



# Induction Brazing

**BRAZING**



## Ajax TOCCO is your partner for Induction Brazing Solutions

“DO MORE WITH LESS” — this is the challenge you face every day. Make the most of your existing resources. Maximize your return on new technology. Achieving this balance is difficult. When rising to the challenge, it helps to have a partner — both a technology provider and an expert on how to implement it — that partner is Ajax TOCCO.



Silver brazing a tube and flange assembly



Dual station brazing cell with shield gas for fluxless brazing applications

### Solutions Designed for You

When you have unique requirements, Ajax TOCCO will tailor a solution based on our extensive application experience. Through a combination of standard products and innovative engineering, Ajax TOCCO will meet your most demanding production and quality needs. With a wide range of field-proven solutions, our engineering team can provide the experience and expertise to optimize your process.



## A Heritage of Excellence

Ajax TOCCO Magnethermic is a leading supplier of induction heating and brazing equipment. Reflecting the proud heritage of more than 85 years of induction brazing experience with our group of companies, our personnel and innovative traditions remain central to our strategy and future. Our high-quality standards match our reputation, as does our expertise in process engineering and modernization resulting in stable, long-term solutions that last for decades.

## Continuous Innovation

Not only are we one of the worlds largest induction suppliers, we are one of the most progressive market leaders in developing customer-valued new technology. Finite element analysis, process heating simulations, state-of-the-art manufacturing capabilities, application laboratories, and on-staff metallurgists guarantee that our customers always stay ahead of the industry.

## Your Process Partner

Through close collaboration and personal attention, Ajax TOCCO is dedicated to sharing our customers' passion and focus on their business goals. Ajax TOCCO doesn't just sell equipment, we provide the right solution. We optimize your floor plan. We streamline your energy consumption. By applying our years of experience and knowledge of best practices, our customers are empowered to compete more effectively.

## Product Solutions

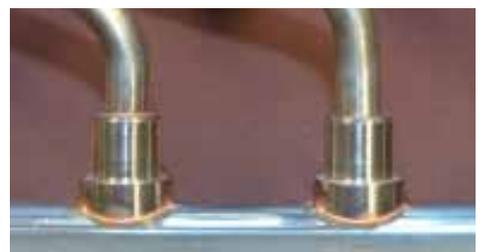
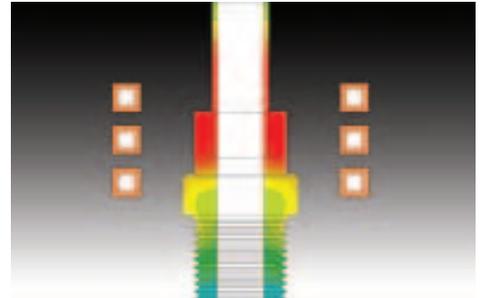
Our systems capabilities include application review, development, induction heating equipment, process tooling, material handling with installation and commissioning services available to complete a 'full turn key' manufacturing solution.

## Customer Service and Support

Before the contract is signed and for years beyond start-up, customers can count on Ajax TOCCO. Whether creating a turnkey solution from scratch, retrofitting and updating your existing lines, or evaluating future possibilities, the level of service is the same. Our maintenance specialists are available 24 / 7 and customers can enroll in preventive maintenance contracts to keep their lines up and running.

## Ajax TOCCO Support Network

Along with providing each customer personal service, a proven process, and reliable equipment, Ajax TOCCO customers can benefit from the resources of a global corporation. We provide worldwide assistance through our network of regional sales and service engineers. Wherever you are, we can help.



## Induction Brazing Technology

Direct localized induction heating of the braze area minimizes distortion and oxidation, while providing a safe, repeatable operating environment for factory assembly or automation needs.

