Preheated Combustion Air

For fuel-fired industrial heating processes, one of the most potent ways to improve efficiency and productivity is to preheat the combustion air going to the burners. The source of this heat energy is the exhaust gas stream, which leaves the process at elevated temperatures. A heat exchanger, placed in the exhaust stack or ductwork, can extract a large portion of the thermal energy in the flue gases and transfer it to the incoming combustion air. Recycling heat this way will reduce the amount of the purchased fuel needed by the furnace.

Many processes produce dirty or corrosive exhaust gases that will plug or attack heat exchangers. Some exchangers are more resistant to these conditions than others, so if your process is not a clean one, do not give up without investigating all the options. When discussing it with potential vendors, be sure to have a detailed analysis of the troublesome materials in your exhaust gas stream.

Fuel savings for different furnace exhaust gas temperature and preheated combustion air temperatures can be found in the table on page 2 and can be used to estimate reductions in energy costs.

There are two types of air preheaters: recuperators and regenerators. Recuperators are gas-to-gas heat exchangers placed on the furnace stack. Internal tubes or plates transfer heat from the outgoing exhaust gas to the incoming combustion air while keeping the two streams from mixing. Recuperators are available in a wide variety of styles, flow capacities, and temperature ranges. Regenerators include two or more separate heat storage sections, each referred to as a regenerator. Flue gases and combustion air take turns flowing through each regenerator, alternately heating the storage medium and then withdrawing heat from it. For uninterrupted operation, at least two regenerators and their associated burners are required: one regenerator is needed to fire the furnace while the other is recharging.

Payback Period = (Cost of combustion air preheating system, obtained from the supplier or contractor) ÷ (Reduction in fuel usage, Million Btu/hr x Number of operating hours per year x Cost of fuel per Million Btu)

Example

A furnace operates at 1,600°F for 8,000 hours per year at an average of 10 million British thermal units (MMBtu) per hour using ambient temperature combustion air. At $9 per MMBtu, annual energy cost is $720,000. Use of preheated air at 800°F will result in 22% fuel savings, or $158,400 annually. The preheated air system installation is estimated to cost $200,000 to $250,000, with a simple payback period of 15 to 19 months.

Payback Guidelines

Process temperature is customarily used as a rough indication of where air preheating will be cost effective. Processes operating above 1,600°F are generally good candidates, while preheated air is difficult to justify on processes operating below 1,000°F. Those in the 1,000° to 1,600°F range may still be good candidates but must be evaluated on a case-by-case basis.

These guidelines are not ironclad. Financial justification is based on energy (or Btu) saved, rather than on temperature differential. If a low temperature process has a high enough exhaust gas flow, energy savings may still exist, even though the exhaust gas temperature is lower than 1,000°F.

Suggested Actions

- Using current or projected energy costs, estimate preheated air savings with this example or the Process Heating Assessment and Survey Tool (PHAST) available from the U.S. Department of Energy's (DOE) Industrial Technologies Program.
- Contact furnace or combustion system suppliers to calculate payback period or ROI.

References

Combustion Technology Manual. Published by Industrial Heating Equipment Association (IHEA), Arlington, Virginia 22209.

Maintenance and Adjustment Manual for Natural Gas and No. 2 Fuel Oil Burners. Technical Information Center, U.S. Department of Energy.

Handbook of Applied Thermal Design, edited by Eric C. Guyer. Published by McGraw Hill Book Company.

Resources

For additional information on process heating system efficiency, to obtain DOE's publications and Process Heating Assessment and Survey Tool (PHAST) software, or learn more about training, visit the Industrial Technologies Program Web site at *www.industry.energy.gov.*

节能措施——工艺加热

工艺加热内情报告1

助燃空气预热

对使用燃料的加热工艺来说，提高能效和生产能力的最有效的方法之一就是对进入燃烧炉的助燃气体进行预热。工艺系统排出的废气具有较高的温度，可用来预热助燃空气。安放在排气管和排气管道系统中的换热器可以从烟气中吸取大部分的热能，并将它转移到助燃空气中。这样，通过热力的回收利用，锅炉需要的燃料量将会降低。

许多工艺会排出很脏的或有腐蚀性的废气，这些废气会堵塞或损坏换热器；但有些换热器抵抗废气的能力要好于其他换热器。因此即使工艺排出的废气不干净，也不要放弃对所有可能性的探索。在与潜在的设备商进行洽谈时，确保对废气中所有可能带来麻烦的成份进行一次详细的分析。

