Efficiency rises with convection

CONVECTION HEATING TECHNOLOGY IS PROVIDING INDUSTRIAL BAKERS WITH INCREASED END-TO-END BAKING EFFICIENCY, MAXIMISING THROUGHPUT AND REDUCING ENERGY CONSUMPTION.

++ **author:** Osvaldo Demin, Auto-Bake chief design engineer

++ figure 1

++ **figure 1**
Auto-Bake's two-pan-wide convection oven allows industrial bakers to leverage Auto-Bake's convection baking technology, while dramatically increasing production

Over the years, modern industrial bakers have fine-tuned the baking process, in order to consistently produce a diversity of product. By combining traditional recipes with a range of sophisticated automated baking technologies and heating systems, bakers are able to tailor baking profiles, while increasing throughput, reducing bake times and minimising energy consumption.

These automated high-volume continuous industrial baking systems usually incorporate radiant or convection heating systems (or a combination of the two). Conduction heat transfer is also prevalent in both convection and radiant baking processes. Often, it is the chosen heating system that holds the key to achieving optimal baking-line efficiency, as well as desired product taste, texture and finish.

Convection baking technology in particular, is emerging as one of the most versatile and energy-efficient heating mediums. To leverage the benefits of convective baking, it is crucial that bakers understand the physics of convection and how it differs from other heating mechanisms.

Convection class

Convection is an ideal heating mechanism for baking a range of products, especially those that require an all-over finish, colour or texture, such as breads, cakes, pastries and cookies. Currents of hot air are circulated around the entire exposed surface of the product, permeating the smallest gaps and crevices. The pervasive nature of convective heat enables products to be baked from all angles--top, bottom and sides. This is ideal for high-volume applications where products are often closely packed throughout the baking process.

While convection employs hot air to transfer heat, radiant heat transfer relies on a heat source emitting electromagnetic waves. Rather than heating the surrounding air, the radiant electromagnetic waves cause the atoms within the nearby objects to vibrate and heat up, or bake. The temperature and shape of the heat source impact on the velocity, frequency, and length of the radiation wave, and therefore affect the resultant bake. Electric coils are a common source of radiant heat, however radiant heating elements often employ intermediate heating mediums such as thermal oil. The radiant heat produced by such thermal oil systems, delivers a softer heat that provides a gentler bake, ideal for slower baking applications.

In the broader sense, convection involves the transfer of heat through a fluid (liquid or gas) medium, whereby the molecules of the fluid actually carry the heat. As air is heated, it expands, becomes less dense, and rises, displacing cold air in its path. The hot air then cools and drops, resulting in a 'heat-rise-cool-drop' cycle. This type of convection is normally described as 'natural convection', while the flow of fluid is referred to as 'convection currents' (see figure 2). When the fluid motion is generated by any external source, such as a pump or fan, it is termed 'forced convection'.

When foods are cooked in a convection oven, heat and mass transfer take place simultaneously. Heat is transferred from the air to the product, while at the same time moisture is ▶

Auto Bake Serpentine with convection heating

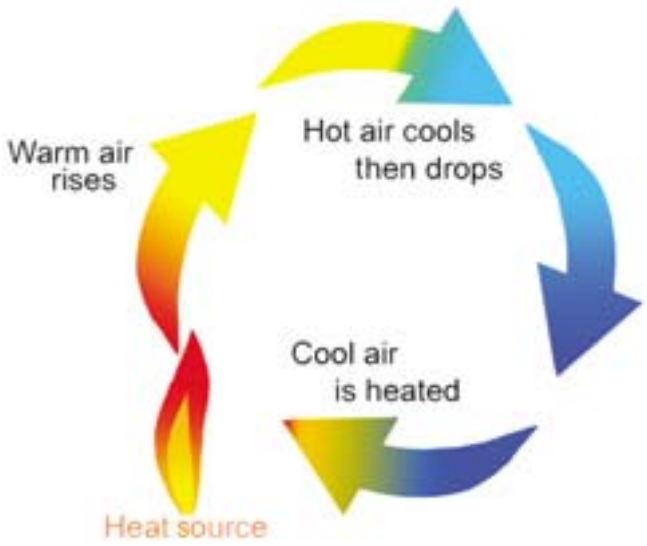
Auto-Bake, has developed a variant of its compact Serpentine oven, featuring convection heating. The Serpentine convection technology allows bakers to leverage the unique compactness of the Serpentine oven, while utilising the characteristic pervasive heat of convection systems.

The Auto-Bake convection oven is based on simple principles. Air is heated and transported to the baking chamber where it is 'blown over' the product, causing it to bake. The cooled air is then returned to the burner where it is reheated. Auto-Bake's convection oven incorporates sophisticated air distribution and recycling technology, that enables uniform heat distribution, without 'hot' or 'dead' spots. A direct-fired burner heats incoming air, while a fan system delivers the heated air to the baking chamber via thermally-insulated ducting. The ducting is, in turn, linked to a number of perforated 'plenums' that span the width and length of the oven, and distribute the heated air into the various levels of the baking chamber. Damper mechanisms on each of the plenum inlets control the distribution of heated air to the top and underside outlets of the plenums, allowing a tailored and consistent heat distribution across the oven. The plenums present not only a means by which to distribute the heated air, but, once heated, are a source of soft radiant heat that complements the convective heat.

