Process Heating: The Basics – IHEA Series Part 1

Process heating—the practice of applying heat in an industrial setting to achieve material transformation during the production of products—is older than you may think.

Yes, today process heating is used in a number of manufacturing, energy-related, and science-based industries, with specific sub-processes of process heating totaling more than a dozen. In fact, of all manufacturing operations, process heating consumes more energy in the United States than any other manufacturing system.

That said, the art of process heating dates back to a simpler time and a much simpler process. It can easily be said that the origins of process heating lie in the work of the blacksmith—and the task of heating metal over an open flame for the purpose of re-shaping some sort of metallic material. In a sense, those simple roots carry through today. In fact, there are still only three types of process heating: Fuel-Based Process Heating, Electric-Based Process Heating, and Steam-Based Process Heating.

Fuel-Based Process Heating

In a fuel-based process heating system, heat is generated by any combustion of solid, liquid, or gaseous fuel, and is then transferred either directly or indirectly to the material. The combustion gases can either be in contact with the material (direct heating) or be confined—that is, separated from the material (indirect heating: radiant burner tube, retort, muffle). Examples of fuel-based process heating equipment include furnaces, ovens, kilns, lehrs, and melters.

Electric-Based Process Heating

In an electric-based process heating system (often called *electrotechnology*), electric currents or electromagnetic waves are used to heat materials. Direct heating methods generate heat within the workpiece itself, by either (1) passing an electrical current through the material, (2) inducing an electrical current (an eddy current) into the material, or (3) exciting atoms and/or molecules within the material with electromagnetic fields—such as radio frequency (RF) or microwave (MW).

Steam-Based Process Heating

Steam-based process heating systems are used to deliver energy needed for process heating, pressure control, mechanical drives, separation of components, and production of hot water for process reactions. Steam has several favorable properties for process heating applications, including the ability to hold a significant amount of energy on a unit mass basis (between 1,000 and 1,250 British thermal units per pound [Btu/lb]). Because most of the heat content of steam is stored as latent heat, large quantities of heat can be transferred efficiently at a constant temperature, which is a useful attribute in many process heating applications. Steam-based process heating has low toxicity, ease of transportability, and high heat capacity. And by the way, steam-based process heating accounts for approximately 30% of the total energy used in industrial applications for product output.

With the three basic types of process heating defined, it's important to remember that each application has one thing in common—the generation and transfer of heat, which falls into these major categories:

Agglomeration and **Sintering** refers to the heating of a mass of fine particles (such as lead concentrates) below the melting point to form larger particles or solid parts. Sintering is commonly used in the manufacturing of advanced ceramics and the production of specialty metals.

Calcining is the removal of chemically bound water and/or gases, such as carbon dioxide, through direct or indirect heating. Common applications include construction materials such as cement and wallboard, the recovery of lime in the kraft process of the pulp and paper industry, the production of anodes from petroleum coke for aluminum smelting, and the removal of excess water from raw materials for the manufacture of specialty optical materials and glasses.

Curing is the controlled heating of a substance to promote or control a chemical reaction; in the manufacture of plastics, curing is the cross-linking reaction of a polymer. Curing is a common process step in the application of coatings to metallic and nonmetallic materials, including ceramics and glass.

Drying is the removal of free water (water not chemically bound) through direct or indirect heating. It is common in the stone, clay, and glass industries, where the moisture content of raw materials, such as sand, must be reduced; and in the food processing, textile manufacture, and chemical industries, in general.

Fluid Heating is used to increase the temperature of a liquid or gas, including the complete or partial vaporization of the fluid, and is performed for a wide range of purposes in many industries, including chemicals, food processing, and petroleum refining.

Forming operations, such as extrusion and molding, use process heating to improve or sustain the workability of materials. Examples include the extrusion of rubber and plastics, the hot-shaping of glass, and plastic thermoforming.

High-Temperature Heating and Melting are conducted at temperatures higher than most steam-based systems can support (above 400˚F, although very high-pressure steam systems support higher temperatures and are used in applications like petroleum processing). High-temperature heating is typically performed on metals, but this category does not include metals reheating or heat treating.

High-temperature melting is the conversion of solids to a liquid by applying heat, and is common in the metals and glass industries. Melting can be combined with refining processes, which demand the increase of temperature to remove impurities and/or gases from the melt. Metal melting processes comprise both the making of the metals, such as in the conversion of iron into steel, and the production castings. Energy-intensive nonmetal melting applications include container and flat-glass production.

Low-Temperature Heating and Melting is done at temperatures that steam-based systems can support (less than 400˚F), although not all applications are steam-based. Nonmetallic liquids and solids are typically heated or melted.

Heat Treating is the controlled heating and cooling of a material to achieve certain mechanical properties, such as hardness, strength, flexibility, and the reduction of residual stresses. Heat treating is used extensively in metals production, and in the tempering and annealing of glass and ceramics products.

Incineration is the process of reducing the weight and volume of solids through heating, whereas thermal oxidation refers to heating waste (particularly organic vapors) in excess oxygen at high temperatures. The main application is the treatment of waste to render it disposable via landfill.

Metal Reheating is used to establish favorable metalworking properties for rolling, extrusion, and forging. Metal reheating is an important step in many metal fabrication tasks.

Smelting is the chemical reduction of a metal from its ore, typically by fusion. This process separates impurities, thereby allowing their removal from the reduced metal.

For those new to the concept of Process Heating, bear in mind that this is a basic introduction to the technological advances made over centuries to a very simple idea—that of applying heat to material to enhance or even define a manufacturing process. And consider this: New ideas are being applied every day to this technology. For example, hybrid systems, which use a combination of one or more process heating systems by using different energy sources or different heating methods of the same energy source, are becoming more common in a number of industries—proof that there is always something new to learn when it comes to Process Heating.

This article is Part 1 of our series on improving process heating system performance. If you would like more information about such systems, or process heating in general, contact us here at BDC, Inc.