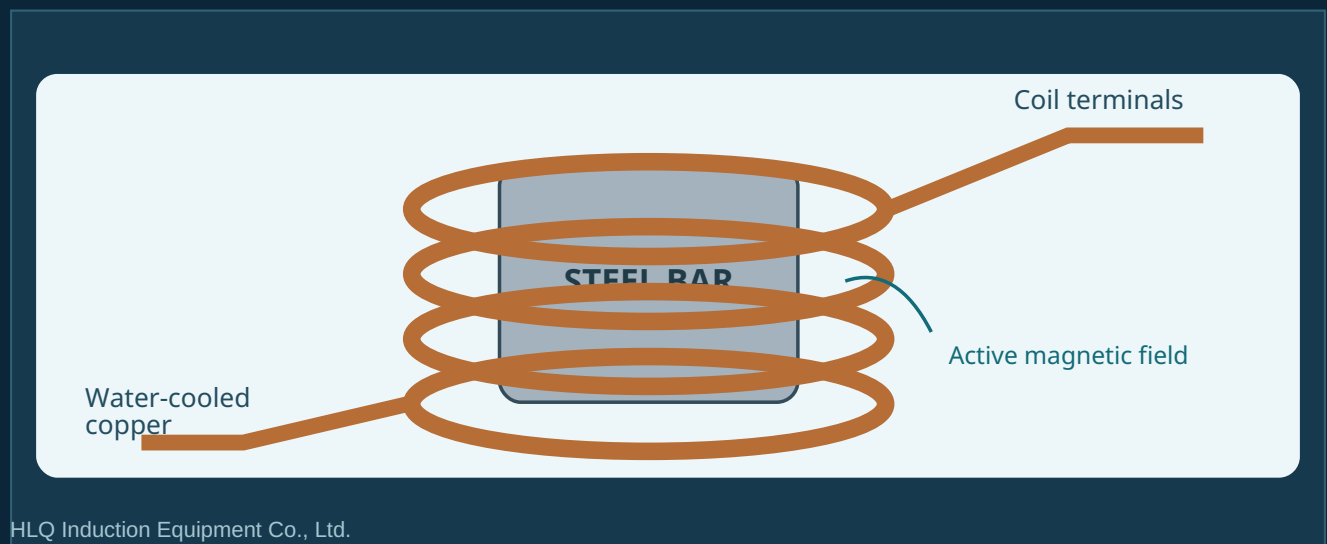


Induction Heating Coil Design

Custom copper inductors for brazing, hardening, annealing, forging, shrink fitting and precision heating.



HLQ Induction Equipment Co., Ltd.

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Engineering illustration not to scale. Dimensions are based on measured load or original product photograph.

Custom Coil Design - Quick Answer

An induction heating coil is a copper inductor matched to a specific workpiece and inverter. It creates the magnetic field that determines where induction energy is deposited. HLQ offers helical, pancake, internal, channel, split, multi-turn and application-specific coils. There is no universal coil power, frequency or cooling specification: each is engineered with the load and power supply.

7+ TYPOLOGIES

Common copper inductor configurations

PROJECT-SPECIFIC

Frequency, current, gap and cooling

FAT-BASED

Verify heating and water performance

What a design proposal should specify

Design Variable	Information Required
Workpiece	Drawing, material grade, heated zone and tolerances
Heating objective	Start/end temperatures, cycle time, production rate
Inductor interface	Existing generator make/model, available kW and operating kHz range
Copper assembly	Tube/plate section, coil inner clearance, turn spacing, connection pads
Utilities and safety	Water flow/quality, insulating supports, leak test, guarding
Acceptance	Measured temperature map, heating time, joint/hardness test as applicable

Buyer decision: Select the coil and its power source as one electromagnetic system. An attractive copper shape is not proof of proper heating depth, matching or long coil life.

Typical industries

HVAC copper-tube brazing; automotive shafts and gears; steel bar and billet heating; tube and pipe heating; precision annealing; tooling and shrink-fit assembly.

