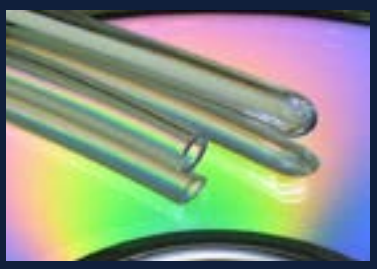
Medical Applications with Precision Induction Heating

Ambrell®
INDUCTION HEATING SOLUTIONS
an inTEST Company



Experience the Excellence.™

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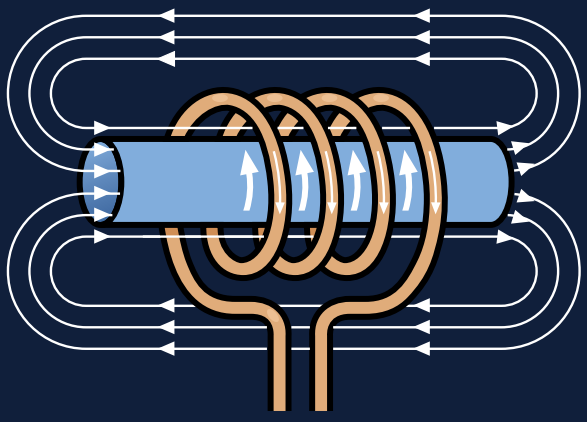
» What is Induction Heating

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.



Research is a very common induction heating application. Induction heating supplies a clean, very localized and controllable heat.

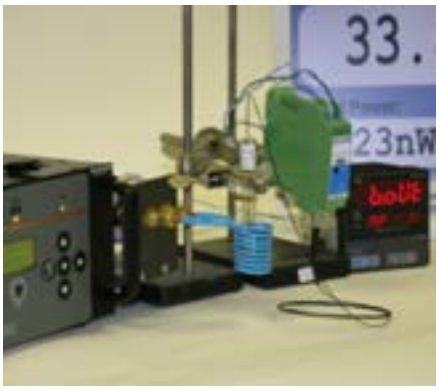
>> Advantages of Induction Heating

Improved Productivity

Improved Energy Efficiency

Improved Design; Integration

Improved Features



Ambrell's complete package for Hyperthermia Research

- Meets tight production tolerances with precise localized heat to small areas creating pinpoint accuracy
- Increased production rates with faster heating cycles
- Reduce defect rates with repeatable, reliable heat
- Eliminate variability from operator-to-operator, shift-to-shift
- Maintains metallurgical characteristics of the individual metals
- Use less energy-immediate heating
- Non-contact heating
- Generate heat only where needed; no wasted energy
- Produces no harmful exhaust gases
- Does not contaminate material being heated
- Reduce 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