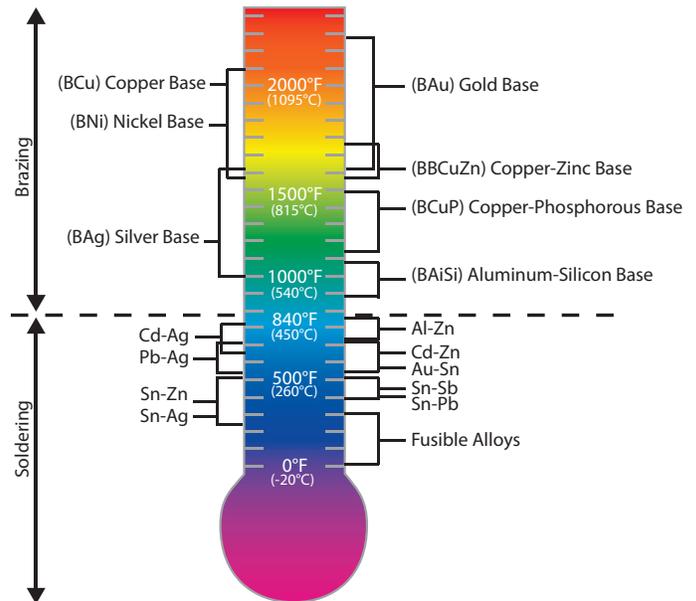
### Principles of Brazing

Brazing and soldering are processes of joining similar or dissimilar materials using a compatible filler material. Filler metals include lead, tin, copper, silver, nickel and their alloys. Only the alloy melts and solidifies during these processes to join the work piece base materials. The filler metal is pulled into the joint by capillary action. Soldering processes are conducted below 840°F (450°C) while brazing applications are conducted at temperatures above 840°F (450°C) up to 2100°F (1150°C).

The success of these processes depends upon the assembly's design, clearance between the surfaces to be joined, cleanliness, process control and the correct selection of equipment needed to perform a repeatable process.

Cleanliness is ordinarily obtained by introducing a flux which covers and dissolves dirt or oxides displacing them from the braze joint.

Many operations are now conducted in a controlled atmosphere with a blanket of inert gas or combination of inert / active gasses to shield the operation and eliminate the need for a flux. These methods have been proven on a wide variety of material and part configurations replacing or complimenting atmosphere furnace technology with a just in time – single piece flow process.



Brazing temperatures of common alloys



Examples of brazing alloy preforms in ring, strip, washer, etc.

### Brazing Filler Materials

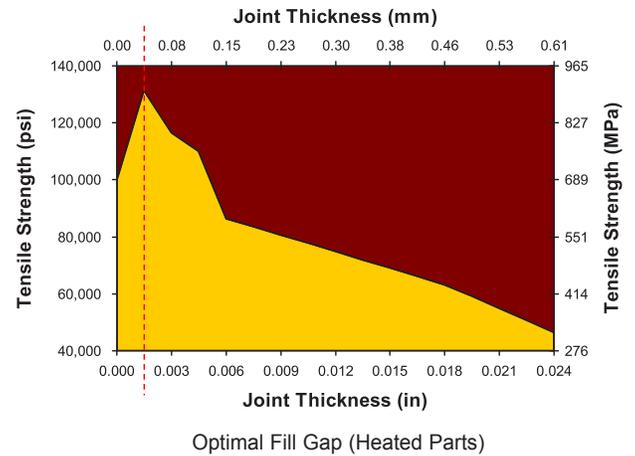
Brazing filler metals can come in a variety of forms, shapes, sizes and alloys depending on their intended use. Ribbon, preformed rings, paste, wire and preformed washers are just a few of the shapes and forms alloys that can be found.

The decision to use a particular alloy and/or shape is largely dependent on the parent materials to be joined, placement during processing and the service environment for which the final product is intended.

