Mass Production Quality Control for Liquid Cooling Plates

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Core Objectives and Principles

This list aims to provide efficient quality control guidelines for mass production of liquid-cooled plates. In response to stringent reliability requirements, we must prioritize core objectives including "zero leakage, low deformation, high-precision flow channels, and stable performance." By adopting a systematic approach of "process optimization + precision control + full-process inspection," we ensure a production yield stability exceeding 98%.

Production yield target

98%+

Process Optimization · Precision Control of Full-Process Detection System

Zero Leak

Ensure the product has no coolant leakage risk throughout its entire lifecycle.

Low Distortion

Strictly ensure flatness and dimensional accuracy to guarantee optimal adhesion to the heat source.

High Precision Flow Channel

Ensure the coolant flow path fully complies with the design specifications to achieve efficient heat transfer.

Stability performance

Ensure reliable performance of products under various operating conditions including high and low temperatures as well as high loads.

General Principles: Automation and Standardization

Core objectives

Minimizing quality fluctuations caused by human factors and ensuring consistency and stability in the production process are the cornerstones of high-quality manufacturing.

Deep Application of Automation Equipment

Mandatory inspection: Are automated loading/unloading, cleaning, welding, and other equipment systems employed? Purpose: To eliminate uncertainties associated with manual operations and ensure precise and repeatable actions.

Standardized Fixture and Process Parameters

Mandatory inspection: Is a unified high-precision fixture used? Are the parameters solidified as SOPs? Purpose: To ensure consistent quality benchmarks across different batches and production lines.

Quick Changeover capability

Key indicators: Production line model changeover time must be ≤ 30 minutes to support flexible multi-model mixed-line production.

General Principles: Data Traceability System

Core Objective GOAL

Establish a product lifecycle data chain to provide comprehensive and accurate data support for root cause analysis of quality issues and continuous optimization of production processes.

Unique identity identifier IDENTIFICATION

Mandatory inspection: Assign a unique QR code to each liquid-cooled plate prior to welding. Purpose: Serving as the products "ID card" throughout the entire process including welding, inspection, and packaging.

Data Binding and Records BINDING

Mandatory inspection: Bind QR codes to process curves, inspection data, and personnel/equipment information in the MES system. Objective: Enable rapid and accurate batch localization during anomalies to achieve closed-loop management of issues.

Key detection methods

stress testing

Objective: To verify the structural strength and sealing performance of the product.

Method: Apply 1.5 times the working pressure and maintain it for 1-5 minutes, then observe the pressure drop.

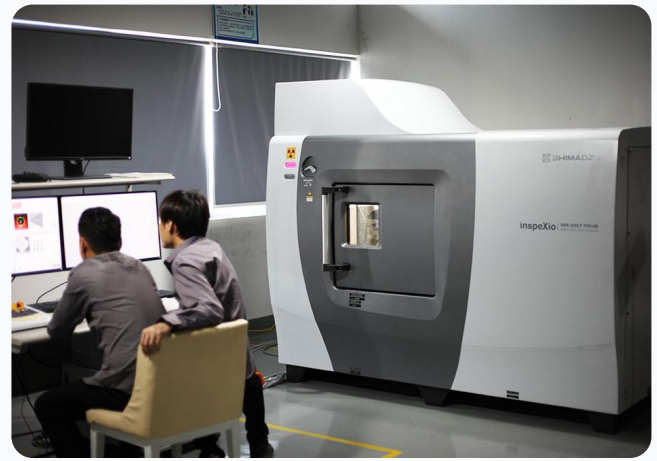
Qualified standard: No pressure drop during pressure holding period

helium mass spectrum leak detection

Objective: To perform high-precision and high-sensitivity detection of minute leaks.

Method: Helium mass spectrometry leak detector was used for detection, employing either the vacuum chamber method or the suction gun method.

