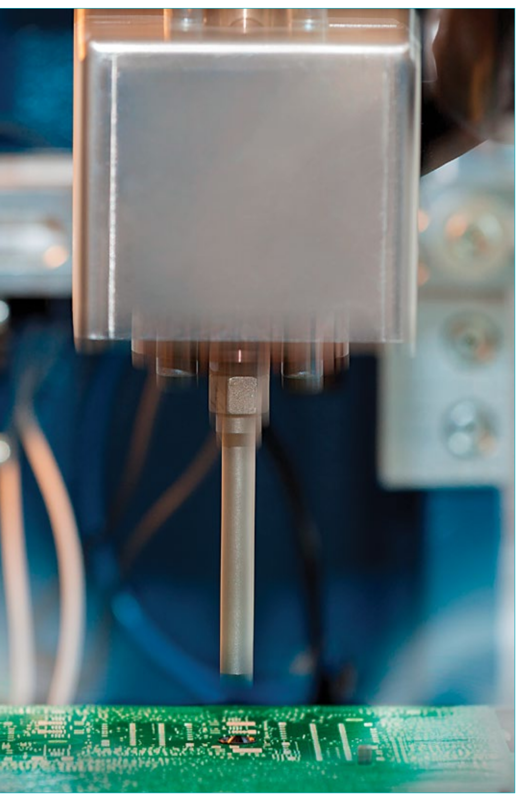
Staking for Plastic Parts *Assembly*

A wide range of staking methods produce quality plastic assemblies with stress-free joints.



This photo shows a two-phase thermoforming machine staking a plastic part within a PCB. ***Photo courtesy Dukane***

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How well an assembled plastic part performs depends a great deal upon how its component pieces are joined. Those made of strong, hard plastic may be fastened together or bonded. Thermoplastic pieces allow for even more options, including screws and rivets, various types of adhesives or welding, staking and being snap-fit.

Staking is one of the quickest and least-expensive of all these joining methods. In staking, a part with one or more holes in it is slipped over corresponding posts (bosses) on a base part held in a fixture. The posts are then either: directly contacted and deformed with a hot tool; heated and deformed with a cold tool; or directly deformed with a cold tool that is mounted on a press and traps the top part tightly against the base.

Medical device manufacturers regularly use staking to assemble small and large parts. In 2012, Thermal Press International Inc. developed the MicroLAB thermal press to help a medical device maker perform hot-tool staking on tiny implantable devices. Lance Crawford, vice president of sales at Thermal Press, says the customer currently uses several MicroLAB presses, which replaced more than 15 custom presses made by local shops.

The company likes the thermal presses' low maintenance and high flexibility, as they can be used with various actuators and tooling sets. Another benefit is all the presses have common features, such as HMI controls. Crawford says this has enabled the manufacturer to lessen downtime by 20 percent, while streamlining training processes.

Automotive, appliance and electronics manufacturers are also big fans of staking thermoplastic parts, including those made of polyethylene, polypropylene, ABS, polycarbonate, acetal and polyamide. Many companies use a heat-based staking method, while others prefer ultrasonics or cold forming. Which approach is best depends on application-specific factors like annual volume, required cycle time, type of material, part size and whether it has one or multiple planes.

Hot From the Start

Heat-based staking methods include hot-tool (also known as thermal), hot-air cold, impulse-power, thermoforming and infrared light. All of these processes are effective with thermoplastic resins that contain fillers such as glass or talc, so long as reasonable process control measures are in place.

Hot-tool is the oldest heat-based staking method, having been first introduced in the late 1960s. With this approach, the post is directly melted with a heated tool (or thermal head) that is pressed down on it. Post cooling is an optional step when metal needs to be retained in a plastic housing.

The post-cooling process involves blowing compressed air onto the post for 1 to 2 seconds after the tool retracts to slightly cool down the post after forming. This ensures a clean release from the part and prevents the plastic from springing back to its original shape. Total cycle time varies from 5 to 20 seconds.

The tool is heated by either an internal electric coil or one or more cartridge-type heating elements that convert electrical current into thermal energy. Tool temperature is regulated by a controller.

Because hot-tool staking keeps the heat localized to the post, it's particularly good for plastics with a high glass content. This method also allows manufacturers to simultaneously form a large number of posts, and the posts do not have to be located in the same plane.

"Parts for medical devices, including the electronics, are getting smaller and more delicate all the time," explains Jason Barton, national sales and marketing manager for Dukane. "Thermal staking is good for these applications because it is non-vibratory. The vibration from ultrasonic staking, for example, may damage these parts."

Dukane offers the STS-2000 thermal heat staking press, which features servo control of the Z axis so users can adjust stroke distance in 0.001-inch increments and speed by as little as 0.1 inch per minute. The press' standard stroke is 20 inches, and its throat is 12 inches from the center of each tool head.

