Improved Shrink Fitting with Induction Heating

Ambrell®
INDUCTION HEATING SOLUTIONS
an inTEST Company

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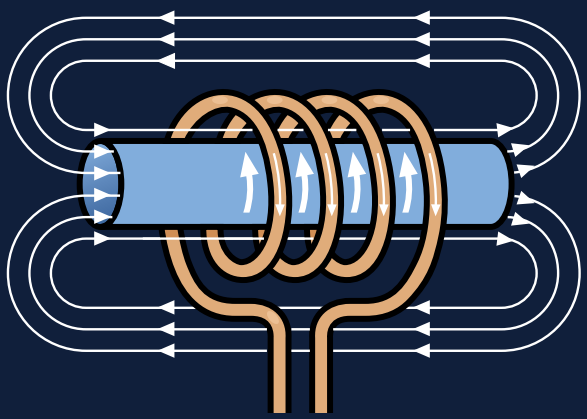
» What is Induction Heating

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 Shrink Fitting?

Metals typically expand when heated and contract when cooled. This response to a change in temperature is known as thermal expansion. With induction shrink fitting, you use thermal expansion to fit or remove parts. A metal component is heated to 150-300 °C (305-572 °F), and that causes it to expand. This allows for the removal or insertion of a part.

For example, for disassembly, induction is used to create thermal expansion to loosen the joint. For assembly, one part might be heated until its diameter expands sufficiently for it to fit over the other part of the assembly. Then, the heated part cools and the joint is strong, which is "shrink fitting." A wide array of metals are used when shrink fitting, whether it's steel-to-steel, steel-to-copper, aluminum-to-steel, etc.

Why Use Induction for Shrink Fitting?

Induction heating delivers several benefits when shrink fitting. Repeatability, accuracy, energy efficiency and speed are four hallmarks of induction heating for virtually any application. Additionally, induction delivers heat to the targeted part, not the atmosphere around it, so there is no risk of distortion. Safety is another considerable benefit, as there is no open flame, which makes it a viable option for almost any manufacturing environment. With induction, temperature can be controlled in a precise manner, so clients enjoy consistency with ramp up times and holding temperatures. Finally, induction systems are conducive to integration into automated processes thanks to its comparatively modest size and remote workheads.

What Industries Use Induction for Shrink Fitting?

Shrink fitting is used for countless automotive applications, including shrink fitting bearings, motor housings, gears to shafts, carbide rings into valve seats and more. Induction shrink fitting is also commonly used in numerous industries including the aerospace and rail industries.

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 shrink fitting. 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

Shrink Fitting Applications

- Automotive
- Aerospace
- Transportation
- Industrial Manufacturing
- Energy/Oil & Gas
- Consumer Products

» Shrink Fitting a Stainless-Steel Sleeve and Shaft

OBJECTIVE	**Heating a stainless steel sleeve for shrink fitting on to a shaft for industrial washer.**
EQUIPMENT	Ambrell 4.2 kW induction heating system, equipped with a remote workhead containing two 1.0 µF capacitors for a total of 0.5 µF An induction heating coil designed and developed specifically for this application
FREQUENCY	277 kHz
TEMPERATURE	500 °F (260 °C)
MATERIAL	Stainless steel sleeve 4.33” (109.98 mm) OD, 3.58” (90.93 mm) ID, 2” (50.8 mm) long.
TESTING	A three turn helical coil is used to heat the stainless steel sleeve. The part is placed in the coil and power is applied for 110 seconds to reach 500 ºF (260 ºC) for the shrink fit application. Once the sleeve reaches 500 ºF (260 ºC), the sleeve is placed on a stainless steel shaft and allowed to cool to shrink fit the sleeve to the shaft.
BENEFITS	Currently using electric ovens that run 24 hours a day, 5 days per week and their primary concern is to save on the energy cost of heating the parts in the ovens. By switching to induction heat the customer saves by only using power for 110 seconds per part vs. a continuously running electric oven. This worked out to a daily running cost of $2.16 for the induction system, compared to $46.08 for the four ovens at a $0.12/kWh cost for electricity. The customer will save $11,418 on energy per year with a ROI of 1.75 years for the investment of the induction system. Additional cost savings from improved production efficiency and environmental cooling to counteract the effect of the ovens should also be considered in the overall ROI.

Stainless steel sleeve heating in coil prior to shrink fit application.