右表中列出在不同废气温度和不同的助燃空气温度下，可以实现的燃料节省量。该表也可以用来估算能源成本节省量。

有两种空气预热器，一种是传热型余热回收器，另一种是蓄热型余热回收器。传热型余热回收器是气体到气体的换热器，通常放置在炉体上。该回收器内部管道将向外流动的废气中的热量转移到向内流动的助燃气体中，与此同时，避免两股气体的接触和混合。传热型余热回收器有多种不同的模式，流量大小和温度范围。蓄热型余热回收器包括两个以上的单独的蓄热区，每一个蓄热区都是一个余热回收器。废气和助燃空气轮流穿过每一个蓄热区，交替地加热蓄热体，然后又从蓄热体中提取热量。如果要不间断的运行，则至少需要两个蓄热区和蓄热区配备的燃烧炉，因为当一个蓄热区对锅炉进行加热的时候，需要另一个蓄热区进行余热回收。

回收期 =（助燃空气预热系统的成本，从供货商或承包商处获得）÷（燃料节省量（吨标准煤/每小时）× 每年运行小时数 × 燃料的单位成本（美元/每吨标准煤）

示例

一台锅炉在871摄氏度（即1600华氏度）的状态下每年运行8000小时，每小时能耗为360 千克标准煤（即1千万英国热量单位），利用的是处于室温状态下的助燃空气。因为每36千克标准煤（即1百万英国热量单位）的成本为9美元，因此年能源成本是72万美元。将助燃空气预热到427 摄氏度（即800华氏度）将带来22%的燃料节省量，即每年节省158,400美元。安装空气系统预热器的成本大约在20万美元到25万美元，该预热系统的简单回收期是15到19个月。

投资指南

工艺温度通常作为衡量进行空气预热是否经济有效的一个粗略指标。如果工艺系统运行温度超过871摄氏度（即1600华氏度），它们通常可以考虑使用预热空气；而对于运行温度低于538摄氏度（即1000华氏度）的系统，则不太适用。对于运行温度介于538摄氏度（即1000华氏度）和871摄氏度（即1600华氏度）之间的工艺系统，他们可以考虑使用预热空气，但是必须对具体情况进行具体分析。

这些指导原则并不是一成不变的。对经济效益的考虑应该基于节能量大小而不是温度的差别。如果一个低温工艺系统有很高且足够的废气，这个工艺系统仍然有能源节省量，哪怕废气温度已经低于538摄氏度（即1000华氏度）了。

Percent Fuel Savings Gained from Using Preheated Combustion Air 使用预热的助燃空气可以获得的节能比例

Furnace Exhaust Temperature, ˚C	Preheated Air Temperature, ˚C					
	316	427	538	649	760	871
538	13	18	–	–	–	–
649	14	19	23	–	–	–
760	15	20	24	28	–	–
871	17	22	26	30	34	–
982	18	24	28	33	37	40
1,093	20	26	31	35	39	43
1,204	23	29	34	39	43	47
1,316	26	32	38	43	47	51

Fuel: Natural gas at 10% excess air: Source: IHEA Combustion Technology Manual (see References).
注：左边纵轴显示的是废气温度（摄氏度），右边为预热的助燃空气温度（摄氏度）。
燃料为天然气，在过量空气10%的状态下使用。来源：IHEA 《燃烧技术指南》（见参考资料）。

建议采取的行动

- 利用目前或预计的能源成本，估算预热助燃空气带来的节省量。可以采用上述提到的例子，也可以采用美国能源部工业技术项目提供的工艺加热评估和测量工具（PHAST）。
- 与锅炉或燃烧系统供应商联系，计算投资回收期或投资回收率（ROI）。

参考资料

《燃烧技术指南》。由工业加热设备协会（IHEA）出版。阿灵顿，弗及利亚 2009.
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《应用热力设计手册》，Eric C. Guyer主编，McGraw Hill Book Company 出版。
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如想进一步了解工艺加热系统提高能效的信息，获取美国能源部的报告以及工艺加热评估和测量工具（PHAST），或想进一步了解有关的培训，请访问美国能源部工业技术项目的网站*www.industry.energy.gov*。

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DOE/GO-102010-3161 • October 2010

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