

Improved Soldering with Induction Heating



Ambrell[®]
INDUCTION HEATING SOLUTIONS
an inTEST Company



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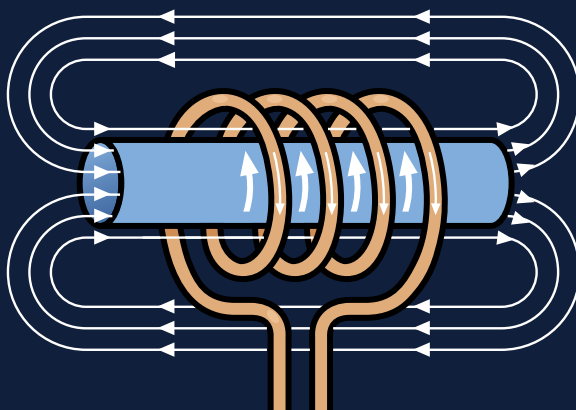


>> What is Induction Heating

Induction heating is a method of providing fast, consistent heat for manufacturing and research applications which involve bonding or changing the properties of metals or other electrically conductive materials. The process relies on electrical currents within the material to produce heat. Although the basic principles of induction are well known, modern advances in solid state technology have made induction heating a remarkably simple, cost-effective heating method for applications which involve joining, treating, heating and materials testing.

The basic components of an induction heating system are an AC power supply, induction coil, and workpiece (the material to be heated or treated). The power supply sends alternating current through the coil, generating a magnetic field. When the workpiece is placed in the coil and enters the magnetic field, eddy currents are induced within the workpiece, generating precise amounts of clean, localized heat without any physical contact between the coil and the workpiece.

There is a relationship between the frequency of the alternating current and the depth to which it penetrates in the workpiece; low frequencies are effective for thicker materials requiring deep heat penetration, while higher frequencies are effective for smaller parts or shallow penetration. Power levels and heating times are closely related to the characteristics of the workpiece and the design of the induction coil. Coils are normally made of copper with appropriate water cooling and vary considerably in shape according to the application.



>> What is Soldering?

Induction soldering is an induction process in which two separate pieces are fused together using a filler metal or other material that melts at a temperature below 427 °C (800 °F). The filler metal varies depending on the other components being joined, but the most common fillers for induction soldering include alloys such as tin-silver, tin-zinc, and tin-lead.

Soldering differs from brazing because it is performed at lower temperatures. When compared to brazing, soldering may have a slightly weaker joint, but that can be preferable for some applications such as those involving small components. Soldering differs from welding because it does not involve the melting of joints.

Why Use Induction for Soldering?

Fast Heating Cycles: An induction heating system typically consists of three parts: the power unit, the work head, and the work coil. First and foremost, induction is a rapid method of heating. Depending on the work piece and system being used, the process can take just seconds. Consequently, if a company needs to solder metals quickly, induction is a great choice.

Reduced Error Potential: Induction is a precise method of heating, which makes it a great choice for soldering. Once the process is set up, organizations can expect the same result time after time. It helps minimize the odds of inconsistencies which might otherwise be seen if using a soldering iron or torch.

Enhanced Control: Induction soldering enables companies to control the process thanks to the precise heating that induction offers while also avoiding thermal stress. The result is the creation of a consistent, clean joint.

Energy Savings: Compared to flame or resistance heating, induction is typically more energy efficient which can result in significant energy savings. It also can offer safety benefits over a torch, as there is no open flame.

Why Use Ambrell for Induction?

Ambrell has installed over 15,000 systems into over 50 countries. THE LAB at Ambrell offers complimentary applications testing and has a wealth of experience with induction soldering. Ambrell was founded in 1986, its systems are built in its state-of-the-art ISO-certified facility in the United States, and they are backed with an industry-leading two-year warranty.

