Flexible Packaging Challenges Met with Ultrasonic Sealing Solutions

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Plastics packaging is marvelously versatile, not only in terms of materials and designs but also in terms of the technology that seals and holds it together. This versatility is very important because, from the time that plastics became mainstream packaging materials some 50 years ago, enormous changes have occurred among the consumers who shape the demand for packaging.

Many households are much smaller: 61 percent of U.S. households today have just one or two people. More consumers are opting for smaller package sizes and single-serve portions, choosing to prepare and eat an entire, fresh portion at each meal. Further, many consumers are willing to pay a bit more for what they want--be it convenience and easy preparation, healthy or premium ingredients, or the assurance of freshness.

Adapting to these continued changes can lead to complexity and headaches for those whose packaging lines must keep pace. Packagers face continual challenges including thinner-gauge materials for food pouches, evolving package designs and shapes, and more frequent product and package changeovers.

Should any of these fast-changing factors pose problems for aging or less-than-agile packaging operations, costs escalate quickly. Packagers can face increased costs for product and package waste, in-line product losses due to leakage or seal failures, and increased downtime to resolve these quality problems. Worse, there's the threat that quality problems will emerge downstream, in transport, in storage, on store shelves, or in the hands of consumers. So, it's important to ensure that flexible packaging operations keep pace, not only with evolving materials and package designs but also with the agility and adaptability that ensure the packager can maintain tight control over the entire process.

For reasons like these, packagers who once relied on thermal sealing technology are taking a closer look at what ultrasonic sealing technology can do for them. Ultrasonic sealing technology is a plastic welding process that manages recent packaging challenges--the threat of contaminated and leaking seals, the use of thinner materials, and the rising cost of energy—while delivering a far higher margin of control, quality assurance, uptime, and operator/process safety than is possible with thermal sealing technologies.

Thermal vs. Ultrasonic Sealing: What are the Differences?

Let's explain why these differences are possible by few quick comparisons of the two sealing technologies: thermal and ultrasonic.

Thermal seals operate by process of conduction. Package material surfaces are held together, with heated sealing bars applied on one or both sides. Heat flows through the material to the seal interface, where the mating surfaces melt to form a bond (see Figure 1). Sealing controls are straightforward, with process temperature, pressure, and dwell

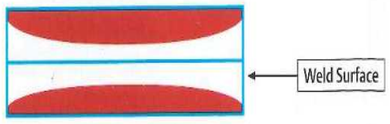

Figure 1: Heat Seal - A conduction heat seal applies the heat source to either side of the mating surfaces to create molten material, then compresses the two sides into a bond. As shown by the red areas, heat is conducted through the material from the heat source and has to gather at the weld surface in order to create a seal. Courtesy of Branson

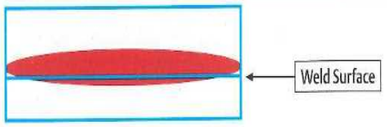

Figure 2: Ultrasonic Seal - An ultrasonic weld applies mechanical vibration between the sealing surfaces, creating frictional heat that melts the material on facing surfaces that are then compressed into a bond. Courtesy of Branson

time selected according to the melt characteristics of the thermoplastic package materials.

Ultrasonic sealing generates and applies heat and pressure in a different way. Heat is generated by applying a precise frequency and amplitude of vibration between the surfaces of the thermoplastic layers. This frictional heat melts the interior of these surfaces and, under pressure, creates a permanent weld.

How Ultrasonic Sealing Works

In ultrasonic sealing, high-frequency vibrations are applied to two parts, or to mating surfaces, by a vibrating tool, commonly called a "horn" or "sonotrode." The ultrasonic vibrations are created and delivered by a series of components—the power supply, converter, booster, and horn.

As seen in Figure 3, the power supply takes a standard electrical line voltage and changes it to an operating frequency (i.e., 20 kHz), which is sent through an RF cable to the converter. The converter, in turn, converts this electrical energy to mechanical vibrations at the operating frequency of the power supply. The amplitude of these vibrations is based upon the thermoplastic materials being welded.

In operation, mechanical vibrations are delivered to the parts to be sealed, which are put under a mechanical load using an actuator that holds the booster and horn. Under this load, the mechanical vibrations are transmitted to the interface between the material surfaces, which focuses the vibration to create intermolecular and surface friction. This friction creates heat and a subsequent melt, which solidifies into a welded bond.

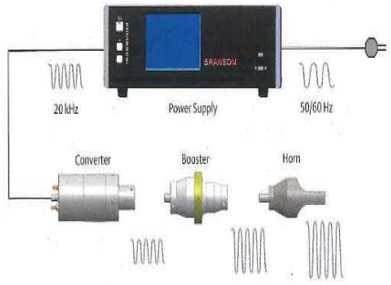

Figure 3: Converting electrical energy into ultrasonic welding energy. Courtesy of Branson

Figure 4: Ultrasonic welder, showing weld "stack"—An ultrasonic welder, like the Branson 2000 XC, includes a power supply (left), an actuator (top right, front) which contains a "stack" assembly consisting of a converter, booster and horn, and a base equipped with a metal fixture or "anvil." When production requirements dictate, modular versions of these ultrasonic welding components can be integrated into larger, automated assembly or packaging lines. Courtesy of Branson

Differences in Process Control

Thermal sealing is controlled by three factors: heat energy (temperature) + pressure + time. All three of these factors must be tightly controlled for maximum consistency. Variances in temperature or dwell time raise the potential for failures: incomplete seals, melt-through, or burn-through.

