

**U.S. Department of Energy - Energy Efficiency and
Renewable Energy
Energy Matters**

**Increased Efficiency through Waste Heat
Recovery**

From the [Fall 2001](#) issue of *Energy Matters*

*By Richard L. Bennett, President, Janus Technology Group Inc.,
Rockford, IL*

Many industrial heating processes generate large amounts of waste energy that simply pass out the stacks and into the atmosphere. When energy is abundant and cheap, no one seems to notice, but when supplies get pinched and prices climb, people begin to realize just how much of their fuel dollar goes sailing into the blue.

Techniques for Heat Recovery

Stack exhaust losses are part of all fuel-fired processes, and they increase with the exhaust temperature and the amount of excess air the exhaust contains. At stack gas temperatures greater than 1,000°F, the heat that is carried away is likely to be the single biggest loss in the process. Above 1,800°F, stack losses will consume at least 50% of the total fuel input to the process. Waste heat recovery offers a great opportunity to put some of this energy to work, reducing energy consumption and emissions and increasing productivity. There are several techniques for heat recovery, all based on intercepting the waste gases before they leave the process, extracting some of the heat they contain, and recycling that heat.

Direct heat recovery to the product. This is the most efficient method. It takes advantage of the fact that even in the highest temperature processes, the product or charge enters the process at ambient temperature. If exhaust gases leaving the high temperature portion of the process can be brought into contact with a relatively cool incoming load, energy will be transferred to the load, preheating it and reducing the energy that finally escapes with the exhaust.

More often, heat is transferred to a surrogate medium, like combustion air to the burner system. This reduces the amount of

purchased fuel required to sustain the process. Figure 1 shows how preheating combustion air affects available heat, which is the thermal efficiency of the combustion process itself.

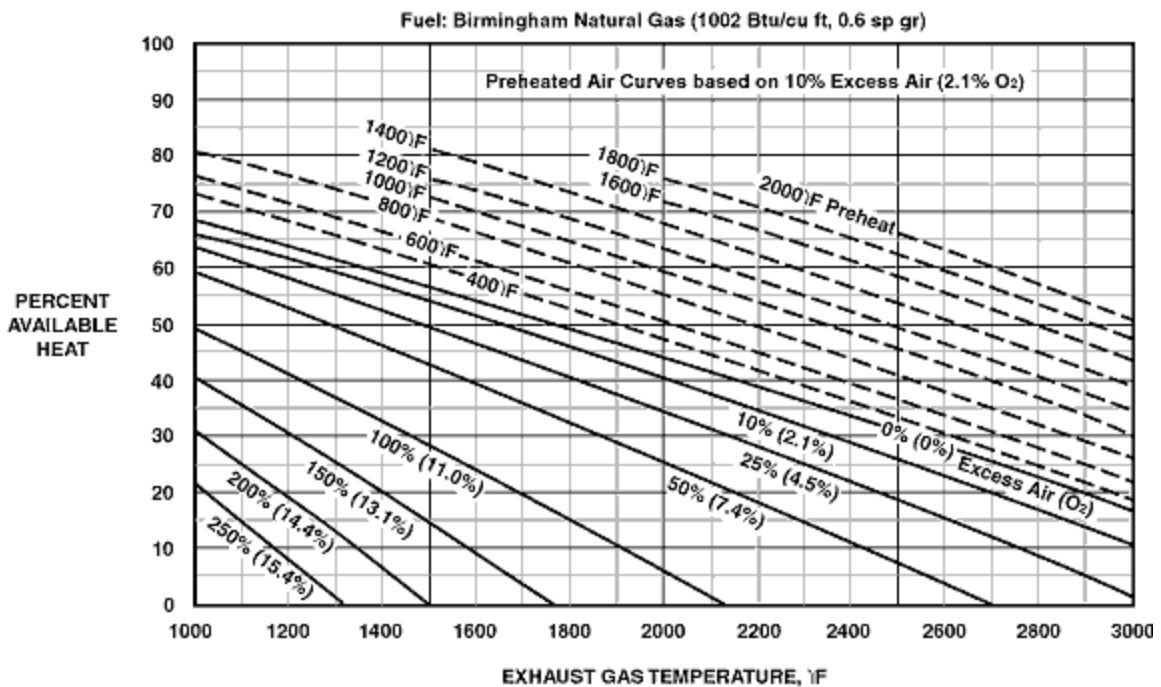


Figure 1. Effects of preheating combustion air on available heat.