>> Advantages of Induction Heating

Improved Productivity

Improved Energy Efficiency

Improved Design; Integration

Improved Features



- Meets tight production tolerances with precise localized heat to small areas creating pinpoint accuracy
- Increases production rates with faster heating cycles
- Reduces defect rates with repeatable, reliable heat
- Eliminates variability from operator-to-operator, shift-to-shift
- Maintains metallurgical characteristics of the individual metals
- Uses less energy-immediate heating
- Non-contact heating
- Generates heat only where needed; no wasted energy
- Produces no harmful exhaust gases
- Does not contaminate material being heated
- Reduces energy costs with our high AC mains power factor
- Convert AC mains to RF power with our advanced product designs
- Requires a small footprint
- Integrates well into production cells
- Uses compact workhead, optimizing workspace
- Integrates with automated control systems (analog & digital I/O)
- Presents user-friendly interface
- Carries built-in operator safety features
- User-friendly adjustable tap settings, interchangeable coils
- Convenient bench models
- Wide range of frequencies (1-400 kHz) and power (50 watts to 500 kW)
- Environmentally friendly – creates clean, pleasant operating environment

>> Soldering Applications



- Aerospace
- Appliance Manufacturing
- Automotive
- Consumer Products
- Hand Tools
- Industrial Manufacturing
- Medical & Dental Tools

>> Soldering Four Fusible Copper Strips

OBJECTIVE	To heat copper strips of various sizes to 400 °F (204 °C) for a soldering application; the client was heating two fusible strips concurrently but would like to heat four concurrently with induction.
EQUIPMENT	Ambrell EASYHEAT™ 5 kW, 150-400 kHz induction heating system equipped with a remote workhead. A single position four turn double wound helical coil designed specifically for this application.
FREQUENCY	175 kHz
TEMPERATURE	400 °F (204 °C)
MATERIAL	Copper strips and solder.
TESTING	Initial tests were conducted to optimize the power delivered to the copper strip. Four parts were placed under the coil approximately 0.25 inches (6.4 mm) away from it. The power was turned on and after seven seconds the larger parts began to separate indicating that the solder had reached the flow point. A heating time of 10 seconds will ensure good flow. Placing the center of the coil turn over the center of the joint area offers the best performance for this application.
BENEFITS	<ul style="list-style-type: none">• Speed: It took 10 seconds (or less) to heat four copper strips concurrently, resulting in a boost in throughput for the client.• Precise, repeatable heating: Induction is a highly repeatable process that heats just the required area of the copper strip.• Safety: There is no open flame with induction, which makes it safer than competitive heating methods.



Four copper strips being heated concurrently with an induction coil.

>> Soldering a Pair of Magnetic Steel Pins

OBJECTIVE	To solder a pair of magnetic steel pins/posts to create an automotive component.
EQUIPMENT	Ambrell EASYHEAT™ 1 kW, 150 to 400 kHz induction heating system equipped with a remote workhead containing one 1.33 µF capacitor for a total of 1.33 µF. A single-position two-turn pancake induction heating coil designed and developed specifically for this application.
FREQUENCY	214 kHz
TEMPERATURE	1400 °F (760 °C)
MATERIAL	Coil and steel pin assembly (5/16”/7.9 mm pin/post O.D.) and solder rosin core.
TESTING	Any remaining insulation on the wire was removed with sand paper. A foot peddle was part of the induction heating system setup to facilitate manual feeding of the solder. The part was placed in the coil and the power was turned on. After seven seconds the solder began to flow and the solder was fed to the joint. Power was pulsed for one additional second to allow the solder to continue to be fed. The overall process took less than ten seconds.
BENEFITS	<ul style="list-style-type: none">• Speed: Heating took less than 10 seconds, and while this is a new process for the client, other heating methods would be slower.• Precise, repeatable heating: Induction is a highly repeatable process so the customer can expect the same result every time with only the portion of the part requiring heating being heated.• Safety: There is no open flame with induction, which makes it a safer method of heating than torch heating.



The assembly inside the coil prior to heating.