Coil Shapes & Best-Fit Applications

Coil	Typical Load	Primary Design Risk
Helical / solenoid	Bars, shafts, tubes, small billets	Axial end effects; part centering
Pancake / flat spiral	Plates, discs, localized flat surfaces	Edge concentrations and backside losses
Internal diameter (ID)	Bores, bearing rings, sleeves	Small coolant passages, access and collision
Hairpin / U-shaped	Seams, rails and accessible surface bands	Uneven return-leg heating
Split / open-ended	Parts that cannot enter an enclosed coil	Coupling asymmetry and mechanical alignment
Channel / tunnel	Continuous wire, strip or conveyed parts	Line speed and heated-zone uniformity
Profile / formed copper	Complex joints, teeth or irregular parts	Hot spots and serviceability

Original HLQ gallery reference

Current page includes a nine-type copper-inductor montage, a multi-part coil collage, a copper tool-group photograph and a Nitinol-wire heating image. Because originals could not be retrieved as standalone image files in this production environment, this brochure links to the verified source gallery rather than substituting generated images for real product photographs.

View original copper coil photographs

[Open the current HLQ product image gallery](#)

Original site images are preserved in the WordPress replacement code.
QR link shown at right.

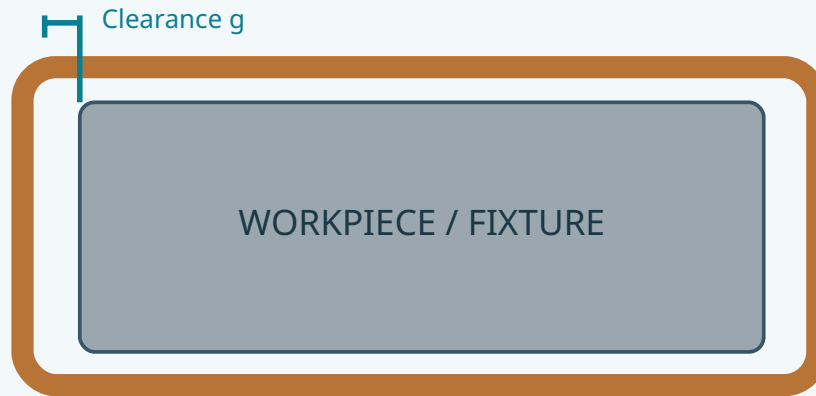


Scan to view the four existing coil images

Photo licensing, image-resolution and watermark upgrades should be handled using HLQ's master asset library; the linked page retains its current original images.

Clearance, Field Pattern & Fixture

Coil-to-part gap affects magnetic coupling and heating distribution. Reduce the gap only as far as thermal expansion, insulation, mechanical runout, loading and vibration permit. No single inverse-square efficiency law applies to every coil geometry.



Smaller feasible gap improves coupling, but safe clearance is mandatory.

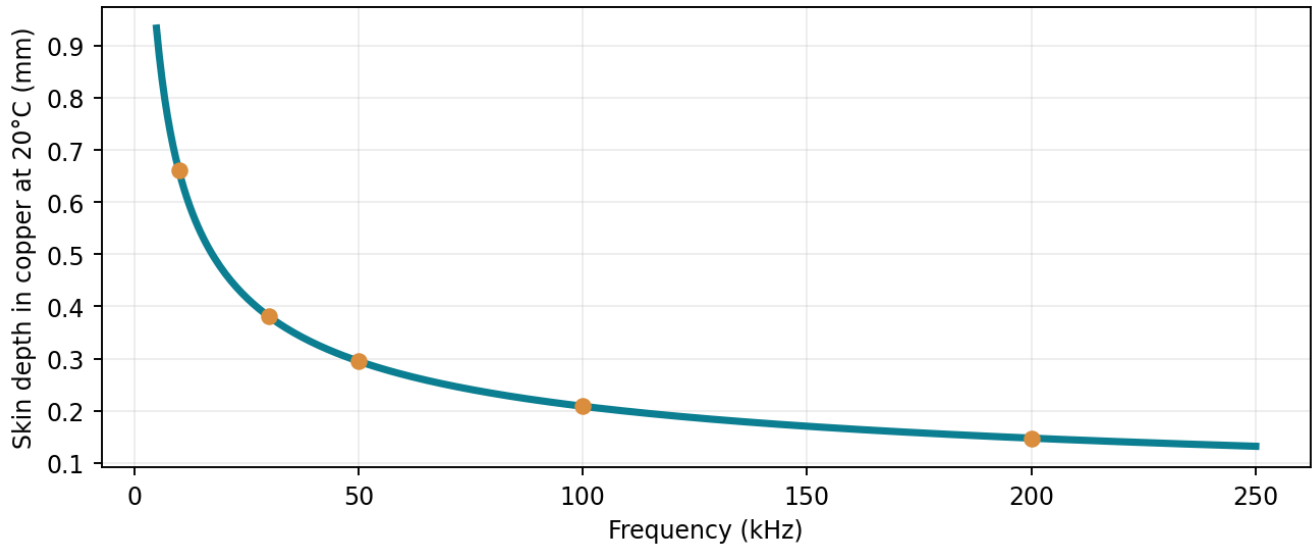
Decision	Best Practice	Validation
Radial clearance	Set an achievable minimum after expansion and tolerance stack-up	Cold/hot dimension check
Coil centering	Use repeatable fixturing or spin/scan where justified	Temperature distribution
Turn pitch	Balance axial uniformity, field interaction and insulation	Heating pattern/IR or probe map
Lead geometry	Manage current return path, support and induced stray heating	Power match and inspection
Flux concentrators	Consider where selective field shaping is required	Material temperature rating, stability and trial

