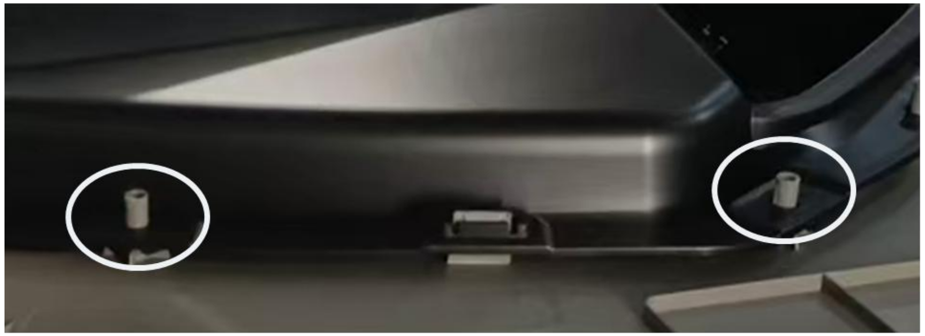
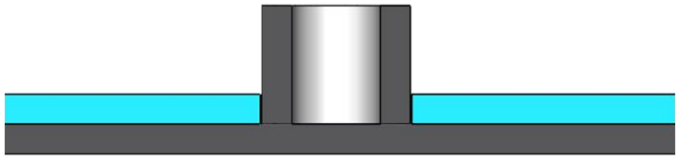
I. Definition & Principle

Plastic thermal staking (also known as heat staking or hot riveting) is a permanent fastening method used to join plastic parts to other plastic parts, or plastic parts to metal components and other materials. The basic principle is: a local protrusion (called a staking boss or stud) is designed on the plastic part, with a corresponding hole in the part to be assembled. The boss passes through the hole and is heated to soften or melt, then pressure is applied to reform it into a rivet head shape according to the tool design, and finally cooled to solidify, thereby securing the other part.

The essence of thermal staking leverages the property of thermoplastics that they can soften and flow when heated above their glass transition temperature (Tg) and return to solid state upon cooling, enabling permanent connections without adhesives, solvents, fillers, or additional fasteners.