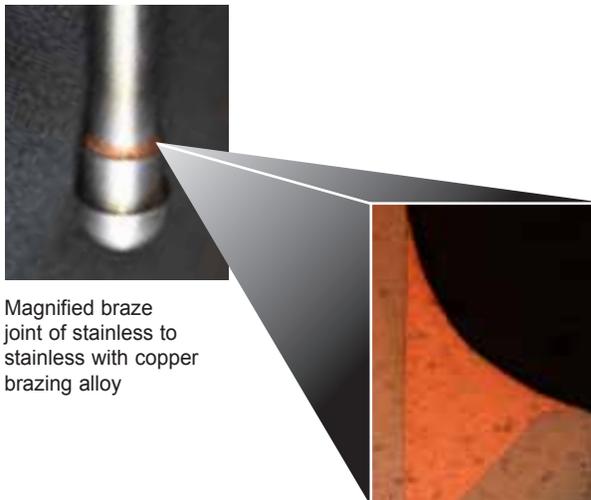
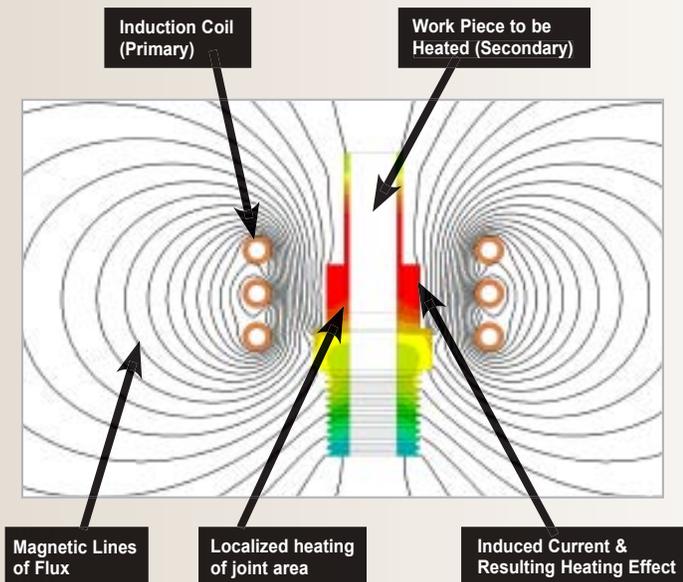
## Clearance Affects Strength

Clearance between the faying surfaces to be joined determines the amount of braze alloy, capillary action / penetration of the alloy and subsequently the strength of the finished joint. The best fit up condition for conventional silver brazing applications are 0.002 inches (0.050 mm) to 0.005 inches (0.127 mm) total clearance. Aluminum is typically 0.004 inches (0.102 mm) to 0.006 inches (0.153 mm). Larger clearances up to 0.015 inches (0.380 mm) usually lack sufficient capillary action for a successful braze.

Brazing with copper (above 1650°F / 900°C) requires the joint tolerance kept to an absolute minimum and in some cases press fit at ambient temperatures to assure minimum joint tolerances while at the brazing temperature.



Induction Transformer Effect on a Workpiece



## Induction Heating Theory

Induction systems provide a convenient and precise way to quickly and efficiently heat a selected area of an assembly. Consideration must be given to the selection of power supply operating frequency, power density (kilowatt applied per square inch), heating time, and induction coil design to provide the required depth of heating in a specific braze joint.

Induction heating is non-contact heating by means of transformer theory. The power supply is an AC source to the induction coil that becomes the primary windings of the transformer while the part to be heated is the transformer's secondary. The work piece heats by the base materials' inherent electrical resistivity to the induced current flowing in the assembly.

Current passing through an electrical conductor (the workpiece) results in heating as current meets resistance to its flow. These losses are low in current flowing through aluminum, copper and their alloys. These non-ferrous materials require additional power to heat than their carbon steel counterpart.

The alternating current tends to flow on the surface. The relationship between the frequency of the alternating current and the depth it penetrates the part is known as the reference depth of heating. Part diameter, material type and wall thickness can have an effect on heating efficiency based on the reference depth.

## Induction Brazing Coils

High productivity, quality and close tolerance have placed new demands on induction brazing systems. It is the induction coil complimented by the correct tooling that very often dictates the success or failure of the entire system.

### Induction Coil Design

Fabricated from highly conductive copper tubing or plate, the induction coil's design is influenced by the application, the selection of frequency, power density and heat time. The purpose of the induction coil is to create a magnetic flux pattern to generate a current path in the work piece to selectively heat the area of the assembly to be brazed.

The coil must be correctly positioned on the assembly allowing the required heating to be accomplished. The air gap or coupling space between the work piece and the inside of the coil should be minimized for reasons of efficiency. Typical design gaps of 0.125 inch (3.175 mm) to 0.250 inch (6.350 mm) are reasonable for brazing with a helical coil.