Mechanical safety: coil-to-workpiece contact can cause electrical faults, water leaks, damaged parts and personnel exposure. Do not select clearance from a marketing rule alone.

Frequency, Skin Depth & Temperature

For a homogeneous conductor with constant electrical properties, reference skin depth is $\delta = \sqrt{\rho / (\pi f \mu)}$, where ρ is resistivity ($\Omega \cdot m$), f is frequency (Hz) and μ is absolute magnetic permeability (H/m). This predicts the exponential current-density decay length, not necessarily final thermal penetration after conduction.

Reference skin-depth relationship, copper at room temperature



Frequency	Approx. Copper Skin Depth at 20°C	Interpretation
10 kHz	0.66 mm	Reference electrical depth only
30 kHz	0.38 mm	Higher frequency gives shallower skin depth
100 kHz	0.21 mm	Final temperature still depends on time/conduction
200 kHz	0.15 mm	Coil copper current distribution also changes

Critical distinction: these reference values concern copper at room temperature, not steel hardening case depth. Steel magnetic permeability and resistivity change strongly with temperature and around the Curie transition.

Frequency is a system parameter

For each quote, verify that the complete loaded resonant circuit - transformer, capacitor bank, leads and coil - falls within the generator's allowed tuning and current range.

From Drawing to Production Coil

Material +
Part Drawing

Frequency +
Coil Layout

Prototype +
Water Test

Heat Trial +
Inspection

Approval +
Production

Illustrative sizing exercise - not a commissioned project

Example: a 0.5 kg steel section is heated from 25°C to 750°C in 20 seconds. With an assumed average heat capacity of 0.60 kJ/(kg·K), useful sensible heat is $Q \approx 217.5$ kJ or 0.0604 kWh. Average useful thermal power ≈ 10.9 kW. At an illustrative 45% total electrical-to-part efficiency, estimated input is about 24.2 kW - before final electromagnetic design and validation.

Input / Result	Illustrative Value	Status
Heated mass	0.5 kg	Assumed
Thermal rise	725 K	Assumed
Average specific heat	0.60 kJ/kg·K	Approximate illustration
Useful energy	217.5 kJ	Calculated
Average useful power	10.9 kW	Calculated
Illustrative input	24.2 kW	Assumed 45% efficiency - not a selected HLQ model

Actual sizing additionally accounts for nonuniform heating, fixturing, surface losses, coil current limits, transient changes in material properties and production duty. Coil turns and copper section are not chosen by this heat equation alone.

Water Cooling, Fabrication & FAT

Item	What to Inspect	Evidence / Acceptance
Copper material	Tube or plate grade, wall and bends	Drawing and supplier traceability where agreed
Coil assembly	Brazed joint integrity, terminal alignment and supports	Dimensions, continuity and visual inspection
Water circuit	Flow path, local restrictions, fouling risk, temperature	Pressure/leak test and flow check at prescribed conditions
Electrical insulation	Turn separation, nearby grounded parts, thermal protection	OEM-standard inspection and test
Power matching	Loaded resonance, current and frequency	Trial log vs generator permissible ranges
Heating quality	Actual temperature pattern and response time	Recorded trial, inspection and customer acceptance

Failure modes and first responses

Observed Symptom	Potential Cause	Engineering Response
Uneven temperature	Off-center part, asymmetrical return, poor pitch	Inspect fixture and map heating
Slow heating	Excess gap, detuning, insufficient useful power	Measure power, frequency, clearance and charge
Premature coil burnout	Low coolant flow, blocked passages or overload	Stop, inspect cooling and verify ratings
Arcing	Contact, insulation failure, excessive voltage	De-energize and investigate qualified electrical faults

Engineering responsibility: test performance at the customer's specified process conditions. A nominal geometry without heat-test evidence does not guarantee part temperature or quality.