Medical Applications

Catheter tipping/Forming

Metal to plastic insertion

Small tool brazing

Powder coating

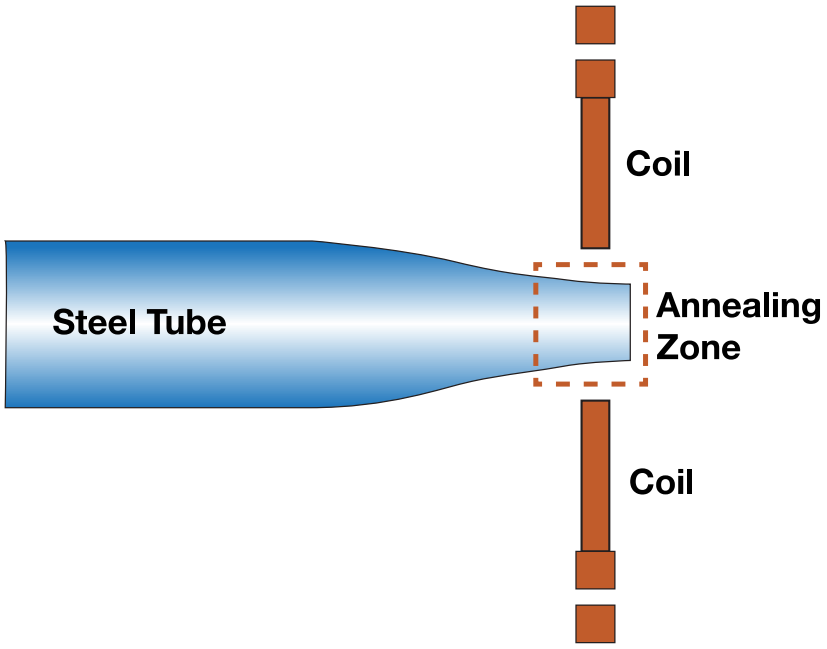
Soldering surgical tools

- Annealing steel tubes
- Catheter tipping
  - Molding
  - Plastic reflow
- Brazing miniature medical parts
- Soldering surgical tools
- Nitinol shape setting
- Curing powder coating
- Metal to plastic insertion
- Annealing tubes and surgical instruments
- Hardening surgical instruments
- Heating catheter tipping dies
- Nanoparticle research

Nanoparticle heating

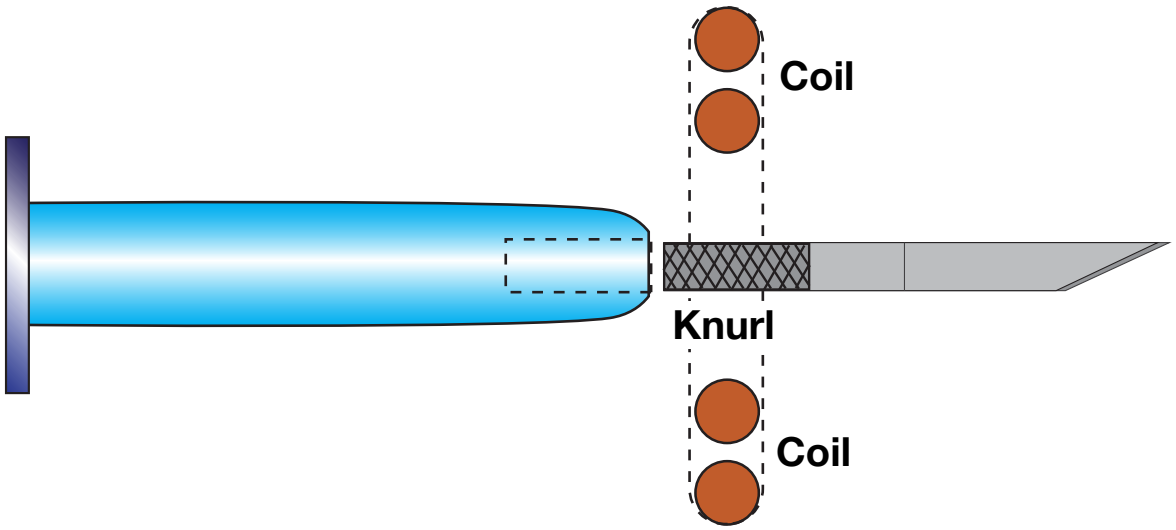
>> Annealing Steel Tubes in an Inert Atmosphere

OBJECTIVE	To heat steel tubes to 2000ºF (1093 ºC) in an inert atmosphere.
MATERIAL	0.1” (2.54mm) diameter stainless steel tube
TEMPERATURE	2000ºF (1093ºC)
FREQUENCY	323 kHz
EQUIPMENT	• Ambrell 1.2 kW induction heating system, equipped with a remote workhead containing one 1.0µF capacitor • An induction heating coil designed and developed specifically for this application
PROCESS	A two turn concentrator coil is used to heat the stainless steel tube. The annealing process takes place in an inert atmosphere to prevent oxidation. The stainless steel tube is placed in the inert atmosphere and heats to 2000ºF (1093 ºC) in 15 seconds to achieve the desired characteristics.
RESULTS/BENEFITS	**Induction heating provides:** • Fast, controllable process • Heat for very small areas within precise production tolerances • Hands-free heating that involves no operator skill for manufacturing • Even distribution of heating



