total of 470,000 Btu/hr. Total net input to the furnace equals heat to the load plus wall and radiation losses, or 470,000 + 100,000 Btu/hr = 570,000 Btu/hr.

For 20% excess air and 2,200°F exhaust temperature, the available heat is 31%, based on Figure 1. This means 69% of the heat input is wasted in flue gases. Divide this into the net input: 570,000 Btu/hr ÷ 0.31 = 1, 838,700 Btu/hr total input to the furnace. The exhaust gas loss is 1,838,700 – 570,000 = 1,268,700 Btu/hr.

The furnace is modified to route the exhaust gases to the stack through a slightly inclined, refractory-lined tunnel. Exhaust gases flow counter to the incoming ingots, preheating them. The ingots are heated to an average temperature of 600°F and contain 120 Btu/lb, or 120,000 Btu/hr, for a 1,000 lb/hr production rate. Preheating the cold ingots to 600°F lowers the amount of heat required from the furnace to (470 – 120) Btu/lb x 1,000 lb/hr = 350,000 Btu/hr.

As an approximation, assume that the flue gas temperature from the melting section of the furnace remains constant at 2,200°F and the available heat remains the same (31%). Total input to the furnace is now (350,000 + 100,000) ÷ 0.31 = 1,451,600 Btu/hr. Savings are (1,838,700 – 1,451,600) / 1,838,700 = 387,100 / 1,838,700 = 0.2105, or 21.1%.

This is a rough estimate. Actual savings will be greater, because lowering the burner firing rate decreases the furnace exhaust gas temperature and volume, resulting in higher available heat with further reductions in fuel input. Because the furnace input could still be 1,838,700 Btu/hr, with net available heat of 470,000 Btu/hr for aluminum, while the heat demand for 1,000 lb/hr aluminum charge is only 350,000 Btu/hr, it is possible to increase production by (470,000 – 350,000)/470,000 = 25.5%. Check the material handling system to see if it is capable of handling the additional load and if the downstream processes can accommodate increased melter production.

Reference

W. Trinks et al. *Industrial Furnaces, Sixth Edition*. New York: John Wiley & Sons, Inc. 2003.

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