Application-Based Coil Selection

Process	Starting Coil Concept	Critical Acceptance Measure
Copper-to-brass brazing	Short helical or localized formed coil	Joint temperature and wetting
Shaft induction hardening	Encircling scan or single-shot coil	Case depth, hardness and runout
Flat surface preheating	Pancake/hairpin with fixture	Thermal map and distortion
Internal bore heating	Small ID coil with custom coolant path	Bore zone coverage and clearance
Steel billet forging	Multi-turn long helical coil/line	Through-temperature and hourly mass
Wire/strip annealing	Channel/tunnel or tailored solenoid	Speed, final temperature and properties
Special complex geometry	Formed coil, flux control and test fixture	Surface pattern and repeatability

Differentiate coil and power supply

A coil is custom tooling, not a standalone heating machine. The manufacturer should confirm maximum coil current, generated voltage, capacitance/matching, effective load impedance, coolant heat rejection and the required generator configuration.

Do not transfer machine model ranges: HLQ power-supply family frequencies can be useful for preliminary discussion, but none of those values is a universal specification for every custom coil.

Product photography and source verification

The WordPress product description retains the original gallery images using their existing URLs. For print, request unwatermarked high-resolution originals from HLQ's media archive; this PDF provides the original gallery link and technical illustrations, rather than a fabricated factory photograph.

Core FAQs & RFQ Checklist

Does one coil suit every induction heater?

No. The load must fall within the inverter and resonant matching limits. Terminal geometry, inductance, current and cooling may differ.

How small should the coupling gap be?

As small as safely and repeatably practical after runout, expansion, insulation and handling have been accounted for.

Is a higher frequency always better?

No. Higher frequency generally reduces electrical skin depth under fixed properties, but heating uniformity and cycle time depend on the whole process.

What proves good coil performance?

Defined temperature distribution, cycle time, product quality, loaded electrical behavior and stable coolant performance.

Can a custom coil be repaired?

Some damage or joints can be repaired, but suitability depends on the affected section, geometry, cooling integrity and qualification.

Provide these inputs for quotation

PART DRAWING / 3D

MATERIAL GRADE

HEATING ZONE

TARGET TEMPERATURE

CYCLE TIME

GENERATOR kW/kHz

COOLING WATER

ANNUAL VOLUME

RFQ Field	Required Customer Data
Machine	Generator model, voltage, rated output and frequency band
Workpiece	Material grade, dimensions, heated zone and access constraints
Quality	Target temperature, hardness/joint strength, tolerance
Production	Cycle and loading method; duty per shift
Utilities	Water temperature, flow, pressure, quality and service clearance

Specify the Coil, Then Validate the Heat

HLQ can review coil geometry, power-supply matching, fixturing and prototype testing when the buyer provides a representative drawing or part sample and clear process acceptance requirements.

REQUEST A CUSTOM COIL QUOTATION

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Photographic media policy

This brochure includes original engineering drawings and a live link/QR to the company's current product gallery. It intentionally does not present fabricated images as photographs of actual manufactured HLQ coils. For a print-ready edition with embedded factory photos, export the four current product photographs from the site's WordPress Media Library at original resolution and replace the linked gallery reference.

Engineering verification notes

- Data status: manufacturer page text plus transparent engineering illustrations; no fabricated equipment model or customer result.
- Skin-depth curve: copper at 20°C, resistivity $1.72 \times 10^{-8} \Omega \cdot m$, $\mu_r \approx 1$; values vary with temperature.
- Worked sizing exercise: hypothetical example, not an actual factory acceptance test.
- All proposed coil arrangements require power, cooling and heated-part qualification before release.

Related HLQ technical pages

[Induction Heating Coils Design](#) · [Induction Brazing Coils](#) · [Induction Hardening Coils](#)

Prepared October 2026. Manufacturer page and reference articles were reviewed; no live Google Search Console access or website admin access was available for index, canonical, schema or speed inspection.