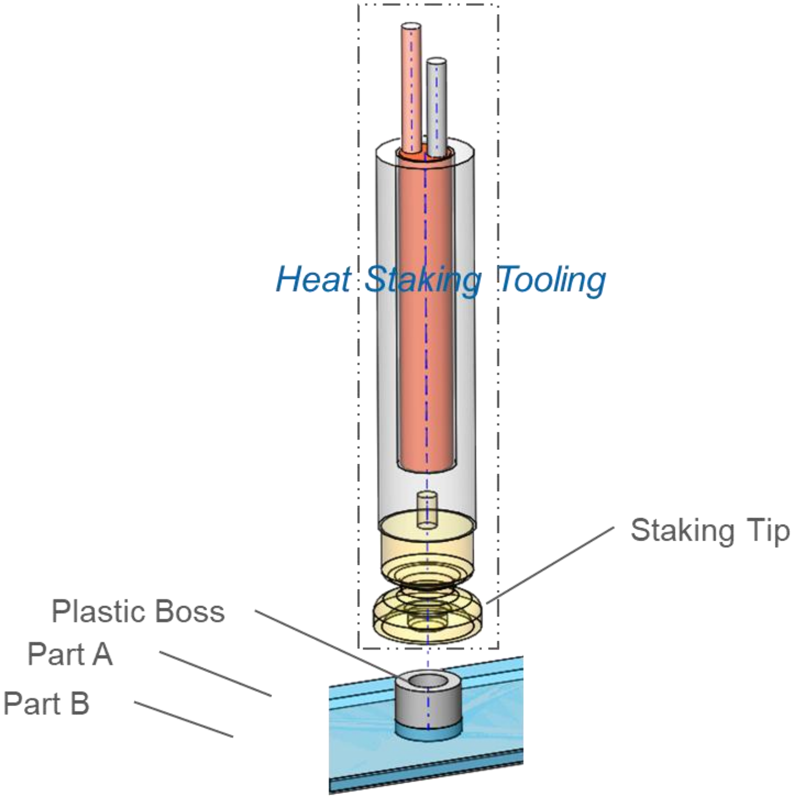


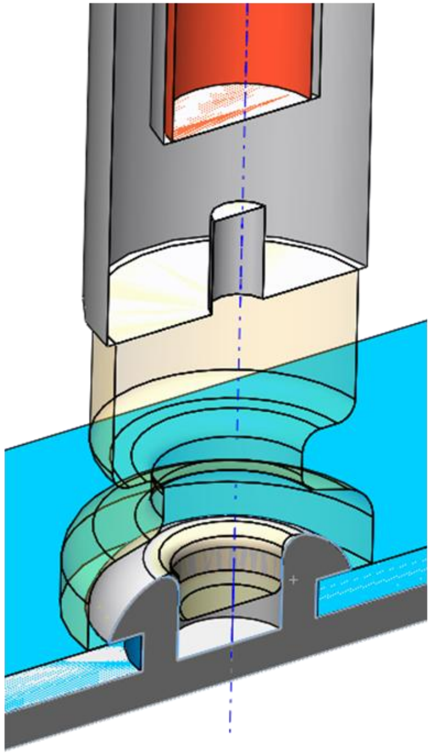


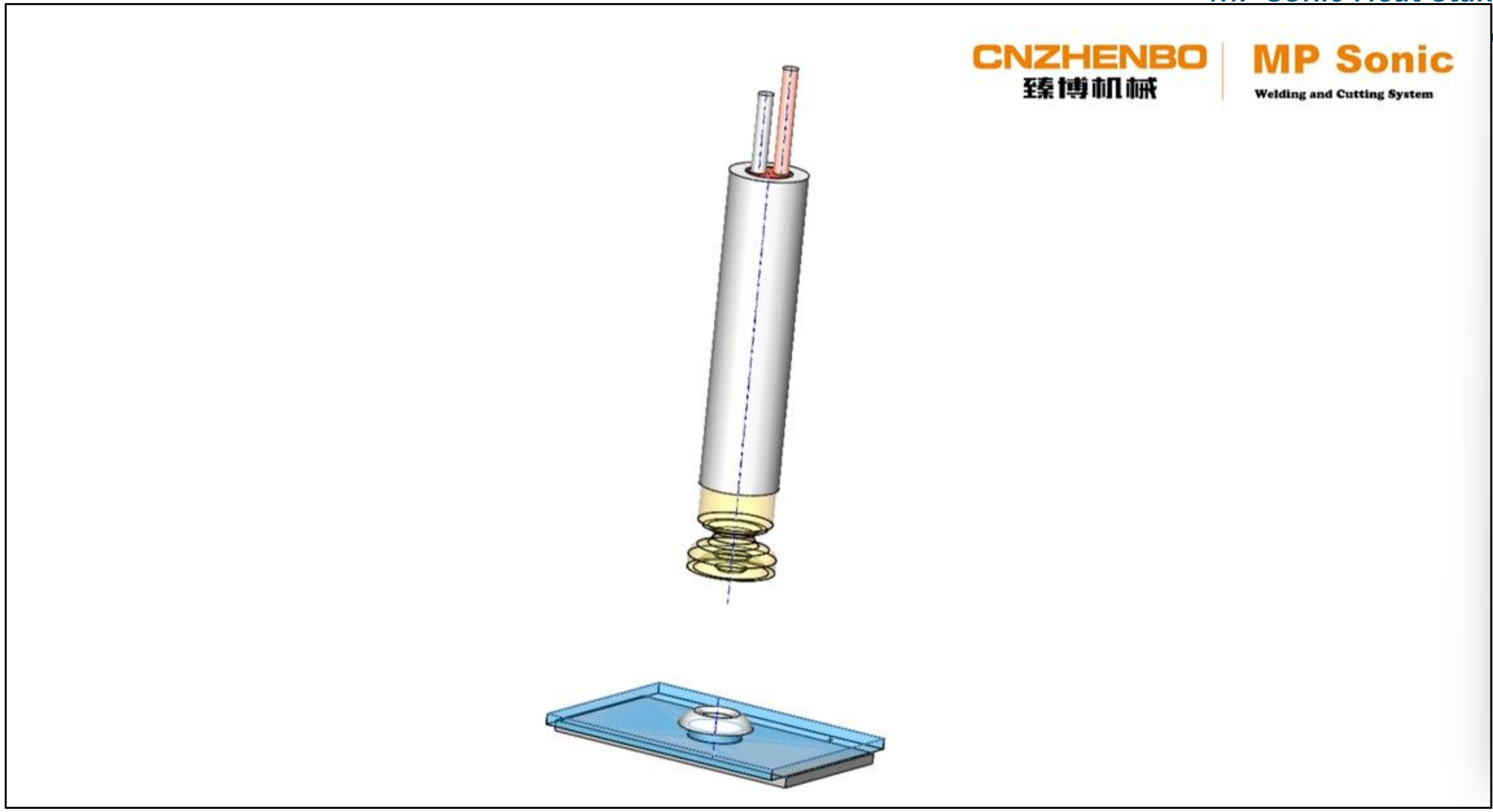
Before Heat Staking

After Heat Staking

II. Heat Staking Operation Process







1. Loading & unloading work-pieces and pre-assemble them together;
2. Heat thermoplastic Boss to pre-heat & melt material;
3. Heat form molten boss material into shape;
4. Cool down to let molten material resolidify and form staking;
5. Release and unload finished product.

III. Key Advantages of Heat Staking

Cost-Efficient Assembly

Eliminates screws, adhesives, and solvents—reducing material spend and inventory overhead. Streamlines high-volume production with faster cycle times and simplified automation.

Superior Joint Integrity

Forms robust, permanent bonds. Controlled cooling induces clamping force, delivering exceptional resistance to vibration, thermal cycling, and corrosion.

Material Versatility

Compatible with diverse thermoplastics (PC, PP, ABS, PA, PBT) and ideal for multi-material assemblies, including metals, PCBs, ceramics, and glass.

Component-Safe Process

Non-impact and vibration-free, protecting delicate electronics and precision parts. Generates zero particulates, meeting stringent medical and cleanroom standards.

Premium Aesthetics

Produces smooth, uniform rivet heads with no flash or sink marks. Minimal heat-affected zone (<2 mm) preserves surrounding surface finish.

Automation-Ready Design

Supports multi-point staking across varied geometries. Precise, repeatable control of thermal and pressure parameters ensures seamless integration into fully automated lines.

Eco-Friendly Operation