The SimpleStake impulse-power system is used to stake automotive parts, including the plastic housing for the S550 fog lamp on the Ford Mustang. ***Photo courtesy ToolTex Inc.***

An over-process control alerts the operator when it takes too long to complete an assembly. The machine's in-temperature feature checks the system prior to every cycle to ensure proper operating tool temperature. It can be adjusted in 1-degree increments above and below the temperature set point. The machine handles one or several thermal heads and allows them to be mounted on any axis. It also stores up to 100 jobs and allows end-users to stake at multiple speeds, feeds and distances within each cycle. A filter-regulator-lubricator assembly for pneumatic part clamping and post cooling is standard.

Suppliers say that some manufacturers have simultaneously staked up to 32 bosses with hot-tool staking equipment. Certain machines are even able to form multiple bosses and install inserts at the same time. Several suppliers offer quick-change tooling for their equipment to increase flexibility.

"The key to quality thermal staking is to not overheat and immediately melt the plastic, but to use the right combination of heat and pressure to cause the plastic to flow and melt under load, so the plastic memory is reset," explains Crawford. "One big advantage of this method, compared to others that start with melted material, is it typically reduces the stresses created in the materials."

Crawford says that Thermal Press specifically developed its WorkStation press line for integrators and manufacturers that perform automated and high-volume thermal staking. The presses feature one to six actuators that are controlled by a single PCB. They also enable communication with other machines, real-time and extensive data acquisition, and remote control. Force-feedback control is optional and involves using applied-force data to accurately control the staking process.

"A well-known electronics contract manufacturer has been using about 200 of these presses at its plants in China since 2010," notes Crawford. "They use them to stake various electronics parts. Other customers use them for staking parts in automobiles and white goods."

In hot-air cold staking, compressed air is heated and blown onto the post through a side or overhead nozzle. Once the plastic softens, an air-cooled staking tool is pressed onto the post to form the head. The tool remains in place until the plastic solidifies. Cycle time can range from a handful of seconds for a single post or simple design, to 60 seconds for many posts or a complex part.

There are two main advantages of the hot-air cold method. The first is joints have a good cosmetic appearance and are structurally sound. This is because the plastic solidifies quickly on contact with the cold tool, eliminating the possibility of plastic sticking to the tool or producing strings of material when the tool retracts.

Another benefit of hot-air cold staking is it can be used to form several posts at the same time, and the posts do not need to be located in the same plane. However, design engineers should provide enough room for each

The 1,200-watt AMG generator, which produces the ultrasonic vibrations in the sonotrode, has integrated a distance measuring device that automatically ensures the proper amount of boss displacement in every staking application. ***Photo courtesy Herrmann Ultrasonics Inc.***

air nozzle to reach its post. They should also make sure that any parts near the posts are not adversely affected by the stream of hot air. This is especially important for sensitive electronics and thin, delicate plastic parts.

The main drawback of hot-air cold staking is it requires a certain amount of recharge time. Between cycles, heat has to transfer out of the tool to cool it down, and then the tool has to be heated up again. The process is also quite noisy and expensive due to compressed air costs.

Several UK-based Tier 1 manufacturers use an advanced hot-air cold HACS system from Telsonic AG to quickly build SUV seat back assemblies. Each assembly consists of an ABS-PC-nylon hybrid material backboard, a map pocket, a carpet panel and metal clips. The individual items are secured and joined with 21 separate stake points within a floor-standing machine, to produce left and right seat versions for two different vehicle models, as well as versions for cars with and without air conditioning.

Fully automatic, the HACS system uses a servo-driven power slide table to transfer the components between the operator load and unload position, heating area and the staking station. Sensors confirm several things before each 45-second cycle begins: the presence of each component, that the correct substrate and carpet components have been loaded, and that the correct number of metal

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clips are present. A temperature controller ensures a consistent heat profile across the 21 staking points and repeatable results on each part.

On the Pulse of Innovation

About 8 years ago, ToolTex Inc. began developing SimpleStake, an impulse-power system to stake plastic parts. The company developed a proof of concept within one year, but kept refining it with new features to optimize efficiency, notes Alex Spurgeon, operations manager at ToolTex. In 2015, the system was introduced.

According to Spurgeon, it works by sending a low-voltage current across a specially designed and patent-pending tip to heat it on demand. The tip is cool at the beginning, but within 2 seconds is heated to a temperature up to 400 F. It stays this hot only as long as the tip touches the boss, and is cool to the touch at the end of the cycle.

"The heated tip makes contact with the boss, stakes to a final depth, and is then cooled with compressed air," explains Spurgeon. "Fully cooling the button before retracting the tip eliminates elastic recovery of the plastic and the risk of a loose mating between the two parts."