Irregularly shaped sections may need additional clearances which require additional power to overcome these poor coupling efficiencies. These cases include situations where a round coil with a large air gap or a non-encircling coil is needed to access the braze area.

The area to be heated determines the length of the induction coil. An induction coil that is too short will require a longer heating time to allow the heat, by conduction, to cover the area. An induction coil that is too wide will heat more metal than necessary, and therefore be less efficient. Ajax TOCCO has many special designs of inductors for localized heating, and coils that heat efficiently without surrounding the work piece.



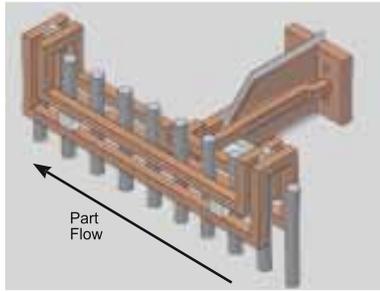
Hand-Held Transformer and Coil Assembly for remote heating locations. This assembly allows for freedom of movement of the coil into the braze area by an operator or attached to a robot end effector.



## Types of Coils



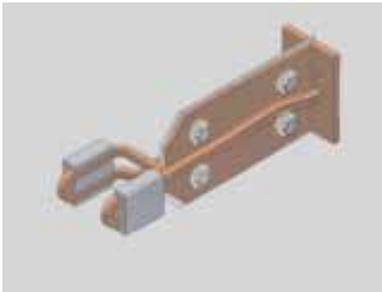
Oval Helical Coil



Channel Coil



Helical Coil (encircling)



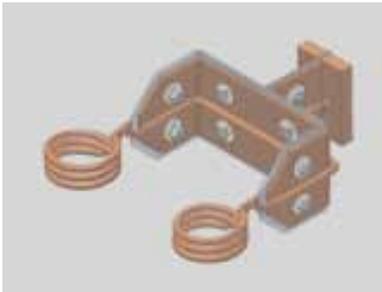
Open Ended Coil



Inside (ID) Heating Coil



ID / OD Coil Assembly



Multi-Position Brazing Coil



Quick Disconnect Assembly



Pancake Coil

A quick change coil adapter is utilized to minimize down time when induction coil changes are frequent because of mixed production, part or tooling changeovers.



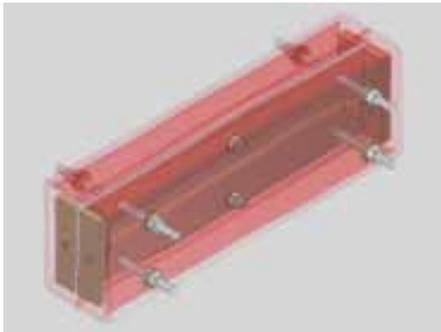
### Split Induction Coil

This pneumatically operated induction coil is designed to fully encompass the part without having to thread the assembly through the center of the coil.

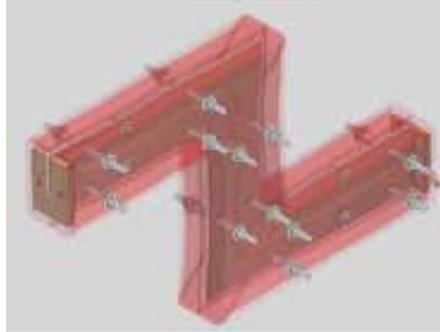


## Induction Coil Interconnect

The connection between the coil head and the output face of the power supply is referred to as the lead structure. When this distance is long, over 6 inches, a rigid bus is normally utilized minimizing transmission loss to the coil. These bus bars assure coil support, electrical continuity and cooling water connections.



Straight Bus Bar



Offset Extension Bus Bar



Right Angle Bus Bar

## Induction Coil Manufacturing

We have developed the specialized expertise to design, build, test and repair any form of coil used in brazing or other selective heating process. State of the art machine tools, materials, engineering and skilled craftsmen all work together to provide the best coil design services available in the industry today.