Recuperators. A Recuperator (Figure 2) is a gas-to-gas heat exchanger placed on the stack of the furnace. There are numerous designs, but all rely on tubes or plates to transfer heat from the outgoing exhaust gas to the incoming combustion air, while keeping the two streams from mixing. They are the most widely used heat recovery devices.

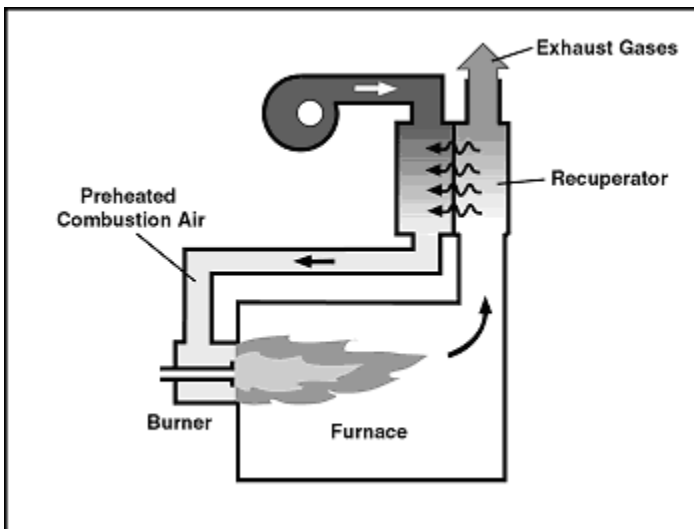


Figure 2. Recuperators transfer heat from outgoing gas to incoming combustion air without allowing streams to mix.

Regenerators. These are essentially rechargeable storage batteries for heat. A regenerator is an insulated container filled with metal or ceramic shapes capable of absorbing and storing relatively large amounts of thermal energy. During part of the operating cycle, process exhaust gases flow through the regenerator, heating the storage medium. After a while, the medium becomes fully charged, so the exhaust flow is shut off and cold combustion air is admitted to the unit. As it passes through, the air extracts heat from the storage medium, increasing in temperature before it enters the burners. Eventually, the heat stored in the medium is drawn down to the point where it's necessary to recharge the regenerator. At that point, the combustion airflow is shut off and the exhaust gases return to the unit. This cycle repeats as long as the process continues to operate.

Obviously, if the process is to operate without interruption, at least two regenerators (and their associated burners) are required—one to provide energy to the combustion air while the other is recharging. It is much like using a cordless power tool—to use it continuously, you must have at least two batteries to swap out between the tool and the recharger.

The fundamental difference between recuperators and regenerators is the way they keep the exhaust gases and combustion air from cross-contaminating each other. Recuperators separate the gas streams with a physical barrier so they can operate continuously.

Regenerators operate intermittently, keeping the streams separated by time.

Waste Heat Boilers. Here is an option for plants that require a source of steam or hot water. They are similar to conventional boilers with one exception—they are heated by the exhaust gas stream from a process furnace instead of their own burners.

Making the Choice

How do you decide which recovery technique is right for your operation? In some instances, more than one might fill the bill, but here are some basic points that factor into the selection process.

- Direct heat recovery to the product has the highest potential efficiency, because it doesn't require any "carrier" to return the energy to the product. However, it does require a furnace or oven configuration that permits routing the stream of exhaust gases counterflow to incoming product or materials. This usually rules out most batch-type heating equipment.
- Recuperators are available in the widest range of sizes, configurations, and temperature ranges, and they don't require elaborate combustion control systems. However, they must be protected against overheating damage on high-temperature processes and may not be suitable for some corrosive or dirty exhaust gases.
- Regenerators can operate at temperatures beyond the range of recuperators and at higher efficiency ratings. They are highly resistant to corrosion and fouling, but because of their back-and-forth switching, they require more complex, expensive flow control systems than recuperators do.
- Waste heat boilers may be the answer for plants seeking more steam capacity, but keep in mind the boiler generates steam only when the process is running. Where this is a concern, boilers with auxiliary burners may be the answer.

Contact Richard Bennett by e-mail at janustech@compuserve.com, or by phone at 815-282-8044.