>> Soldering a Fine Copper Wire to a Connector Assembly

OBJECTIVE	To solder a smaller copper wire and connector assembly within one second, and a larger assembly within two seconds for a battery cable and terminal application for the automotive industry.
EQUIPMENT	Ambrell EASYHEAT™ LI 3542, 4 kW, 150-400 kHz induction heating system equipped with a remote heat station containing one 1.5 µF capacitor. A single position, three-turn helical induction heating coil. A single position, four-turn double wound helical induction heating coil was used for smaller assemblies.
FREQUENCY	273 kHz
TEMPERATURE	437 °F (225 °C)
MATERIAL	Smaller copper wire (OD of 0.41mm/0.02”) and larger copper wire (OD of 8.86mm/0.35”). Connectors and solder.
TESTING	Initial tests were conducted to optimize power for the smaller and larger assemblies. The larger assembly was placed into the single position, three-turn helical coil and power was turned on. The assembly began to heat and the solder was applied as two solder sticks were fed simultaneously to complete the soldering application. The smaller assembly was placed into the four-turn double wound helical coil and power was turned on. The assembly began to heat and the solder stick was applied to complete the soldering application.
RESULTS/BENEFITS	<ul style="list-style-type: none">• Joint quality: EASYHEAT coils delivered a higher quality joint.• Superior energy efficiency: The EASYHEAT is more energy efficient than the outdated system that the client was using.• Support: The company desired personalized, local support from their induction heating vendor, which Ambrell delivered.



The assembly inside a four-turn double wound helical coil.



The part on the right was done by the EASYHEAT, and the part on the left was done by the previous induction heating system – the penetration of the solder is superior on the right.

>> Soldering Steel Canister Reservoir for Sealing

OBJECTIVE	Induction offers benefits over a current hand-soldering operation of these beverage dispenser reservoirs.
EQUIPMENT	Ambrell EASYHEAT™ 2.4kW/300kHz induction heating system, equipped with a remote workhead containing two 0.33μF capacitors for a total of 0.66μF. An induction heating coil designed and developed specifically for this application.
FREQUENCY	248 kHz
TEMPERATURE	500 °F (250 °C)
MATERIAL	Steel canister (reservoir), 6inch x 4 inch oval, end plates.
TESTING	Current hand-soldering process results in uneven, non-uniform joints and requires long production times. Induction delivers uniform, quality joints by generating heat within the end-plate and reservoir walls. A single-turn helical coil is used to heat the steel canister. The part is placed in the coil and heated for 2 minutes to reflow a solder ring placed inside the canister to make a leak proof joint.
BENEFITS	<ul style="list-style-type: none">• Induction heating provides:<ul style="list-style-type: none">- heat generated within the part, saving energy and time- improved throughput since the entire base is soldered at one time- precise controllable heat- uniform, high-quality joints- repeatable results- even distribution of heating



Canister is staged within single-turn coil; solder flows in the cavity formed with the steel end-plate.

>> Soldering a Copper Wire and Contactor Assembly

OBJECTIVE	To heat a copper wire and contactor assembly to 400 °F for a soldering application at a motor manufacturer.
EQUIPMENT	Ambrell EASYHEAT™ 5kW 150-400 kHz induction heating system equipped with a remote work head containing two 1.0 µF capacitors. A multi-turn helical induction heating coil designed and developed specifically for this application.
FREQUENCY	360 kHz
TEMPERATURE	400 °F (204 °C)
MATERIAL	Rotor assemblies and solder
TESTING	High intensity heat must be applied to the joint area for this application so that thermal conduction of the copper does not sink away the heat delivered from the induction process. High intensity heat enables this process to avoid excessive heat to the black plastic body that houses the connectors. The multi-turn helical coil that was used to generate the heat pattern for this application maximizes efficiency. The result is a reduced cycle time. A multi-turn solder wire preform was placed on the joint area. Power was then applied until the solder flowed and created a good joint. The end result was that induction dramatically reduced the cycle time which was four minutes per part with a soldering iron.
BENEFITS	<ul style="list-style-type: none">• Speed: Induction offers considerable time savings when compared to using a soldering iron, which results in increased production efficiencies.• Production Rate: Thanks to induction's faster rate of soldering, it allowed the client to enjoy an improved production rate.• Precision: Induction is precise, and should resolve the client's quality issues that it was seeing with a soldering iron



The copper wire and contactor assembly.