Solvent-free process with zero VOC emissions. Lower energy consumption compared to adhesive bonding and select ultrasonic applications.

IV. Compare between Different Staking Method

Items	Ultrasonic Staking	IR Staking	Impulse Heat Staking	Electrical Heat Staking
Control System Cost	Medium （Ultrasonic Generator)	High, Infrared Power Circuit and Temperature Control Circuit	Medium-High, Pulse Generator & Temperature Control System	Lower, PID Electrical Power Supper Circuit + Temperature Control Circuit

Tooling Cost	High (Ultrasonic Converter/Booster/Horn)	High, Infrared Tooling including IR Lamp, Lens, Housing, Tooling, Temperature Sensor, etc	Medium-High， Staking tip requests special material and precision machining	Economical, the cost of single staking tip is low in average, normally is selected for multiple points staking.
Operation Efficiency	Normally 3~5S, including ultrasonic oscillation time & Cooling time	IR heating time and Cooling time, normally 15 ±5S	Normally less than 10S, pulse heating time including temperature rising time, melting time and	Normally 10~15S including melting time and cooling time
Staking Performance	Perfect, good outlook, no problem of loose in assembly after long time duration.	Good outlook, for low temperature staking, but needs to ensure enough cooling time.	Good for small points staking in both low temperature & high temperature, but need to pay attention to cooling control and tooling sticking.	Good for all size staking in both low temperature & high temperature, but need to pay attention to cooling control and tooling sticking. Hight temperature Staking flash impact outlook.
Staking Ability Size	High, normally Ø3~20mm	Limited, good for Ø 2~5mm	Limited, good for Ø 3~5mm	High, good for ≥3mm