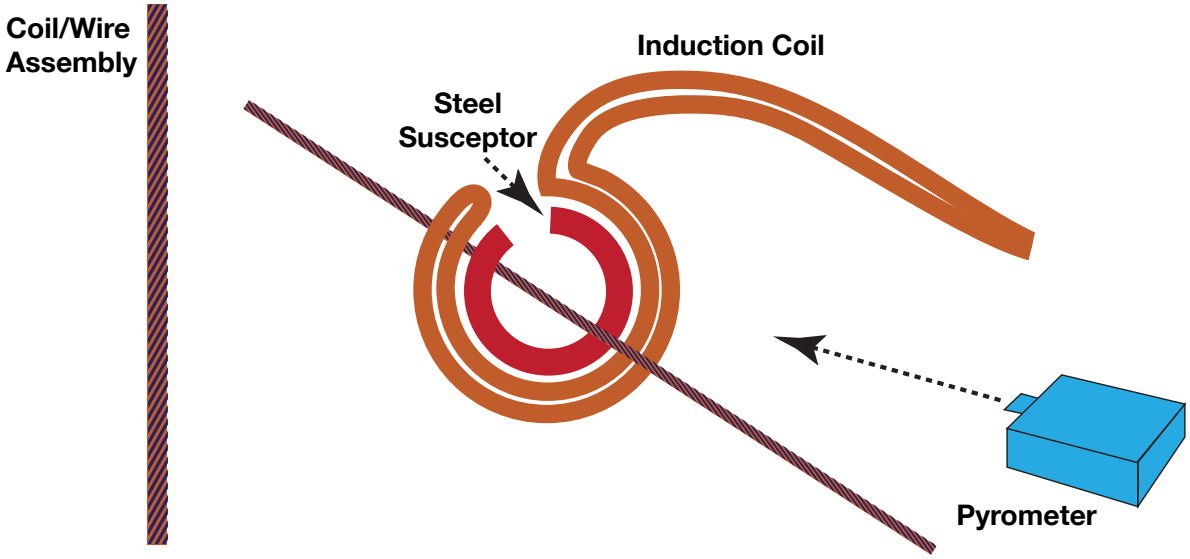
>> Bonding a Plastic Handle to a Surgical Knife

OBJECTIVE	Bonding handle of a stainless steel surgical knife into a plastic handle.
MATERIAL	Plastic tool handle, 0.125” (3.18mm) diameter steel knife
TEMPERATURE	450ºF (232 ºC)
FREQUENCY	390 kHz
EQUIPMENT	• Ambrell 1.2 kW induction heating system, equipped with a remote workhead containing one 0.66µF capacitor • An induction heating coil designed and developed specifically for this application
PROCESS	A four turn split helical coil is used for this application. Power is applied to the steel knife for 2.0 seconds to reach 450ºF (232 ºC). The steel knife is then inserted into the plastic handle to create a solid bond.
RESULTS/BENEFITS	**Induction heating provides:** • Fast, accurate, repeatable heat • Ability to heat very small areas within precise production tolerances • Hands-free heating with no operator skill for manufacturing • Even distribution of heating