Spurgeon says the system requires little maintenance and is used to stake parts designed and made by Honda Acura, Toyota Lexus, Nissan and Ford. It can stake bosses as close as 1 millimeter from a wall, and has traditionally been used for small- to medium-sized bosses. In addition, the company is developing tips to stake 6-millimeter hollow bosses commonly found on door panels. Spurgeon says the system is also able to stake through metalized surfaces, which allows lighting manufacturers to not have to mask the bosses prior to vapor deposition.

Over in Europe, KVT developed the two-phase thermoforming staking method at the start of this century. Dukane purchased the company a year ago, and now offers its Dukane-KVT benchtop press, with rotary indexer, for staking any two parts, so long as one is thermoplastic.

A heating element within the press heats nitrogen gas, which is then blown through several 2-millimeter-wide tubes and onto the boss for 3 or 4 seconds. A cold tool deforms the boss for 1 or 2 seconds and stakes the parts together. When the indexer is rotated, another part stack gets placed under the tubes and the operator removes the joined part.

Barton says the press can simultaneously stake multiple parts that are only 2 millimeters apart. Customers also like that the two-phase thermoforming process leaves no particulates on the joint or heating element, and easily stakes low-viscosity materials.

InfraStake from Extol Inc. is a process that uses infrared light to heat the post before deformation. A reflector inside the forming tool concentrates infrared energy on a narrow spot, uniformly heating the post and limiting

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Since 2012, a medical device maker has used the MicroLAB thermal press to perform hot-tool staking on tiny implantable devices. ***Photo courtesy Thermal Press International Inc.***

the amount of heat transferred to surrounding parts. The focused nature of the heat source is particularly advantageous when staking parts such as PCBs, which have joints that can't be exposed to heat or vibration.

Ultra Quick and Accurate

"To make a better part, you have to measure every process," says Chuck Hannah, ultrasonics engineering manager for the plastics division at Herrmann Ultrasonics Inc. "Ultrasonic machines provide this measurement during staking in the form of a process monitoring signature. This feedback, as well as speed, are the two ways that ultrasonics is unique when it comes to staking."

With traditional ultrasonic staking, the heat to melt the plastic doesn't come from the tool itself, which stays cool throughout the process. Instead, the heat comes from friction between the plastic and the tool face, which is vibrating at ultrasonic frequencies. Cycle times can be less than 1 second because the process requires no recharge time.

This past summer, Herrmann unveiled a new ultrasonic staking process, called compressive staking. It enables bonding between dissimilar materials such as thermoplastic resins, metal-plastic hybrids, thermoset plastics and multicomponent systems. Hannah says the process should benefit automotive manufacturers that use ultrasonics to stake door panels, interior trim on the front, center and rear pillars, cup holders and instrument panels.

In compressive staking, the vibrating sonotrode never touches

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the staked upper part. Instead, the sonotrode warms, plasticizes and shapes a hollow, tubular rivet into a form-fitting bead that joins the parts. Staking takes 1.6 seconds, with a 1-second holding time. Bore depth is customized for each application.

Hannah says the sonotrode is unaffected by temperature, and that the process allows faster production of parts, higher bonding strength and more repeatability than traditional ultrasonic staking.

Herrmann has also developed the AMG generator, which produces the ultrasonic vibrations in the sonotrode. The 1,200-watt generator has integrated a distance measuring device that automatically ensures the proper amount of boss displacement in every staking application. If displacement is too much or too little, the unit stops and the operator is notified why.

Dukane's i*Q* Auto-Plus ultrasonic generator features an integrated Multi Probe Control module, making it ideal for automotive interior door panels and other large multipoint applications. The generator is small enough for internal or external mounting to an electrical cabinet and well-suited for cassette-style automated machines.

Barton says the generator can be configured to have eight staking points, and it has a 0.5-millisecond processing rate and a Trigger by Power feature for consistency. The unit is available in two power ranges (600 and 1,200 watts) and frequencies of 20, 30, 35 and 40 kilohertz.

For quick equipment interaction, the generator is compatible with EtherNet/IP, Modbus, Profinet, Profibus, Powerlink, EtherCAT and CC-Link communication protocols. Multicolor lights indicate the status of each staking point and simplify troubleshooting.

No Heat Necessary

Sometimes, heat is not necessary to form a head on a post. Any malleable thermoplastic with good impact resistance can be cold-formed using a radial or orbital forming machine, or a simple arbor press. Glass-filled plastic, such as acetal or nylon, is the preferred material for cold forming because it is neither brittle nor fragile, and it doesn't have too much memory.

To prevent buckling the post, its length should not be more than twice its diameter. To prevent fracturing the post, the forming force must be applied gradually. A cold-formed plastic post will naturally want to return to its original shape, but holding the post under pressure for a period of time after forming will limit how much spring-back occurs. Pressure of at least 6,000 psi is generally required.

Too much spring-back will make it difficult to form tight assemblies. Another best practice is to not use cold-forming to assemble parts exposed to heat. Cold-formed plastic posts are also more susceptible to fine surface cracking (crazing) and chemical attack. **A**

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