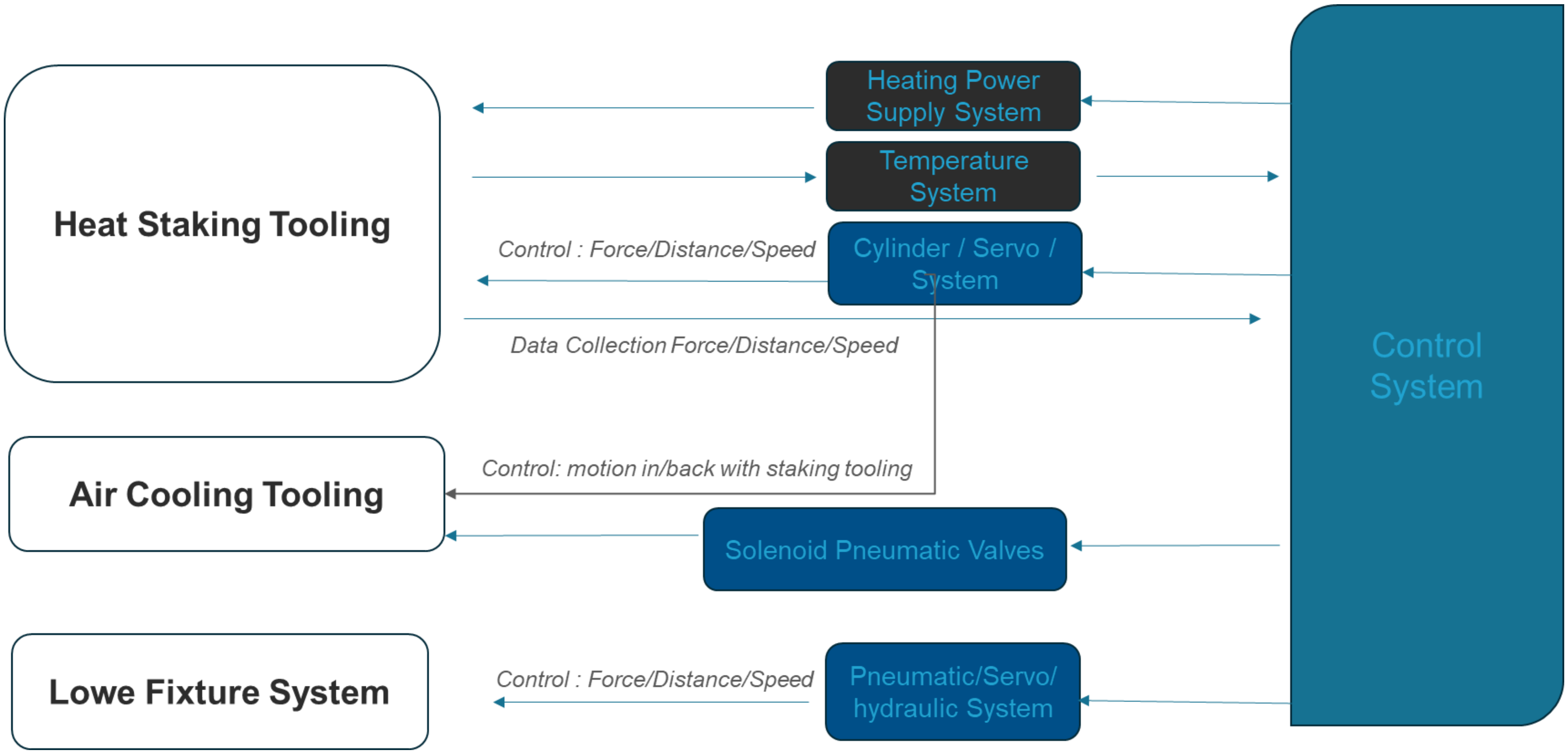
Power Consumption	Medium, ultrasonic System normally 300~1200VA, but power consumption is only when ultrasonic works	Low, normally 50~150VA, only power consumption when IR lamp works	High, a single staking power about 1000~3000VA, but only power consumption when pulse system works.	Low, a single staking tooling power normally 50~200VA, higher power consumption during melting, and lower consumption for keep temperature in range after melting.
Selection	Can be applied on handheld type machine, robotic work station or multi-heads machine table operation	Good for multiple heads machine table operation	Good for both handheld type machine and multiple heads machine table operation	Normally only operates on machine table, especially for multiple points staking.