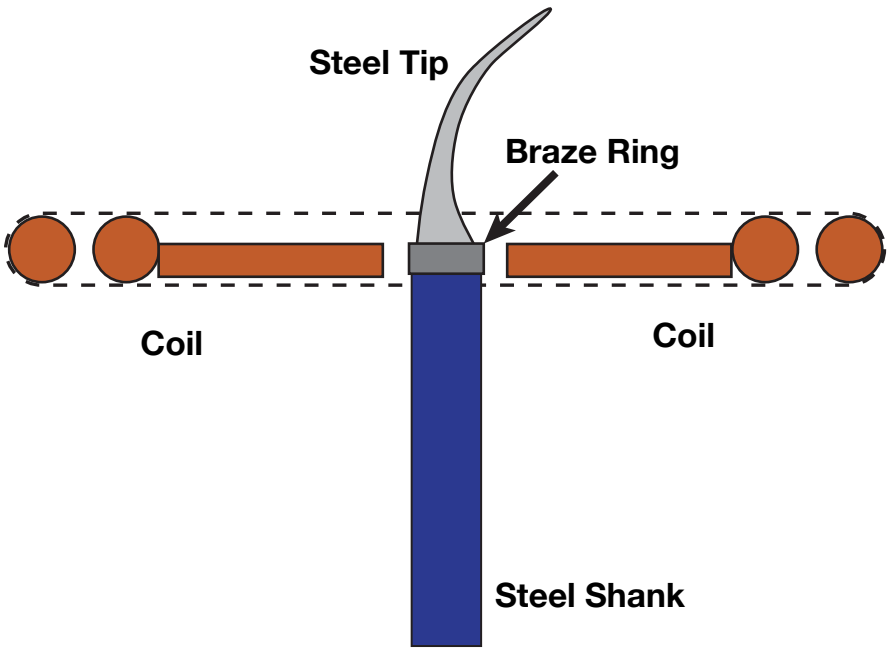
Brazing a Heat-Sensing Probe

OBJECTIVE	To heat a coil and a wire assembly to 1300°F (704°C) within 60 seconds for brazing.
MATERIAL	Platinum coil, steel wire, braze paste
TEMPERATURE	1300°F (704°C)
FREQUENCY	307 kHz
EQUIPMENT	• Ambrell 1 kW induction heating system, remote heat station containing one 1.2 microfarad capacitor, a specially-designed induction coil, an optical pyrometer, stainless steel susceptor, and zirconia felt to house the susceptor.
PROCESS	A C-shaped steel susceptor is used to ensure even heating and or ease of loading and unloading the samples. RF power from the power supply heats the susceptor to the required temperature of 1700°F (926°C) in 45 seconds. After braze paste is applied to the wire assembly, the assembly is placed inside the susceptor. It takes 3.5 seconds to heat the wire to the optimum brazing temperature of 1300°F (704°C) and the braze paste flows evenly and consistently.
RESULTS/BENEFITS	**Induction heating provides:** • Fast, accurate, repeatable heat • Heat very small areas within precise production tolerances • Better joint quality, reduced oxidation



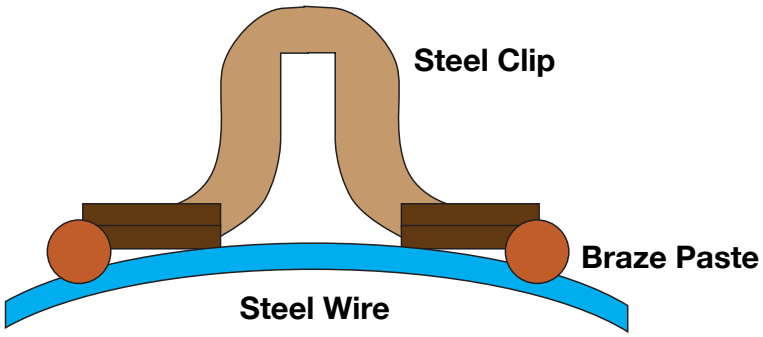
Brazing Steel Dental Tools

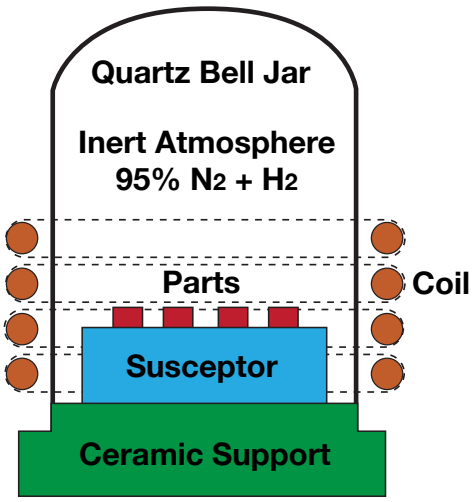
OBJECTIVE	To heat a steel tip and shank assembly to 1300°F (704°C) within three seconds for brazing with induction heating instead of torch brazing.
MATERIAL	0.1” (2.54mm) diameter steel tip and shank, 0.07” (1.78mm) diameter braze ring
TEMPERATURE	1300°F (704°C)
FREQUENCY	278 kHz
EQUIPMENT	• Ambrell 1 kW induction heating system, remote workhead containing one 1.2 microfarad capacitor
PROCESS	A two turn helical coil is used to braze the dental parts. The braze ring is placed at the joint area of the steel tip and shank. Black flux is applied to the joint area. RF power is applied for three seconds to heat the parts to the established target temperature and the braze paste flows evenly and consistently.
RESULTS/BENEFITS	**Induction heating provides:** • Fast, accurate, repeatable heat • Heat very small areas within precise production tolerances • Better joint quality, reduced oxidation • Increased production rates and reduced labor costs