Work cell assembly and brazing coil fabrication



Power supply and system manufacturing

## Induction Work Holding Fixtures

If the shape of the workpiece will not support itself in an upright or conventional position, (self seating / self centering) a nesting fixture is required. Materials for fixturing include non-magnetic stainless steel, ceramics, refractories, high temperature composites. Thermal expansion, material compatibility and thermal conduction of the part during the brazing process are also considered when designing the holding fixture for repeatable everyday operation.



Aluminum Brazing of Condenser Tubes



High temperature copper brazing of stainless to stainless tube assemblies in a shield gas fixture



## Factory Automation

Stand alone – inline or rotary – indexing or continuous – Ajax TOCCO can provide a standard or custom solution. Our team of application and process engineers has the capability and experience to give you the best system for your production needs at a price you can afford.



Rotary indexing soldering system featuring all stainless steel construction, alloy wire feeder and designed for high-volume production of non-ferrous tube and fitting assemblies.

## Factory Automation

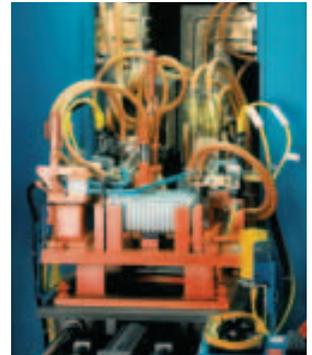
A properly designed material handling system is critical to the success of a brazing process. It needs to retain its integrity throughout the rigors of daily part processing. The material handling system can be as simple as a stand alone manually loaded system where an operator loads the parts into a holding fixture, or as complex as a fully automated system.



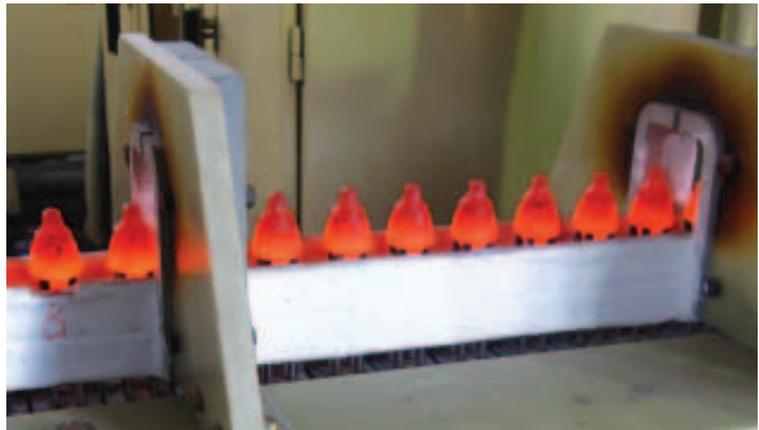
Unitized Dual Station Brazing System with integrated part program storage, illuminated working area and quick change tooling



Six station compound motion for automated brazing of aluminum evaporator cores



Single station manual brazing of aluminum evaporator cores



In-line automated brazing of carbide inserts into mining tools



Adaptable robot configurations for "in-place" brazing



Continuous brazing of hydraulic fittings



Aluminum brazing of tube-to-tube connections

# Fluxless Brazing Systems

High productivity, quality and close tolerance have placed new demands on induction brazing systems. It is the induction coil complimented by the correct tooling that very often dictates the success or failure of the entire system.

## INDUCTION BRAZING ADVANTAGES WITHIN A CONTROLLED ATMOSPHERE OR INERT GAS SHIELDING:

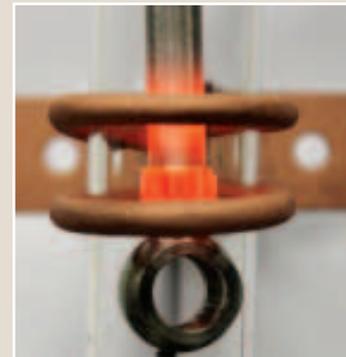
- \* Little or no clean up of the finished brazed assembly
- \* Removal of fluxing preparation, application and clean up steps
- \* The shield gas shroud and tooling serve as work piece locator
- \* Efficient energy usage by on demand selective heating
- \* Near single piece flow with reduced inventory over conventional batch processing
- \* Reduced distortion by heating only the area to be brazed