Pulse/Hot Plate Contact Staking Transformer generates low-voltage high-current, rapidly heating the tip; plastic is softened, formed, then cooled by air Fast heating (reaches set temp within 1s), precise temperature control

Infrared Staking Infrared radiation heats the boss Non-contact, small heat-affected zone

Ultrasonic Staking High-frequency mechanical vibration generates frictional heat at contact surfaces Fast but higher equipment cost

V． Control-Principle of Heat Staking Equipment



The critical control to heat staking including:

1. Temperature control: heat staking including high temperature heat staking (120–210°C) & lower temperature control (220–450°C). The selection of temperature is concerned to the staking measurement and material. Heat staking requests high accuracy of temperature to ensure reliable staking

result and stable staking performance, thus PID temperature control circuit normally is applied for heat staking;

2. The force of melting and cooling/staking forming is critical to the strength of staking assembling as well as staking forming shape outlook. Normally, high temperature staking requests lower force while low temperature staking requests high force;
3. The motion distance control including heating depth control and staking forming depth control. The motion control normally can be by mechanical stopper or servo system.

The staking motion can be realized by pneumatic cylinder, servo motor system or booster-cylinder. The detail comparison as below:

	Pneumatic Cylinder	**Booster-Cylinder**	**Servo Motor System**
Force Control	By pressure regulators, difficult to realize double or multiple steps force control	By regulators, can realize double steps force control	By motor torque output control, easy realize multiple steps force control.
Motion Control	By buffer or mechanical stopper, low depths precision control	By buffer or mechanical stopper, low depths precision control	By servo system control in high precision.
Motion Speed control	Low accuracy control to speed, normally controlled by throttle valve.	Low accuracy control to speed, normally controlled by throttle valve.	Controlled by servosystem high accuracy
Loading Ability	Low, normally applied for small heat staking tooling	High, no limit is staking tooling weight	High, no limit is staking tooling weight
Cost	Economical	Little higher than Pneumatic cylinder type	High
Application	For small parts staking without high precision control; normally high temperature heat staking	Normally applied for low temperature staking	Suitable for both high temperature staking and low temperature staking, mostly selected for big parts staking or staking requests high precision control.

VI. High Temperature Heat Staking VS Lower Temperature Heat Staking

High-strength thermoplastic riveting process that uses a thermal tip at 220–450°C to melt and form plastic studs into permanent, load-bearing rivets. It features fast forming cycles, strong shrink clamping force, and compatibility with high-melting engineering plastics, designed for heavy-duty industrial and automotive applications where joint durability and mass production efficiency are critical.

Low-Temperature Heat Staking, a precision thermoplastic joining process operating at 120–210°C, with a low-power constant-temperature tip that delivers gentle, controlled heating. It creates an extremely small heat-affected zone, preserves the original surface finish of workpieces, and causes no thermal damage to heat-sensitive components, making it ideal for precision electronics, medical parts, and thin-wall plastic products with strict appearance requirements.

Comparative Analysis: High-Temperature vs Low-Temperature Heat Staking

1. Core Technical Parameters

Parameter	High-Temperature Heat Staking	Low-Temperature Heat Staking
Working temperature range	220–450 °C	120–210 °C
Heating method	Electric thermal tip direct conduction / hot air convection	Low-power constant-temperature thermal tip, soft contact heating
Heating cycle	1.5–5 s heating; 2–4 s cooling holding	3–8 s heating; 3–6 s cooling holding
Pressure range	0.3–0.8 MPa	0.1–0.4 MPa
Heat-Affected Zone (HAZ)	2–3.5 mm around the plastic stud	0.8–1.6 mm around the plastic stud
Temperature control precision	±8–15 °C	±3–6 °C