Qualified standard: Leakage rate <1×10⁻⁷ mbar·L/s



Industrial CT Detection

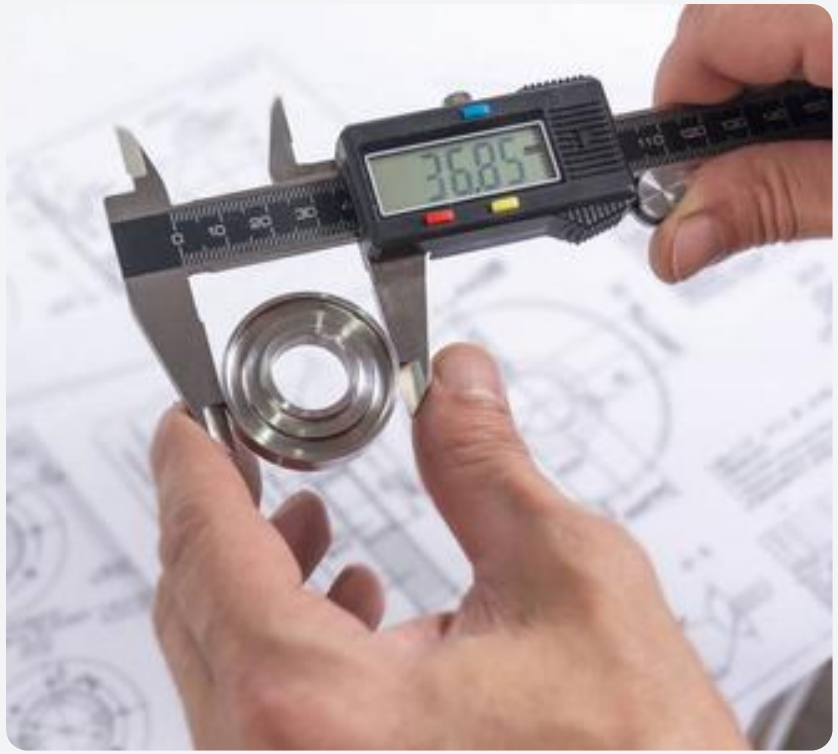
Objective: To detect hidden defects such as internal porosity, shrinkage cavities, and incomplete penetration through radiographic inspection.

Method: The product was scanned in cross-section using CT equipment to generate 3D image analysis.

Qualified standard: No internal defects affecting performance

First Article Inspection

Upon commencement of each shift, product model replacement, or adjustment of critical process parameters, a comprehensive first-piece inspection must be conducted on the initial product, which serves as the first line of defense in quality control.



Essential inspection items before welding/pre-casting

Dimension inspection: Use three-coordinate measurement to verify critical assembly dimensions and ensure tolerance compliance. Cleanliness inspection: Perform particle count analysis, requiring ≤100 particles with particle size ≤10μm.

Mandatory inspection items after welding or die casting

Basic inspection: Visual inspection reveals no defects, with three-coordinate re-measurement of flatness/contouring. Performance testing: Conducted a 1.5 times working pressure hold test (no pressure drop), and helium mass spectrometry leak detection meets standards. Depth and traceability: XRT/ultrasonic C-scan for internal defect detection, and verification of QR code data integrity.

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In-Process Quality Control

During the production process, inspections must be conducted at the preset frequency (e.g., hourly/batch) to continuously monitor process stability, promptly identify and mitigate abnormal quality trends.

Before welding / Before die casting

Key Controls: Cleanliness

Special spot check on cleanliness
Regularly use specialized tools to inspect the surface cleanliness of workpieces, with a focus on confirming the absence of oil stains, metal debris, and dust residues, thereby mitigating defect risks at the source.

producing process monitor and control

Dual monitoring: Parameters + Curves

1. Monitoring of key process parameters
Confirm that core parameters such as temperature and pressure fall within the set tolerance range.
2. Random sampling of process curves
Retrieve torque/power curves and analyze for any abnormal fluctuations.

Post-welding/post-casting inspection

Finished product quality: Sampling verification

1. Appearance and stress testing
Perform batch visual inspection of appearance; conduct stress testing at a ratio of 5-10%.
2. Precise Leak Detection Using Helium Mass Spectrometry
Sampling is conducted at a ratio of 1-5% to strictly control product air tightness indicators.

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Key Points of Mass Production and Quality Control

01 Full-process monitoring

Pre-welding · Strict material control

Dimensional three-coordinate inspection; cleanliness requirement: ≤10μm particles ≤100 particles.

Welding Process · Process Monitoring

Real-time laser vision-guided welding; torque monitoring with automatic recording of key parameters.

Post-welding · Comprehensive Acceptance

Required helium mass spectrometry leak detection; XRT scanning for internal defects; 1.5 times pressure test.

02 Full-chain Data Traceability

One item, one code · ID

Each circuit board is assigned a unique QR code that spans the entire lifecycle from material receipt to production and shipment.

Data to the cloud · Complete records

Automatically upload welding process parameters, AI visual results, and operator information.

Problem Reset · Reverse Traceability

Achieve 100% traceability of data throughout the entire process, enabling rapid identification and resolution of quality issues.

03 Automation and Standardization

Highly automated · Reduced variability

The introduction of automated loading/unloading, cleaning, and welding equipment has significantly reduced human operational errors.

Process Standardization · Flexible Production

Standardized fixture tooling and core process parameters enable flexible support for mixed-line production of multi-model products.

Rapid Model Switching · Efficiency Enhancement

Optimize the model switching SOP process to achieve product model transition on the production line within ≤30 minutes.


Thank you for watching