As with all Serpentine ovens, baking trays move through the Serpentine ovens and coolers via an ingenious vertical 'S' configuration transport system, allowing the product to be conveyed horizontally through numerous thermal zones. Bakers are able to tailor the baking profile via the precision-control of these thermal zones. Each zone is equipped with its own separate heating system, including burner, fan, ducting and plenum. The compact design of the Serpentine convection oven – having a footprint just one-tenth of an equivalent tunnel oven technology – allows heat to be delivered where and when it is needed. Its streamlined construction enables the effective distribution and efficient recirculation of heated air. The baking chamber air-intake is located within one metre of the combustion chamber, ensuring minimal energy is lost in transit and heat is retained. This is made possible by the compact design of the Serpentine convection technology.

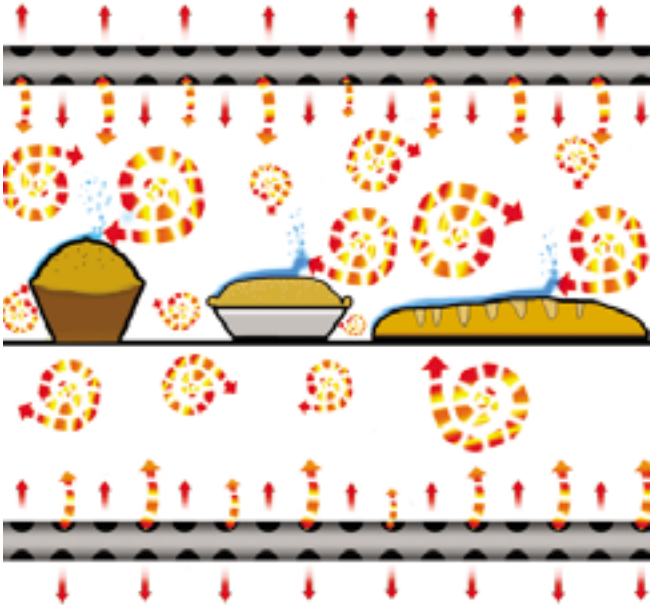
Another contributor to the energy efficiency of Auto-Bake's Serpentine convection oven is its direct-fired heat transfer technology. Direct flame-to-air heat transfer provides immediate and effective heat, and is not susceptible to heat losses associated with the use of intermediate heat exchangers. Furthermore, with natural gas and diesel fuel often the most cost-effective energy sources compared with electricity, operating expenses can be further reduced. +++

++ figure 2



++ figure 2
Convection currents are caused by the 'heat-rise-cool-drop' cycle that occurs when air is heated

++ figure 3



++ figure 3
Convection currents 'blow away' the insulating boundary layer, allowing 'fresh' hot air to directly contact the baked product, enabling a faster, more efficient heat transfer

evaporated from the product into the air. The quantity of energy transmitted depends on the temperature of the air, its physical characteristics, the flow of air around the product, and the speed at which it flows. As moisture evaporates from the food, a cool and moist insulation barrier is formed in the air around the product's surface, slowing the cooking process.

The characteristic 'all-encompassing' heat of convection baking systems is effective in overcoming this hindrance to the baking process. The movement of the convection currents 'blow away' the insulation layer, allowing 'fresh' hot air to directly contact the baked product (see Figure 3). The outcome is a fast and efficient heat transfer. As a result convection baking systems are able to bake food quick, and at lower temperatures as usual. This baking efficiency will of course fluctuate, depending on the product being baked and the individual characteristics of the oven. Different products produce boundary layers with varying heat transfer characteristics, which can significantly affect the efficiency of convection ovens.

Convection – a flexible future

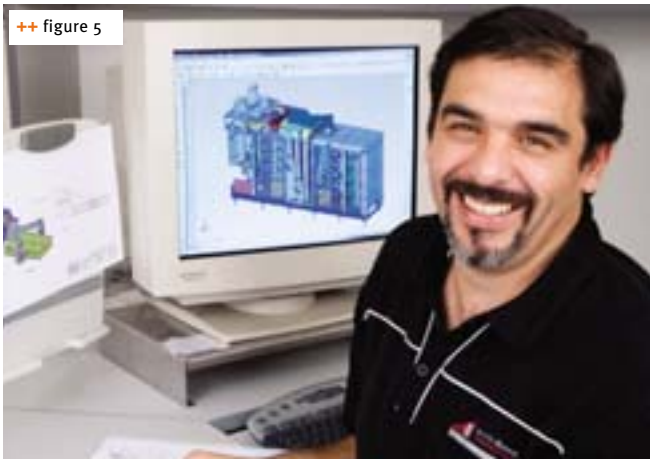
While convection heat is suitable for baking nearly any product imaginable, there are many applications that require alternative heating mechanisms – such as hybrid ovens which combine convection and radiant heating systems.

Auto-Bake's hybrid and convection Serpentine ovens incorporate a range of optional features, including top and bottom entry, a 'steam zone', and the capacity for stone hearth baking surfaces. The Serpentine can be custom-configured to any requirement. +++

++ figure 4

++ figure 4
Auto-Bake's convection oven is available in one- and two-pan-wide (pictured) variants

++ figure 5



++ figure 5
Auto-Bake chief design engineer, Osvaldo Demin; the convection heating technology featured in the convection Serpentine oven provides a pervasive heat, ensuring a consistent high-quality bake and product colour

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Reference guide of industrial processes and market analysis


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