2. Advantages

Advantage Item	High-Temperature Heat Staking	Low-Temperature Heat Staking
Production efficiency	Fast forming cycle, high efficiency for mass automation lines	Longer heating/cooling cycles, lower production throughput
Joint strength	Strong rivet shrink clamping force; superior vibration/thermal cycling resistance	Weak shrink clamping force; poor performance under severe vibration/extreme temperature swings
Material compatibility	Compatible with high-melting-point engineering plastics	Only compatible with low/medium-melting thermoplastics
Equipment requirement	Less strict demand for preheating auxiliary equipment	Higher requirement for precise temperature/pressure closed-loop control
Workpiece protection	High risk of thermal damage to sensitive components	Minimal HAZ, preserves original surface finish; safe for precision parts
Energy consumption	Higher energy consumption; faster thermal tip wear	Lower energy consumption; longer heating tip service life
Surface quality	Risk of over-melting, flash, stringing on thin studs	Smooth, burr-free rivet heads, zero post-processing needed

3. Disadvantages

Disadvantage Item	High-Temperature Heat Staking	Low-Temperature Heat Staking
Thermal damage risk	Large HAZ; easy to cause discoloration, warpage, sink marks on thin-wall parts	Low thermal stress; effectively avoids plastic warpage/deformation/discoloration

Component safety	High risk of damaging nearby sensitive electronic components (PCB, micro-sensors)	Safe for precision electronics, fragile thin-wall plastic, heat-sensitive assemblies
Material limitation	Cannot process low-melting plastics prone to thermal deformation	Cannot process high-melting plastics or thick large-diameter studs
Equipment cost	Lower equipment procurement cost	Higher equipment cost due to high-precision control requirements
Production capacity	High production throughput	Lower production throughput due to longer cycle time

4. Applicable Materials

Material Type	High-Temperature Heat Staking	Low-Temperature Heat Staking
Engineering thermoplastics	High-melting grades: PBT, PA66, PA6T, PC+GF, PET, PPS	Low/medium-melting grades: PP, ABS, PC, TPU, PE, PMMA
Stud specification	Thick, large-diameter studs (diameter ≥3 mm)	Thin-wall, thin studs (diameter ≤2.5 mm)
Filled plastics	High content glass fiber/mineral powder filled plastics	Unfilled or low-filler-content plastics prone to thermal deformation
Special materials	Plastic-metal composite assemblies with thick plastic substrates	Transparent plastics requiring zero surface haze/discoloration

5. Application Scenarios

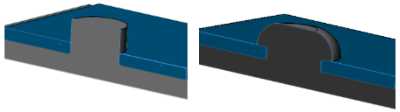
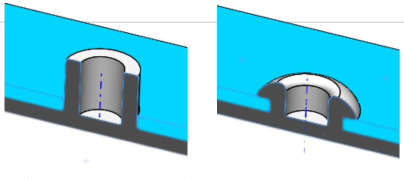
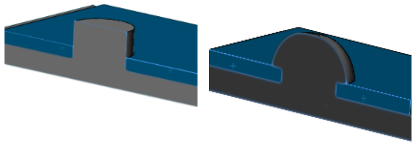
Application Field	High-Temperature Heat Staking	Low-Temperature Heat Staking

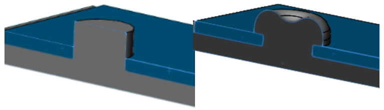
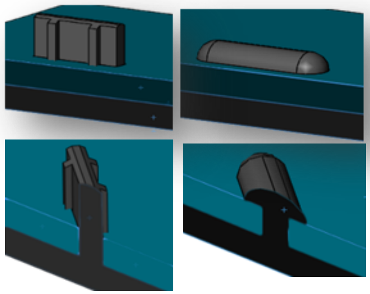
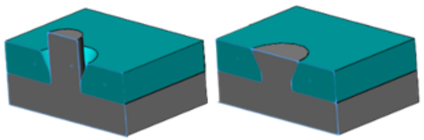
Automotive industry	Structural plastic parts: door panels, bumper brackets, motor housing assemblies	Precision interior components with strict appearance requirements
Electronics industry	Heavy-load electronic modules: new energy battery brackets, PCU housings	Consumer electronics: smart watch housings, mobile phone middle frames, camera modules
Appliance industry	Large household appliance structural components: washing machine frames, air conditioner brackets	Small precision home appliance parts
Medical industry	Heavy-duty medical device structural parts	Disposable precision medical parts: surgical instrument components, transparent medical casings
Industrial fixtures	Industrial mechanical plastic fixtures requiring long-term vibration resistance	PCB integrated assemblies with micro chips, sensors and fragile wiring
Consumer goods	Large plastic structural parts	Thin-wall cosmetic packaging, transparent plastic decorative parts, wearable device components