### Low Cost Table Top Brazing Machine

#### FEATURES:

- Can be used with a variety of brazing process
- Up to 10 KW of output capability
- Ramp & Soak Power Control
- Adjustable coil height
- Coil & Fixture Quick Connect
- Inert gas controls and flow monitoring (Optional)
- Easy access for tooling changeover and maintenance operation



### Universal Inert Gas Conveyor Tube End Annealing / Brazing System



#### FEATURES:

- Able to process tubing ranging from 3 inches (75 mm) - 51 inches (1300 mm) in length
- Maximum up time through quick changeovers of tooling assisted with stored process parameter
- Reduced cycle times through continuous brazing / annealing
- Integrated PLC for process status and process data
- Touch screen operator interface
- Independent gas control and flow monitoring



## Fluxless Brazing Systems

### Universal Single, Dual or Rotary Station

#### FEATURES:

- Can be used with a variety of brazing fixtures to produce continuous or mixed production in process
- Maximum up time through easy access for tooling changeover and maintenance operations
- Tooling Identification with stored process program in each tooling cassette
- Multi-part brazing fixture capability (2, 3 or more parts simultaneously at each station)
- Integrated Induction Heating Power Supply with touch screen for status and process data
- Individually controlled power supplies available on dual station
- Adaptable for shield gas controls and flow monitoring of pure Nitrogen or Nitrogen/Hydrogen mixture
- Adaptable for braze tooling designed with chambers providing atmosphere cover during process heating and cooling



Integrated dual station system with optical pyrometer sensing

### Universal Single



Universal single and dual station platforms are the foundations to integrate application specific features including shield gas controls, process tooling, coil assemblies, temperature sensing and process controls.

### Universal Dual

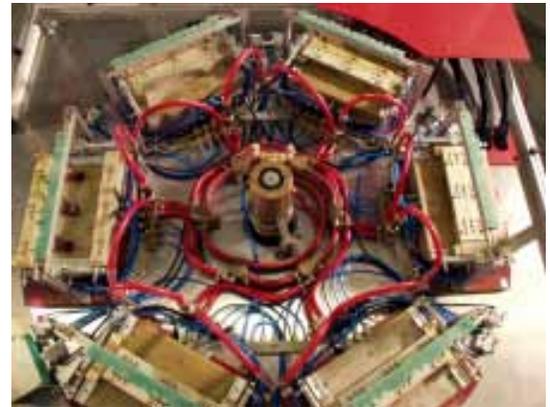


Interchangeable applications cassette with inert gas cover enclosures and induction coil assembly