>> Soldering a Copper Tube to a Brass Flow Valve

OBJECTIVE	To heat a copper tube and a brass valve to 356 °F for a brazing application.
EQUIPMENT	Ambrell EASYHEAT™ 9kW 150-400 kHz induction heating system equipped with a remote work head containing two 1.5 µF capacitors. A single-position two-turn C-shaped induction heating coil designed and developed specifically for this application.
FREQUENCY	258 kHz
TEMPERATURE	358 °F (180 °C)
MATERIAL	Copper tubes (various sizes), brass valves (various sizes), solder and general purpose flux
TESTING	The assembly was placed into the induction heating coil and the power was turned on. After 12 seconds solder was fed to the joint of the assembly. Flux core tin lead solder was used for this application. With a 9kW EASYHEAT, the assembly heated to 358 °F within 12 seconds.
BENEFITS	<ul style="list-style-type: none">• Speed: The heating process was completed within 12 seconds and proved to be faster than the client's gas torch.• Repeatability: Induction is a repeatable heating process, while gas torches are generally less dependable which can impact part quality.• Safety: Induction does not present a flame, so it helps create a safer, cooler working environment.



The assembly inside the induction heating coil during soldering.

>> Soldering Brass and Steel Radiator Caps

OBJECTIVE	To heat brass and steel radiator caps to temperature for a soldering application.
EQUIPMENT	Ambrell EASYHEAT™ 9kW 150-400 kHz induction heating system equipped with a remote workhead containing two 1.0 µF capacitors. A single-position two-turn split helical induction heating coil.
FREQUENCY	350 kHz
TEMPERATURE	450 °F (232 °C)
MATERIAL	<ul style="list-style-type: none">• Brass radiator caps• Steel radiator caps• Solder and Flux
TESTING	<p>For the brass cap, the Ambrell team found that by varying the position of the part axially in the coil, more or less heat could be applied to the top or bottom of the assembly. A position was found to heat the top and bottom of the part at the same rate. It took 15 seconds for the solder to flow and create a good joint.</p> <p>For the steel cap, it was noticed that because of the thickness of the solder wire the top of the assembly was closer to the top turn of the coil which caused it to heat more quickly. Consequently, an attempt to solder from the bottom was also made. In both cases, the soldering process took just 15 seconds.</p>
BENEFITS	<ul style="list-style-type: none">• Speed: The heating process was completed within just 15 seconds.• Repeatability: Induction is a repeatable heating process, so a consistent result is achieved each time.• Safety: Induction does not present a flame, so it helps create a safer, cooler working environment than other methods



The brass radiator cap, immediately following heating.



The steel radiator cap, immediately following heating.

>> Soldering a Copper Lug and a Wire

OBJECTIVE	To heat a copper lug and a wire to temperature for a soldering application to create grounding connections.
EQUIPMENT	Ambrell EKOHEAT™ 10 KW, 50 KHz to 150 KHz solid state induction power supply, equipped with a remote heat station containing (3) 1.4 μ F capacitors for a total of 4.5 μ F. A single-position two-turn C-shaped induction heating coil designed and developed specifically for this application.
FREQUENCY	109 kHz
TEMPERATURE	370 °F (188 °C)
MATERIAL	Wire, lug, solder and flux
TESTING	The parts were fluxed and the solder wire was folded two times and twisted to enable a greater feed rate. The assembly was then placed in the coil and the power was turned on. The coil was designed to focus heat on the large lug and to keep solder from running over the wires. After 40 seconds, the assembly reached soldering temperature. It was observed that the lug could easily be filled with solder when it's placed in a vertical direction and the solder will run out of the bottom when full. If the lug was oriented in a horizontal position the solder could be more readily kept in and around the lug.
RESULTS/BENEFITS	<ul style="list-style-type: none">• Speed: The heating process was completed within 40 seconds.• Repeatability: Induction is a repeatable heating process, so a consistent result is achieved each time.• Safety: Induction does not present a flame, so it helps create a safer, cooler working environment than other methods.