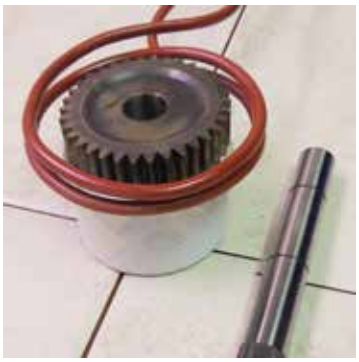
» Shrink Fitting an Aluminum Motor Housing

OBJECTIVE	**To heat an aluminum motor housing to 400 ºF (204 ºC) for a shrink fitting application.**
EQUIPMENT	Ambrell EASYHEAT LI 7590 9 kW, 150-400 kHz induction heating system equipped with a remote heat station containing two 1.0 µF capacitors. A single position eight-turn helical coil designed and developed for this application.
FREQUENCY	208 kHz
TEMPERATURE	400 °F (204 °C)
MATERIAL	4.5”/114 mm outside diameter by 4”/102 mm inside diameter by 7.5”/191 mm tall aluminum motor housing and stator.
TESTING	Initial heat trials were conducted, and temperature indicating paints of 350 ºF (177 ºC) and 450 ºF (232 ºC) were applied. The part was heated to desired temperature and the stator was inserted into the housing. With the 9 kW EASYHEAT LI power supply, the part can be heated to temperature within two minutes for this shrink fitting application.
BENEFITS	• **Part quality:** The customer was using a cold press, but it was creating part defects. This was resolved with induction heating. • **Speed:** The client tested an oven, but it took 40 minutes to heat it to temperature. Induction took just two minutes. • **Production rate**: Thanks to the faster heating time of induction, they were able to achieve their targeted production rate. • **Repeatability:** Induction’s fast, precise heating means the client can count on consistent results once it is implemented into their process. • **Hands-free Heating:** no operator skill for manufacturing • **Even distribution of heating**

The aluminum motor housing and stator after shrink fitting inside the induction heating coil.

>> Shrink Fitting a Gear to a Shaft (Automotive)

OBJECTIVE	**To heat a steel gear to 500 ºF (260 ºC) for a shrink fitting application.**
EQUIPMENT	Ambrell EASYHEAT 0224 2 kW, 150-400 kHz induction heating system equipped with a remote heat station containing two 0.17 µF capacitors. A single position two-turn helical coil designed and developed for this application.
FREQUENCY	304 kHz
TEMPERATURE	500 °F (260 °C)
MATERIAL	Customer supplied steel gear and steel shaft.
TESTING	The part was placed into the helical coil on top of a ceramic cylinder. The ceramic cylinder had a hole in it with a depth of approximate 24 mm (2.4 cm). The induction power was turned on. After 30 seconds the gear heated to temperature. The shaft was then inserted into the part and the bottom of the ceramic cylinder acted like a stop and positioned the shaft to the correct height. The parts were then allowed to cool.
RESULTS/BENEFITS	• **Part quality:** The customer was using a torch, which can lead to inconsistent part quality. Conversely, induction is highly repeatable. • **Speed:** The gear heated to temperature within 30 seconds, which is an improvement for the client. • **Repeatability:** Induction's fast, precise heating means the client can count on consistent results once it is implemented into their process.
PROCESS VIDEO	https://www.youtube.com/watch?v=F-z48KQx8nA

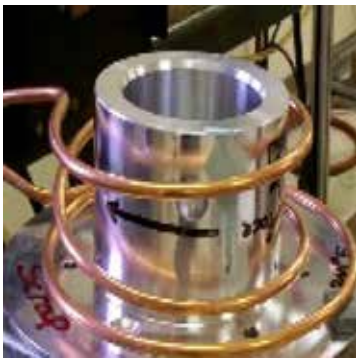


The gear and the shaft prior to heating.

The gear and shaft after shrink fitting.

Inserting a Steel Bushing to an Aluminum Hub

OBJECTIVE	**To heat an aluminum hub to enable the insertion of a steel bushing for a shrink fitting application.**
EQUIPMENT	Ambrell EKOHEAT 30 kW, 50-150 kHz induction heating system equipped with a remote workhead containing eight 1.0 µF capacitors. A single position three-turn pancake combination coil designed and developed for this application.
FREQUENCY	121 kHz
TEMPERATURE	300 °F (149 °C)
MATERIAL	Aluminum hub and steel bushing.
TESTING	The part was painted with temperature indicating paint that would melt to a clear color once it achieved the targeted temperature. The aluminum hub was then placed into the coil and the power was turned on. After 60 seconds the temperature indicating paint had melted and the part had reached the targeted shrink fitting temperature.
BENEFITS	• **Speed:** The client currently uses an electric oven and the heating time is two hours, so the time savings with induction is very significant. • **Energy efficiency:** Induction is fast and it's instant on/off, presenting significant energy savings over an electric oven. • **Footprint:** Induction requires a more modest footprint than an electric oven requires. • **Increased production rates and reduced labor costs**



The aluminum hub inside the induction coil.