## Rotary Table Brazing

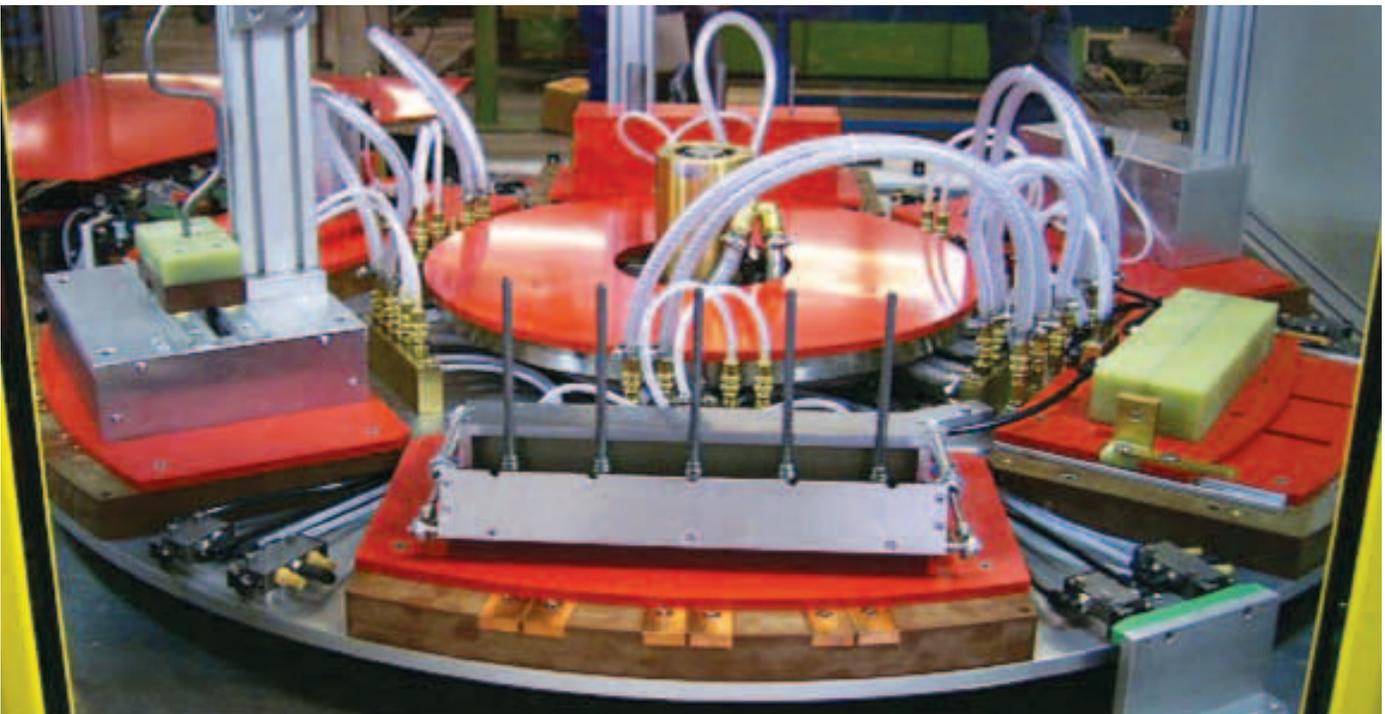


Independently controlled power supplies with braze tooling designed with chambers providing atmosphere cover of pure Nitrogen or Nitrogen/Hydrogen mixture



Dial systems available in 2, 4, 6 and 8 station designs

Utilizing the modular concept of the single and dual station universal brazing system, the rotary dial allows for even greater production capabilities. Beyond the operator loading station, the first cassette is under power and brazing while the successive stations are used for continuous gas cooling of the parts preventing oxidation.



System utilizes a variety of brazing fixtures to produce continuous or mixed production. The process tooling identification with stored process parameters are programmed and identified in each tooling cassette.

## Induction Power Supplies

As an innovator and leader in induction power supply design Ajax TOCCO will recommend the appropriate induction heating power supply based upon previous experience, calculation and best practice design parameters.



## Water Cooling Systems

Ajax TOCCO offers a full line of water cooling systems to support the Induction equipment supplied for your brazing process. Air cooled, water to water, dry coolers, evaporative systems and refrigeration (chiller) heat exchangers are available to keep an induction heating system operating at peak performance providing years of continued service and trouble free operation.



## Process Temperature Controllers & Flux/Alloy Dispensing

A complete line of accessories including temperature controllers, alloy wire feeding systems and brazing flux dispensers are available to simplify your induction brazing process.

Let our experienced application team review these options for your specific needs to produce a safe and repeatable process reducing the need for skilled labor and extensive training.

## Laboratory Development

Our Process Development Centers are a valuable resource in meeting the most challenging of induction brazing applications. With our experienced staff of engineers, metallurgists and technicians, we are capable of meeting virtually any processing requirement. The goals of our application development laboratories are to take the guesswork out of the process before implementation on the production floor.



## Commercial Heat Treat & Brazing Services

Ajax TOCCO has a state-of-the-art commercial processing facility in our Detroit Development Center and in various other facilities around the world. Our commercial induction processing facilities have rigid quality systems in place to make sure your parts are universally accepted. Ajax TOCCO has numerous quality certifications to assist you in your production needs and is recognized as a world leader in the induction heating industry.



## Total Quality Monitoring System (TQMS)

The TQMS is an innovative diagnostic software package that provides greater monitoring capability over the entire induction heating process. This information facilitates the isolation and correction of process deviated conditions that may occur within the induction installation. As a result, the use of the TQMS can assure consistent quality, decrease rejected parts and increase overall productivity.

BRAZING



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