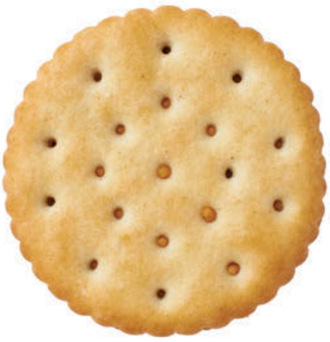
Hybrid Tunnel Ovens: Enabling Easier, More Efficient Cracker Production

Combining direct gas fired and convection baking zones, hybrid tunnel ovens give today's bakers a more flexible, sustainable way to mass produce crackers with better product quality and consistency than ever before.

By Reading Bakery Systems

Until the relatively recent development of the hybrid tunnel oven, the evolution of industrial oven systems for traditional cracker production has been slow, with bakers somewhat constrained by the limitations of their era's technology. Consider, for example, the mechanized reel oven from the late 1890s. Bakers had to load pans of sheeted crackers into the oven and onto a rotating wheel of plates. By the early 1930s, mass food production had become much more automated, and the brick-and-mortar tunnel ovens of the day featured automatic conveyor belts.

A switch to steel exterior frames soon followed, as did advances in burner technology. A series of line burners, evenly spaced above and below the conveyor belt, provided a more uniform bake across the width and along the length of the oven.



Commonly referred to as direct gas fired (DGF) tunnel ovens, these new steel ovens automated baking even more, allowing increases in mass cracker production.

This basic DGF oven technology has served the snacking industry well for many decades. But the development of the hybrid tunnel oven has taken cracker production efficiency and process control to the next level.

Combining direct gas fired and convection baking zones in one unit, hybrid tunnel ovens give today's bakers a more flexible, sustainable way to mass produce crackers with better product quality and consistency than ever before. To understand how, a look at what happens during the three phases of cracker baking is instructive.

THE CRACKER BAKING PROCESS

Thanks to technology advances, bakers now have a very detailed view of the science behind cracker baking. Oven-profiling devices such as the SCORPION® Data Logging Measurement System from Reading Bakery Systems (RBS) have unlocked the discrete processes that occur within ovens, showing how heat transfer, humidity and air movement impact a product's attributes. In fact, the data logging of these processes helped inform the development of hybrid tunnel ovens in the first place.

No matter how long the oven, the process of cracker baking can generally be divided into three oven product flow phases. Each phase plays a key role in establishing a product's characteristics and quality.

In both DGF and hybrid ovens, the first phase involves the development of dough pieces as well as flavor development. In general, the DGF ribbon burners in this part of the oven are set to lower firing rates resembling the first stage of a bell-curve temperature profile. Upper ribbon burners heat the passing product, air and oven ceiling. Lower burners beneath the belt are set to heat the combined mass of the oven belt and the cool dough sitting on top of it. To retain humidity and encourage development, operators typically set exhaust flows in this phase to a minimum. The high humidity helps the product retain surface moisture that shields it from the high radiant heat of the surrounding oven structure. The moist product surface also allows the dough to grow and expand without cracking as water begins to vaporize and the chemical reactions within the dough entrap forming gases.

In the second product flow phase, the majority of moisture is removed from the product. Upper burners are set for an aggressive heat application to fix the product's surface structure and prevent it from collapsing as gases and water vapor escape. Lower burners are set for a high belt temperature to ensure the bottom surface of the product bakes properly. Depending on the type of product and the amount of water to be removed, exhaust flows are generally targeted around 50%.

During this second phase, the outside of the product begins to set. The moisture layer on the product's surface has evaporated and the product begins to dry from the outside in. Water slowly migrates from the product's interior, leaving behind a moisture gradient between the insulated interior and the dry product exterior.

In the third and final product flow phase, the baking process completes the evaporation of water from the product's interior and determines its final surface color.

Internal temperature, which at this point exceeds 75oC (167oF), will have no further effect on the development of product flavor or texture. Instead, operators must focus on applying heat to achieve the product's specified final surface color and internal moisture content.

It's in these final two product flow phases where the functionality of DGF and hybrid ovens diverges, with hybrid ovens using convection zones to remove the majority of moisture in the process. And it's here where data logging technology revealed the limitations of DGF ovens and began to show how the convection capabilities of a hybrid oven could make the cracker production process – particularly during the drying phase – much more efficient and flexible.

DGF STRENGTHS AND WEAKNESSES

The oven data loggers showed how the low air flows and high radiant temperatures of DGF ovens are not particularly well suited to the moisture removal phases of cracker production. In effect, the data underlined the need for more controllable air heating zones – that is, convection zones in which both product moisture removal and coloring/drying can be controlled separately and more efficiently.

But at the same time, the data loggers also helped quantify just how and why DGF oven zones work so well in the front of the oven, and why keeping them up front in a hybrid DGF/convection oven would give bakers the best of both worlds.