Brazing Steel Orthodontic Parts

OBJECTIVE	To heat a batch of orthodontic parts to 1300°F (704°C) within one second in an inert atmosphere for brazing.
MATERIAL	Small stainless steel orthodontic parts, silver braze alloy, no flux, 3 1/ 8" (79.3mm) graphite susceptor disk with 1" (25.4) center hole and bell jar made of pyrex or quartz
TEMPERATURE	1300°F (704°C)
FREQUENCY	165 kHz
EQUIPMENT	• Ambrell 3 kW induction heating system and 0.5 microfarad workhead
PROCESS	A four turn helical coil is used to heat parts. Brazing paste is applied to orthodontic parts with a syringe. The parts are placed on the graphite susceptor disk, which is placed on an insulating support in a quartz bell jar. After the jar is filled with inert gas, RF power is applied for 50 seconds at 165 kHz to reach the required temperature, followed by a cool-down cycle.
RESULTS/BENEFITS	**Induction heating provides:** • Fast, accurate, repeatable heat • Heat very small areas within precise production tolerances • Better joint quality, reduced oxidation • Higher production rates, reduced labor costs (100 parts per 50 sec.)

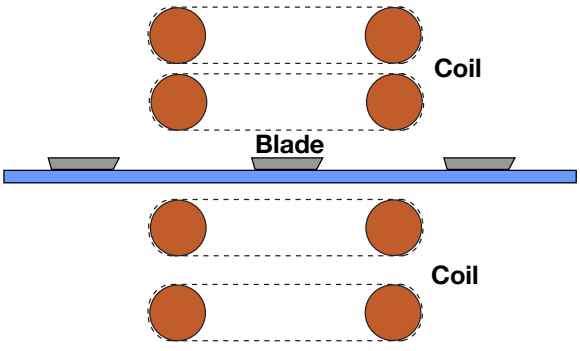




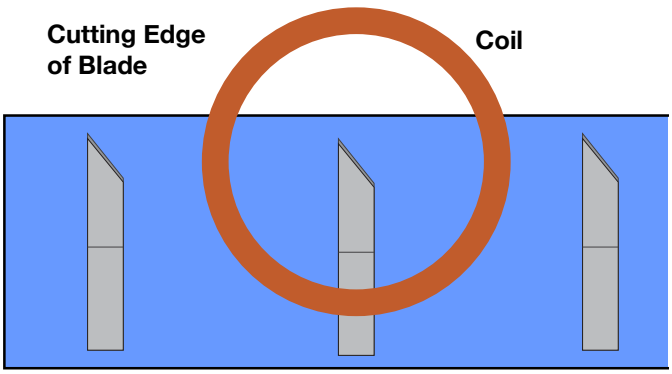
Hardening Surgical Blades

OBJECTIVE	To quickly heat a steel surgical blade to 2000°F (1093°C) within two seconds so as to harden the blade edge.
MATERIAL	Stainless steel surgical blades, temperature sensing paint
TEMPERATURE	2000°F (1093°C)
FREQUENCY	339 kHz
EQUIPMENT	• Ambrell 3 kW induction heating system, remote workhead containing one 1.0 microfarad capacitor
PROCESS	A four turn helical coil is used to harden the blades. The induction coil is designed to provide uniform heat to the entire length of the blade surface. RF power is applied to heat the entire assembly. The blade reaches the necessary temperature for hardening in 1.2 seconds.
RESULTS/BENEFITS	**Induction heating provides:** • Does not affect core structure • Targeted and rapid heat treating • Fast, accurate repeatable heat