The joint made during the horizontal orientation.



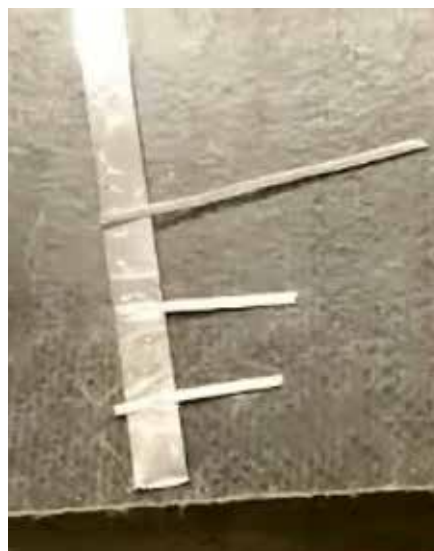
The joint made during the vertical orientation.

>> Soldering Copper Tabs

OBJECTIVE	To heat copper tabs for bonding; this is for a solar cell stringing and tabbing application.
EQUIPMENT	Ambrell EASYHEAT™ 1 KW, 150 kHz to 400 kHz solid state induction power supply, equipped with a remote workhead containing one 0.1 µF capacitor. A single-position solder pen induction heating coil designed and developed specifically for this application.
FREQUENCY	200 kHz
TEMPERATURE	356 °F (180 °C)
MATERIAL	Copper strips.
TESTING	The coil assembly consisted of a 'C' core ferrite, and the copper coil was wound around the core. The heat time for this application was 1-2 seconds.
BENEFITS	<ul style="list-style-type: none">• Speed: Induction proved faster than the client's previous heating process – a torch.• Repeatability: Induction is a repeatable heating process, so the client gets superior results with induction when compared to a torch.• Efficiency: Induction is more energy efficient than torch heating.• Safety: Induction doesn't have an open flame and introduces less heat into the work environment than a torch.



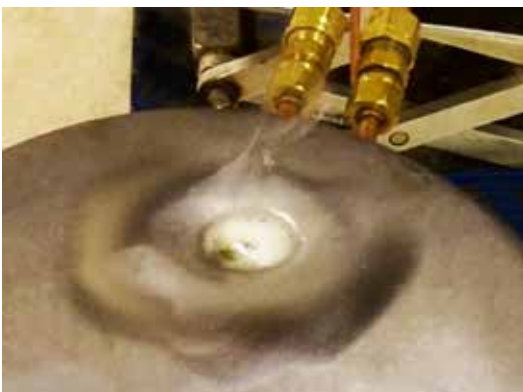
The assembly during heating.



The completed assembly.

>> Soldering a Rivet onto a Steel Tank Cap with Induction Heating

OBJECTIVE	To solder a rivet onto a steel tank cap; the client was soldering with a torch but getting inconsistent results.
EQUIPMENT	Ambrell EASYHEAT™ 2 kW, 150 KHz to 400 KHz induction power supply, equipped with a remote workhead containing two 0.66 µF capacitors for a total of 1.32 µF. A single-position two turn helical induction heating coil designed and developed specifically for this application.
FREQUENCY	300 kHz
TEMPERATURE	450 °F (232 °C)
MATERIAL	6" (152 mm) steel end cap, 0.156" (4 mm) steel rivet, solder paste.
PROCESS	The steel end cap was placed on a slight angle to allow the solder to pool and the coil was located axially to the rivet and approximately 1/8" (3 mm) away from the end cap. The power was turned on and the end cap heated to temperature within 30 seconds and achieved favorable results. The slight angle of the end cap's placement was critical to the application's success.
BENEFITS	<ul style="list-style-type: none">• Speed: Induction proved faster than the client's previous heating process – a torch.• Repeatability: Induction is a repeatable heating process, so the client gets superior results with induction when compared to a torch.• Efficiency: Induction is more energy efficient than torch heating.• Safety: Induction doesn't have an open flame and introduces less heat into the work environment than a torch.