The ultrasonic sealing process is more forgiving and tolerant of variability because it offers more ways to control the energy that goes into each seal, which is a combination of force (pressure and downspeed) and velocity (frequency and amplitude).

Because frequency is selected with the power supply, amplitude is the factor among those that remain. Amplitude is measured in the peak-to-peak movement of the horn. This motion, coupled with force being generated by pressure and downspeed, creates the mechanical waves of energy that result in friction between the thermoplastic surfaces that melts and bonds them together.

Ultrasonic welding controls allow amplitude to be profiled during the sealing process. For example, a higher amplitude can be used to initiate the melt, with lower amplitude(s) then being used to control the viscosity of the molten material as the seal is compressed and completed. Such precise regulation of melt temperature at the seal interface is impossible with the heat bars used in thermal sealing processes. Thus, ultrasonic welding opens up a wider range of possible

Pocket Shot 50 ml "bottle." Pocket Shot Spirits developed an unbreakable, easy-open, pocket-size "bottle" of spirits for people on the go. Using FEA software, Branson developed an ultrasonic horn-anvil combination that reliably sealed these three-layer film packages, even when alcohol residues were present. Courtesy of Branson

solutions for challenging sealing problems.

Like heat sealing, ultrasonic sealing processes can use open-loop, time-mode controls. But when more consistency is required, closed-loop controls can also be used. These allow for automatic adjustment of seal parameters to allow for part-to-part or surface-to-surface variances typical of mass production. In energy mode, the power draw is measured in joules (watts/secons), and the time of the sealing process is varied until a precise energy input is made. If a linear encoder is used, two other ultrasonic control methods are possible. *Absolute* control measures the total travel of the actuator and horn into the sealing surfaces, while *collapse* control measures the height between the sealing surfaces at initial contact versus the end of the weld.

On-the-go pouch for Yumbutter products. Yumbutter designed a lightweight, squeezable plastic pouch for on-the-go consumers. However, oily product residue caused the original package's heat seals to fail. Ultrasonic sealing provided by Branson saved the package design because its high-frequency vibration displaced foods and contaminants from sealing surfaces before bonding them together. Courtesy of Branson

Ultrasonic Sealing Process Benefits

Packagers who use ultrasonic seals typically enjoy a series of benefits that stem largely from the characteristics of the process itself, which can:

Perform in a wide variety of packaging applications.

Ultrasonic sealing is remarkably versatile. It can be applied successfully for a wide range of package materials, sizes, and applications, including:

- Continuous Motion, Form-Fill-Seal
- Spout Welding
- Pouch Side Welding
- Industrial Valve Bags
- Multilayer Film Beverage Packages
- Clamshell Packages
- "On-The-Go" Dispensing Packages

Eliminate seal failures due to contamination.

Contamination caused by the presence of liquid or solids—beverages, leafy produce, powders, or lubricants—on the sealing surfaces. Heat sealing processes simply compress or encapsulate this residue into the seal, resulting in inconsistencies, gaps, or leaks in the seal. However, the vibratory motion and pressure of ultrasonic sealing essentially sweeps or pushes such contaminants out of the way before sealing occurs, ensuring a more consistent seal.

Reduce material consumption.

Small snack bags (6-inch size) consume about 1.0 inch of material per bag for two conventional heat seals (0.500 inch each on top and bottom). Two comparable ultrasonic seals consume just 0.25 inch of total package length (0.125 inch each on top and bottom). The result is a material savings of 0.75 inch (0.375 inch x 2) for a bag with the same net product volume.

	Package 1: Heat seals	Package 2: Ultrasonic seals
Overall package height	6.0"	5.25"
Width per seal (x 2)	0.50" (1.00")	0.125" (0.25")
Internal package height	5.0"	5.0"
Production rate	24 million	24 million
Material savings/pkg.	-	0.75"
Net material savings	-	24 million x 0.75" / 36 ~ 500,000 yards per year

Increase process speed.

Ultrasonic seals can be completed in as little as 150 milliseconds and, unlike heat seals, do not require any setup or cooling time. As a result, packagers may be able to boost package production rates. Typically, production rates of up to 110 packages per minute are possible.

Handle heat-sensitive products.

For heat-sensitive products like electronic parts or potentially flammable products like spirits or lubricants, the use of conduction heat sealing bars may pose risks of product damage or even fire. However, ultrasonic seals confine the application of heat to interior surfaces of packaging material only, thus eliminating these risks.

Improve safety and cut changeover time.

When flexibility is important, ultrasonic sealing equipment lends itself to rapid production changes because the tooling needs no cooling off period; it is always "cold." Often, process operators need only to swap out the converter, horn, and anvil/fixture to suit new production requirements, input process parameters to weld controls, and resume production.

Reduce energy usage.

Conduction heat sealing equipment must be powered and maintained at operating temperature. Thus, it can consume relatively high amounts of energy. By contrast, ultrasonic sealing technology consumes energy only in short bursts (e.g., ~200 milliseconds per weld, or about 20 seconds per minute of power consumption on a line running at 100 packages per minute). So, the estimated power savings of 25 percent is an extremely conservative figure for producers who switch to ultrasonic sealing.

ABOUT THE AUTHOR

Michael Mediana is packaging segment manager for Emerson Americas for Branson. He has had a 10-year career at Emerson, most recently serving as a district sales manager. He holds a bachelor's degree from the University of Illinois and an MBA from the University of Notre Dame. He can be reached at Mike.Mediana@emerson.com or by visiting www.emerson.com/en-us/automation/branson.