SIDE VIEW

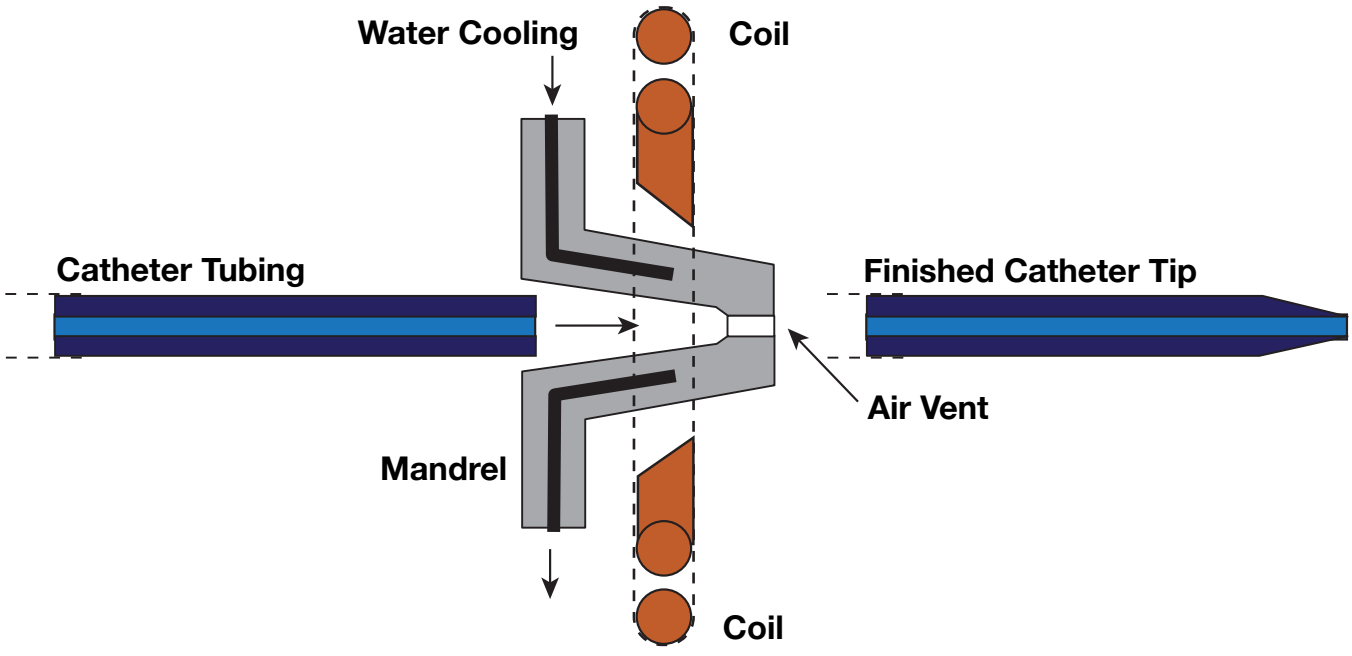


TOP VIEW



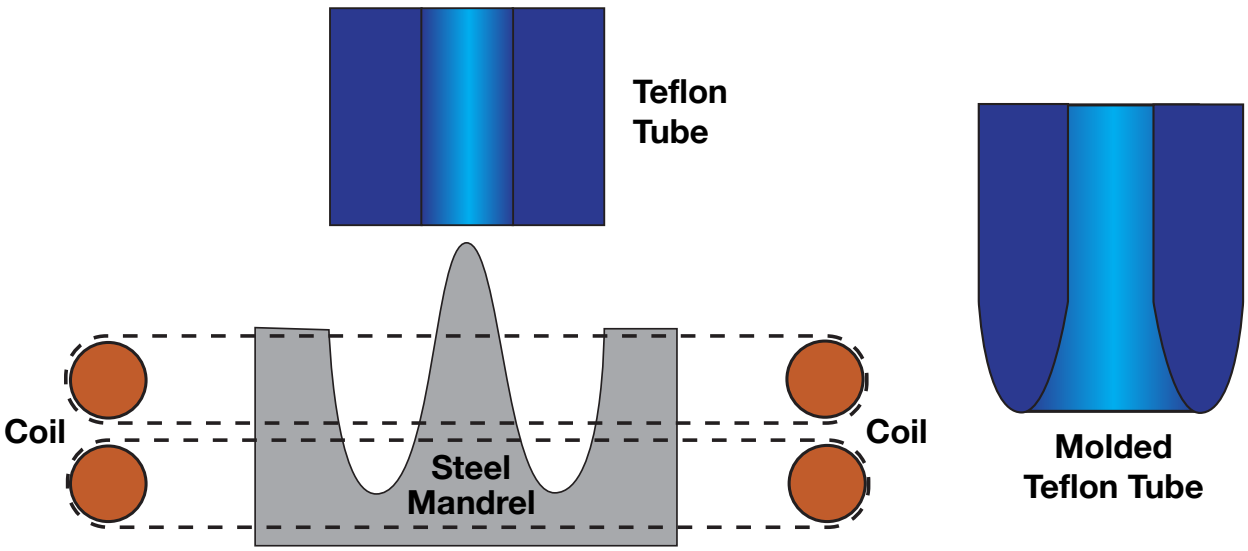
>> Heating a Catheter Tipping Die

OBJECTIVE	To heat a water-cooled mandrel die to 400°F (204°C) within a three to six-second time frame for catheter tipping.
MATERIAL	Water-cooled brass mandrel die, nylon LDPE catheter, “K” type thermocouple and temperature controller
TEMPERATURE	400°F (204°C)
FREQUENCY	325 kHz
EQUIPMENT	• Ambrell 3 kW induction heating system, remote workhead containing one 0.66 microfarad capacitor
PROCESS	A two turn plate concentrator coil is used to heat the die. To measure the temperature on the ID and establish the time-to-temperature relationship, the thermocouple is inserted inside the brass die. RF power is applied for three seconds to heat the die to 400°F (204°C). The nylon tube is pushed into the die and formed into a catheter.
RESULTS/BENEFITS	**Induction heating provides:** • Increased throughput and reduced cycle time • Consistent and repeatable results • Clean heating • Precise temperature control



>> Molding a Teflon Catheter Tip

OBJECTIVE	Heat a water-cooled steel mandrel to 700°F (371°C) to form a high quality Teflon catheter tip.
MATERIAL	Teflon catheter tubing, mandrel assembly
TEMPERATURE	600-700°F (315.6-371°C)
FREQUENCY	376 kHz