6. Selection Guidance		
Selection Condition	**Choose High-Temperature Heat Staking**	**Choose Low-Temperature Heat Staking**
Core requirement	High joint strength, fast cycle time, heavy-duty performance	Heat-sensitive parts, strict surface appearance standards, precision components
Material type	High-temperature-resistant engineering plastics	Low/medium-melting thermoplastics, transparent/thin-wall plastics
Application scenario	Automotive, industrial, large appliance structural parts	Consumer electronics, medical precision parts, wearable devices, PCB assemblies

V . Classification by Boss Structure

Plastic Riveting Boss Types, Applications and Design Parameters Specification Table

Boss Type	Design Reference Diagram	Typical Application	Key Design Parameters
Solid Boss (Solid Rivet Stud)		The most universal riveting type, applicable to studs with diameter ≤3mm; commonly used in low-strength scenarios such as PCB boards and plastic decorative parts	Stud size ≤ 2/3 of the part wall thickness, maximum diameter ≤3mm; recommended stud protrusion height is 1.5~1.75 times the stud diameter
Hollow Boss (Hollow Rivet Stud)		Applicable to large studs with diameter ＞ 4mm; avoids sink marks on the back of the product, suitable for thin-walled plastic parts	Stud diameter ＞4mm; recommended wall thickness range 0.75~2.0mm; riveting volume calculated as S_head=(85%~95%)*S_stud
Knurled/Flat Head (Knurled/Flat Head Rivet Stud)		Applicable to small studs with diameter ＜ 4mm; suitable for high-melting-point, easily degradable plastics to avoid thermal damage	Stud diameter D1＜4mm; rivet head diameter D2≈1.5 times D1, rivet head height H2≈0.5 times D1; stud protrusion height H1≈1.0`1.5 times D1
Dome/Round Head (Semi-circular/Round Head Rivet Stud)		Applicable to small studs with diameter ＜ 1.6mm; suitable for high-melting-point, easily degradable plastics to avoid thermal damage	Stud diameter D1＜1.6mm; rivet head diameter D2≈1.5 times D1, rivet head height H2≈0.5 times D1; stud protrusion height H1≈1.0 times D1

Double Dome Head (Double Semi-circular Head Rivet Stud)		Applicable to studs with diameter ＞ 1.6mm; aesthetic appearance, similar to blind rivets, for scenarios requiring high riveting strength	Stud diameter D1＞1.6mm (recommended 2~5mm); rivet head diameter D2≈2 times D1, rivet head height H2≈0.5 times D1; stud protrusion height H1≈1.5 times D1
Rib-type Boss (Rib-reinforced Rivet Stud)		Scenarios with limited installation space but high fastening strength required; improves the pull-out strength of the stud through reinforcing ribs	Reinforcing ribs are designed at the root of the stud, recommended rib thickness ⩽60% of the part wall thickness; stud diameter refers to the corresponding solid/hollow rivet stud specifications
Counterbore Staking (Countersunk Riveting)		Scenarios with strict requirements for surface flatness; after riveting, the rivet head is fully sunk into the counterbore, with no protrusion on the surface	The mating part shall be designed with a matching counterbore; stud diameter D1＜3mm; stud protrusion height H1≈0.5 times D1; rivet head volume calculated as S head = (85%~95%)*S stud

MP Sonic Heat Staking Equipment