>> Shrink Fitting an Aluminum Motor Housing (Automotive)

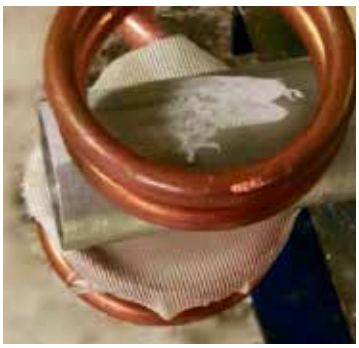
OBJECTIVE	**To heat an aluminum motor housing to temperature to enable shrink fitting; induction will be used within an automated line.**
EQUIPMENT	Ambrell EKOHEAT 45 kW, 50-150 kHz induction heating system equipped with a remote workhead. Ambrell EKOHEAT 45 kW, 50-150 kHz induction heating system equipped with a remote workhead containing eight 1.0 µF capacitors. A single position nine-turn internal bore coil designed and developed for this application.
FREQUENCY	71 kHz
TEMPERATURE	464 °F (240 °C)
MATERIAL	Aluminum housing (4”/102 mm tall with an ID of 1.9”/48 mm) and temperature indicating paint.
TESTING	The part was painted with temperature indicating paint that would melt to a clear color once it achieved the targeted temperature. The temperature indicating paint was also used to show balanced heating. With 0.125” (3.2 mm) radial clearance, the EKOHEAT met the temperature requirements within the targeted seven second rate. The key in the application is to maintain a modest radial clearance as an increase will require more power, increased water flow, and a more complicated coil.
BENEFITS	• **Speed:** The client needed a rapid heating solution to enable high production levels. • **Energy efficiency:** Induction is fast and it’s instant on/off, presenting significant energy savings over an electric oven. • **Footprint:** Induction requires a more modest footprint than an oven requires. • **Integration:** Induction can easily be integrated into an automated process.

The internal bore coil and the motor housing.

>> Shrink Fitting an Aluminum Tube (Optical System)

OBJECTIVE	**To heat an aluminum tube for a shrink fitting application; the customer was seeking to replace their oven with induction heating.**
EQUIPMENT	Ambrell EASYHEAT 2 kW, 150-400 kHz induction heating system equipped with a remote workhead. A single position four-turn split helical coil designed and developed for this application A multi-turn, special series-parallel induction heating coil designed and developed specifically for this application.
FREQUENCY	235 kHz
TEMPERATURE	437 °F (225 °C)
MATERIAL	Aluminum tube (19”/483 mm length x 0.875”/22 mm outside diameter x .065”/1.7 mm wall thickness). Temperature indicating paint.
TESTING	(EASYHEAT 2 kW) the aluminum tube heated to temperature within 30 seconds. Shrink fitting then took place. This met the customer’s requirements for its process. (EASYHEAT 4.2 kW) the aluminum tube’s heating time can be reduced to just 18 seconds. Should additional throughput be required, faster heating can be achieved with a higher power EASYHEAT power supply.
BENEFITS	• **Speed:** The client needed a rapid heating solution to enable higher production levels. • **Energy efficiency:** Induction is fast and it is instant on/off, presenting significant energy savings over an electric oven. • **Footprint:** Induction requires a more modest footprint than an oven requires. • **Integration:** Induction can be easily integrated into an automated process. • **Expertise:** Ambrell and its applications team bring critical knowledge that comes with 10,000 plus installations of various applications and decades of applications experience.

The split helical coil enabled easy loading.



The part inside the coil with temperature indicating paint applied.

Shrink Fitting a Steel Tube

OBJECTIVE

Heating a steel tube to 500-1000 °F for a shrink-fitting application. Determine expansion (growth) of ID at varying temperatures.

EQUIPMENT

Ambrell 7.5, 7.5 kW, 150-400 kHz induction power supply, equipped with a remote heat station containing two 1.5 µF capacitors (for a total of 0.75 µF).

A multi-turn, special series-parallel induction heating coil designed and developed specifically for this application.

FREQUENCY

166 kHz

TEMPERATURE

500, 800, 1000 °F (260, 427, 538 °C)

MATERIAL

- Steel tubes 7” OD x 4.75” ID x 5” heat zone
- Type ‘K’ thermocouple to measure temperature
- Thermal blanket

TESTING

Initial tests were completed on a sample without a thermal blanket. A thermocouple is slipped between the copper ring and the steel tube to measure temperature. The part measured 4.940” (at room temperature with an ID gauge.) The part reaches 1000 °F (538 °C) in about 10 minutes.