EQUIPMENT	• Ambrell 3 kW induction heating system, equipped with a remote workhead containing one 0.66µF capacitor • An induction heating coil designed and developed specifically for this application
PROCESS	A two turn coil is used to heat the steel mandrel to 660°F (371.1°C) in 2.7 seconds. To form the catheter tip, RF power is applied while the catheter is held over the mandrel. The tubing is then pushed on to the mandrel to form a consistent, even tip.
RESULTS/BENEFITS	**Induction heating provides:** • Precise, repeatable application of heat • Non-contact heating • Faster cycle times



>> Heating Nano Particles for Cancer Research

OBJECTIVE

Heat magnetite (Fe_3O_4) diluted in an acid, base and water to 120°F (48.8 °C) for cancer research.

MATERIAL

Sample vials containing Fe_3O_4 in various solutions

TEMPERATURE

120°F (48.8°C)

FREQUENCY

282 kHz

EQUIPMENT

- Ambrell 2 kW 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

PROCESS

A four turn helical coil is used to heat the samples. The sample vials are placed in the coil for 60-600 seconds to reach the required 120°F (48.8 °C). Chart below indicates testing times and temperatures.

RESULTS/BENEFITS

Induction heating provides:

- Direct and precise placement of heat
- Controllable temperature
- Faster heating times