A quick look at the DGF heating process helps explain why.

A DGF oven zone heats the baking chamber with dozens of ribbon burners above and below the baking band, each spaced about 750-1,000mm (30-40in) apart. These burners contribute three types of heat to the oven – convection, conduction and radiation. Convection air currents bake the product with a heated airflow. Conductive heat contact from the oven belt bakes the product from beneath, while surrounding heat radiated from interior oven surfaces bakes the product on its exposed surfaces.

In general, DGF burners provide a controllable radiant and conductive heat flow but do so with very little air movement; convection heat flow is limited by this type of burner design. Having higher humidity ratios in the first phases of baking is important in developing products, as it enables proper product flavor and texture development. But high humidity and a limited ability to control convection heat flow is not helpful for product drying as operators try to achieve uniform product moisture and color.

Over the years, operators have developed ways to compensate for the excessive heat in the last zones of a DGF oven. Often these involve a complicated dance of shutting off burners, increasing exhaust rates and opening oven doors – whatever could be done to reduce the residual heat remaining in the air, product and belt

Traditional DGF Ovens

- Up to 300 individual burners
- Overheating without product
- "Checking" potential
- Product fire potential
- More operator involvement

Hybrid DGF/Convection Ovens

- 1 burner per convection zone
- No overheating
- Even moisture reduction
- Minimal fire potential
- Less operator involvement

from previous oven zones. It's an inefficient prospect at best, and it's one of many that a hybrid oven eliminates.

HYBRID OVEN EFFICIENCY ADVANTAGES

As previously noted, a hybrid tunnel oven complements the cracker-baking strengths of DGF heat with convection zones for drying at the middle and back of the tunnel.
Convection zones are extremely well suited for the drying process, as they circulate high volumes of air through the baking chamber. High air speeds pull moisture away from the product very efficiently as well as increase the coloring rate of the product by drying the surface to very low moisture levels.
In terms of energy efficiency, convection burners deliver distinct advantages vs. DGF burners. Consider that a traditional DGF tunnel oven could easily be 100 meters long and operate with up to 300 individual ribbon burners.
Now consider that for cracker or biscuit making, one third to two thirds of those 300 DGF burners can be replaced with convection burners. The typical RBS hybrid oven, for example, has two DGF zones and four convection zones, with one convection burner per zone replacing about 30 ribbon burners. The specific energy savings will vary depending on the age and type of ovens involved, but the cut in energy consumption and costs could range anywhere from 5-20%.
A switch from an all-DGF to a hybrid oven will also save a great deal of operator energy and time. A DGF oven takes an experienced operator to understand how to manage and control it. Convection technology is much more automated with the four baking parameters easily set and managed by the recipe at the OIT. With the labor problem across the food industry, this makes convection technology much more attractive to bakers.
Thanks to their precise temperature control, the convection zones in a hybrid oven will not overheat if there is no product on the belt moving through them. This is in sharp contrast to conventional DGF ovens, which, following extended lines stoppages, require operators to make a lot of adjustments – shutting off burners, speeding up the belt, or some combination thereof – to help stabilize oven temperatures and prevent burnt products.
Speaking of burnt products, a hybrid oven's convection drying zones will also

drastically reduce the chance of product and productivity losses due to fires. By far, DGF fires tend to occur in the drying zones toward the end of the oven, where the chance of nearly finished products falling off the belt and collecting near an exposed burner flame is far higher than in the front. The absence of exposed flames in the convection zones helps reduce the risk of fires and makes it easier for operators to keep the product in specification between start-up and shutdown.

Keeping the product in specification is also supported by the drying efficiency of the convection burners. Along with saving energy, the hybrid convection process pulls moisture out of the cracker so uniformly that it prevents production problems like "checking," or the appearance of cracks in the product that aren't apparent until after packaging. Eliminating the possibility of checking is just one of several ways that convection oven zones support more efficient cracker production with less waste.

MOVING TO EVEN MORE SUSTAINABLE BAKING

Clearly, today's hybrid DGF/convection ovens offer several energy- and labor-saving benefits compared to traditional DGF

ovens, as well as process efficiency and product quality control improvements. This is as it should be, as the modern hybrid tunnel oven represents more than a century of baking technology upgrades.

But at RBS, our engineers are already working on the next generation of process and energy-efficiency improvements for hybrid oven systems – indeed for all modern oven systems. RBS already offers all-convection zone technology for sheeted baked cracker "crisps" to meet the growing consumer demand for these popular snacks. RBS oven systems are already available with heat recovery systems and more energy-efficient motors. RBS is also exploring cleaner energy sources. And just as data logging technology helped pave the way for hybrid ovens, we are committed to refining our data analysis capabilities to improve process efficiency and usher in the next century of baking technologies. •