The assembly during heating.



The assembly after soldering.



Complimentary Applications Testing

The Gold Standard in the Industry



Our Applications Laboratory – known in the industry as THE LAB – is where we solve our customers' most demanding and challenging heating applications. Led by Dr. Girish Dahake's worldwide team of elite engineers, Ambrell is uniquely qualified to assist you with your heating process needs.

With more than thirty years of laboratory expertise, our engineers have evaluated thousands of applications. Our team consistently provides innovative and effective induction heating solutions that deliver extraordinary results in one application after another. It's why THE LAB is the gold standard in the industry.



We invite you to visit THE LAB in either of our two locations: one in the U.S. and one in Europe. You will experience our state-of-the-art testing facility, which is fully equipped with Ambrell induction heating systems and hundreds of proven coil designs. In addition, you can interface with our engineers and see first-hand how we design prototype coils and develop effective solutions to maximize the efficiency of your heating process.

Applications Laboratory Overview

- Customer access to a wide array of induction heating equipment in THE LAB
- Hundreds of proven coil designs available
- Rapid coil prototyping for unique applications
- Video recording for slow motion studies includes availability of remote access
- Computer software for thermal analysis
- Quenching and closed loop heat-sensing capabilities
- Convenient, easy-to-use online form to get your free PRECISION MATCH Lab service

Free PRECISION MATCH Lab Service

Our engineers will design and test the optimal solution for your application. Follow these three easy steps:

- 1) Send us your parts and process requirements.
- 2) Our engineers will analyze your process and heat your parts to develop the precise and optimal solution to match your needs.
- 3) You will receive your parts back for inspection including a video recording of the induction heating process of your parts as well as a laboratory report with a system recommendation.

>> Free Parts Evaluation

Email this form to sales@ambrell.com and we'll reach out to you to get the process started.
Or contact us today at www.ambrell.com/services/lab-service-request

Service Requested

- Calculations only (with budgetary estimate) Full Feasibility Test* (for formal quotation) Process Development (fee-based service)

*Please include several parts and all other materials necessary to complete your finished samples.

Your Information

Name: _____ State/Prov: _____
Title: _____ Postal Code: _____
Company: _____ Country: _____
Address 1: _____ Phone: _____
Address 2: _____ Fax: _____
City: _____ E-mail: _____

Process Information

- Annealing Brazing Curing Forming Fusing Cath. Tipping
 Hardening Mat. Testing Plastic Reflow Shrink Fitting Soldering _____

Describe your end product: _____

Part Details: _____ Drawing, photo attached Parts included

How do you hold the parts during heating? _____

Are there other requirements we should know? _____

Performance Data

Materials to be heated: _____	Present Results	Present Results
Hardness depth: _____	Method: _____	Method: Ambrell Induction Heating
Weight: _____	Cycle Time: _____	Cycle Time: _____
Solder/Braze/Flux used: _____	Heating Time: _____	Heating Time: _____
Rockwell hardness: _____	Temperature: _____	Temperature: _____

Water Cooling: Induction heating requires a source of cooling water; do you have in-plant cooling?

- Yes; please quote a water-to-water system No; please quote a water-to-air cooler
 No; please quote a standalone chiller No; please quote a tower cooling system
 No; please quote a dry cooling and trim chiller system

Line voltages: 360-520V 3Ø 220V 3Ø 110-220V 1Ø _____

What is the most important thing we need to do for you?

When do you need the solution? _____



About Ambrell

Founded in 1986, Ambrell Corporation, an inTEST Company, is a global leader in the induction heating market. We are renowned for our application knowledge and engineering expertise. In addition, our exceptional product quality and outstanding service and support are at the core of our commitment to provide a superior customer experience.

We are headquartered in the United States with additional operations in Europe including the United Kingdom and the Netherlands. All Ambrell products are designed, engineered and built at our manufacturing plant in the United States, which is an ISO 9001-certified facility. Over the last three decades we have expanded our global reach through an extensive distribution and OEM network, and today we have more than 15,000 systems installed in over 50 countries.



Ambrell®
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