BENEFITS

The part measures 4.975” at 1000 °F yielding an expansion of 0.035” (4.975 minus 4.94). At 500 °F and 800 °F the expansion numbers were 4.950 and 4.964 respectively. When using a thermal blanket the heat time is reduced by about 90 seconds (8.5 minutes as opposed to 10 minutes).

A comparison between theoretical and experimental measured results.

Temp (F)	ID (in)	Growth (theory)	Growth (real)
75	4.94	0.0	0.0
500	4.95	0.016	0.01
800	4.964	0.025	0.024
1000	4.975	0.032	0.035

» Shrink Fitting a Magnetic Steel Gear

OBJECTIVE	**To heat a magnetic steel gear for a shrink fitting application; they're looking to replace an oven that takes over two hours to heat the part to temperature.**
EQUIPMENT	Ambrell EASYHEATTM 2.4 kW, 150-400 kHz solid state induction power supply with a workhead and coil specifically designed for this application.
FREQUENCY	180 kHz
TEMPERATURE	550 °F (288 °C)
MATERIAL	Magnetic steel gear, 2" (55 mm) ID, 12.5" (318 mm) OD.
TESTING	A custom-designed single position multiple-turn pancake coil was built to generate the required heating for this shrink fitting application. Initial tests were conducted to optimize the power delivered to the part. Temperature indicating paint was then applied to the part, which dissolves when the part reaches the target temperature. It was observed that it took 45 minutes to heat the sample to temperature. The coil can be placed beneath the gear to allow oil to burn off without condensing on the coil.
RESULTS/BENEFITS	A custom-designed single position multiple-turn pancake coil was built to generate the required heating for this shrink fitting application. Initial tests were conducted to optimize the power delivered to the part. Temperature indicating paint was then applied to the part, which dissolves when the part reaches the target temperature.

The induction setup with the gear and coil.

- **Speed:** Induction cut the client's heating time in more than half when compared to their oven.
- **Footprint:** Induction requires less space on the factory floor than an oven.
- **Efficiency:** Induction only heats what needs to be heated, so it tends to be more efficient than an oven.

» Heating Hammer Bits for Shrink Fitting

OBJECTIVE	**To heat hammer bits for the insertion of carbide buttons; the end product is a drilling tool for the oil and gas industry.**
EQUIPMENT	Ambrell EKOHEAT® 50 kW, 5-15 kHz induction heating power supply with a workhead and coil specifically designed for this application.
FREQUENCY	8.9 kHz
TEMPERATURE	500 °F (260 °C)
MATERIAL	Magnetic steel hammer bits.
TESTING	A custom-designed single position multiple-turn pancake coil was built for this application. An infrared camera was used to monitor the temperature of the part. The large drill head was then tested. The outer area of the part heated more quickly than the center. The power delivered to the part was adjusted to keep the maximum temperature between 570 °F (299 °C) and 580° F (304 °C) while the center came up to the target temperature through induction and conduction. The carbide bits were then inserted into the part.
BENEFITS	• **Speed:** Induction is typically faster than torch heating for this application. • **Efficiency:** Induction only heats what needs to be heated, so it tends to be more efficient than a torch. • **Safety:** Induction does not introduce an open flame into the work environment, which not only enhances worker safety but also leads to a more comfortable work environment.

The drill head with carbide bits.

» Shrink Fitting Magnetic Steel Pistons

OBJECTIVE	**To heat magnetic steel pistons for shrink fitting onto a chrome shaft; the client was using an unreliable handheld induction system and wanted a higher quality induction solution.**
EQUIPMENT	Ambrell EASYHEATTM 2.4 kW, 150-400 kHz solid state induction power supply with a workhead and coil specifically designed for this application.
FREQUENCY	164 kHz
TEMPERATURE	1,100 °F (593 °C)
MATERIAL	Magnetic steel.
PROCESS	A custom-designed single position multiple-turn pancake coil was built to generate the required heating for this shrink fitting application. Initial tests were conducted to optimize the power delivered to the part. An optical pyrometer was used to monitor one of the pistons as the two were heated. The pistons were heated with a ¼" (6.4 mm) gap between the part and the induction coil. It was observed that the piston reached 1,100°F (593 °C) within one minute.
BENEFITS	• **Speed:** Induction is usually a faster heating method for shrink fitting than other heating options. • **Efficiency:** Induction only heats the portion of the part that needs to be heated, so it tends to be more efficient than other common heating methods. • **Reliability:** The client was having issues with an inexpensive handheld induction unit, and Ambrell systems deliver consistent, repeatable and reliable results.

The test setup for this shrink fitting application.

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: _____

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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