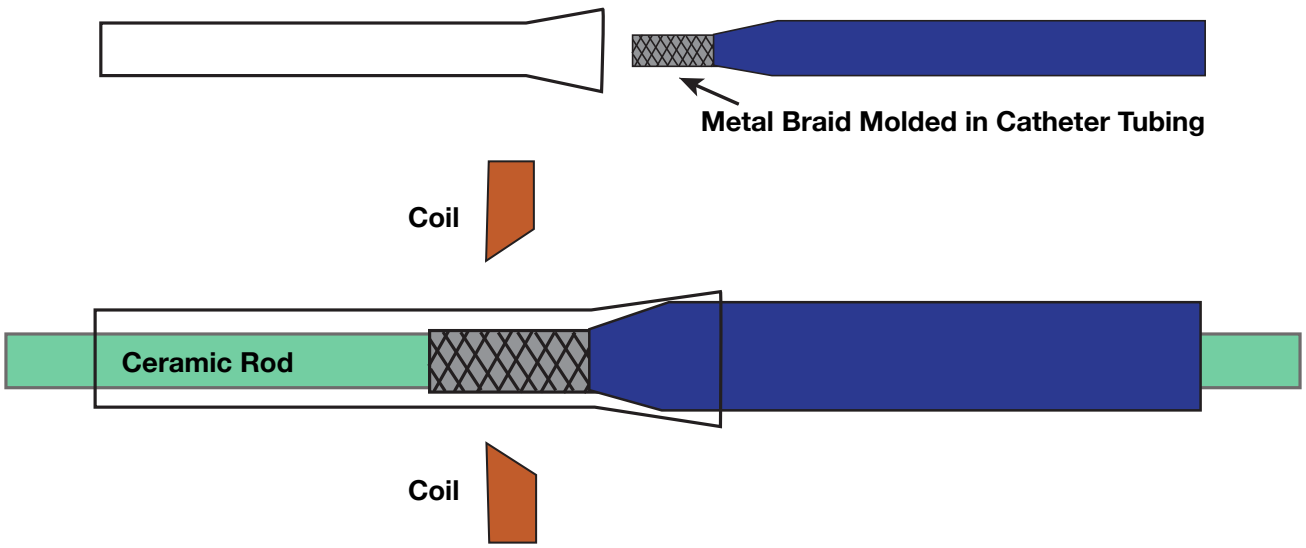
TIME						
Sample	**60 Secs**	**120 Secs**	**150 Secs**	**180 Secs**	**300 Secs**	**600 Secs**
5	77°F	N/A	N/A	N/A	87.8°F	91.4°F
6	98.6°F	116.6°F	N/A	N/A	N/A	N/A
7	84.2°F	N/A	N/A	98.6°F	104°F	109.4°F
8	96.8°F	N/A	107.6°F	N/A	123.8°F	N/A

Vial of magnetite Fe_3O_4 in coil

MAKE UP OF SAMPLES			
Sample #	**Nanoparticle**	**Surfactant**	**Solvent**
5	Fe_3O_4	Amine	H_2O
6	Fe_3O_4	None	NH_4OH in H_2O
7	Fe_3O_4	di-n-propyl amine	H_2O
8	Fe_3O_4	none	HNO_3 in H_2O

>> Plastic Reflow with Catheter Tubing

OBJECTIVE	Heat a metal braid in a plastic catheter tube to 250°F (121°C) so that another catheter tube can be bonded to it.
MATERIAL	0.05” (1.27mm) diameter catheter tubes, some with a metal braid, ceramic rod
TEMPERATURE	250°F (121°C)
FREQUENCY	306 kHz
EQUIPMENT	• Ambrell 1 kW induction heating system, equipped with a remote workhead containing one 1.2µF capacitor • An induction heating coil designed and developed specifically for this application
PROCESS	A single turn helical coil is used to heat the metal braid for plastic reflow. To maintain the correct inside diameter of the tubing. A ceramic rod is inserted through the tubing. Heat is applied for 3.5 seconds to reach 250°F (121°C). The metal braid melts the plastic and creates a bond.
RESULTS/BENEFITS	**Induction heating provides:** • Precise, repeatable application of heat • Non-contact heating • Faster cycle times



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

Send us your parts along with this form and we'll contact you about your free parts evaluation.
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: _____
Title: _____
Company: _____
Address 1: _____
Address 2: _____
City: _____
State/Prov: _____
Postal Code: _____
Country: _____
Phone: _____
Fax: _____
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, sketch, 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: _____
Hardness depth: _____
Weight: _____
Solder/Braze/Flux used: _____
Rockwell hardness: _____

Present Results
Method: _____
Cycle Time: _____
Heating Time: _____
Temperature: _____

Present Results
Method: Ambrell Induction Heating
Cycle Time: _____
Heating Time: _____
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.

ISO 9001:2015 CERTIFIED

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an inTEST Company

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