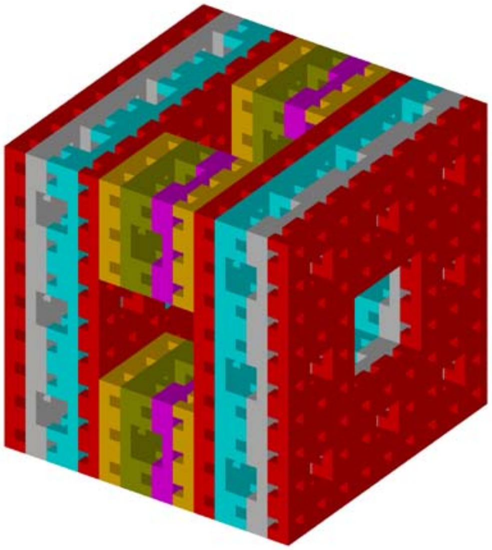
HTG HI TECMETAL GROUP

# Expert Brazing Services Provided by HI TecMetal Group

Furnace brazing is a blend of art and science; HTG is a pioneer and specialist in the field of furnace brazing. HTG has a thorough understanding of this art and science that has evolved into an accepted technology for metal joining. In a very general sense, brazing is a joining process that relies on melting, braze alloy flow and solidification of the braze alloy to form a leak tight seal and strong metallurgical bond between the mating surfaces.

There are many heating methods available to accomplish brazing operations. The most important factor in choosing a heating method is achieving efficient transfer of heat throughout the joint and doing so within the heat capacity of the individual base metals used. The geometry of the braze joint is also a crucial factor to consider, as is the rate and volume of production required. The easiest way to categorize brazing methods is to group them by heating method. Here are some of the most common:

- ✓ Torch brazing
- ✓ Furnace brazing [Exothermic, Hydrogen, Argon and Vacuum Atmospheres]
- ✓ Induction brazing
- ✓ Dip brazing
- ✓ Resistance brazing
- ✓ Infrared brazing
- ✓ Blanket brazing
- ✓ Electron beam and laser brazing
- ✓ Braze welding



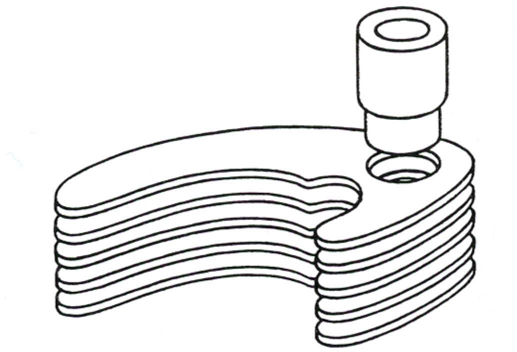
**ILLUSTRATED Example of Brazed Fabrication**

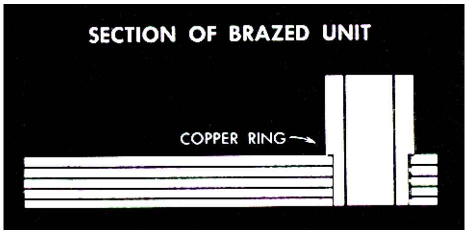
# FURNACE BRAZING

This presentation page is exclusively addressing Furnace Brazing as a metal joining process and technique.

**Brazing** is a metal-joining process whereby a filler metal or alloy is heated to melting temperature above 450 °C (840 °F) and distributed between two or more close-fitting parts by capillary action. The filler metal is brought slightly above its melting (liquidus) temperature while protected by a suitable atmosphere or brazing flux. When the part reaches the liquidus temperature of the filler metal, the filler metal wets a thin layer of the base metal. As the temperature of the part being brazed is lowered to below the liquidus temperature of the braze alloy, the part being brazed is cooled rapidly to form a brazed joint. By design, the melting temperature of the braze alloy is lower than the melting temperature of the materials being joined. Brazed joints are generally stronger than the individual filler metals used due to the geometry of the joint as well as to the metallurgical bonding that occurs.

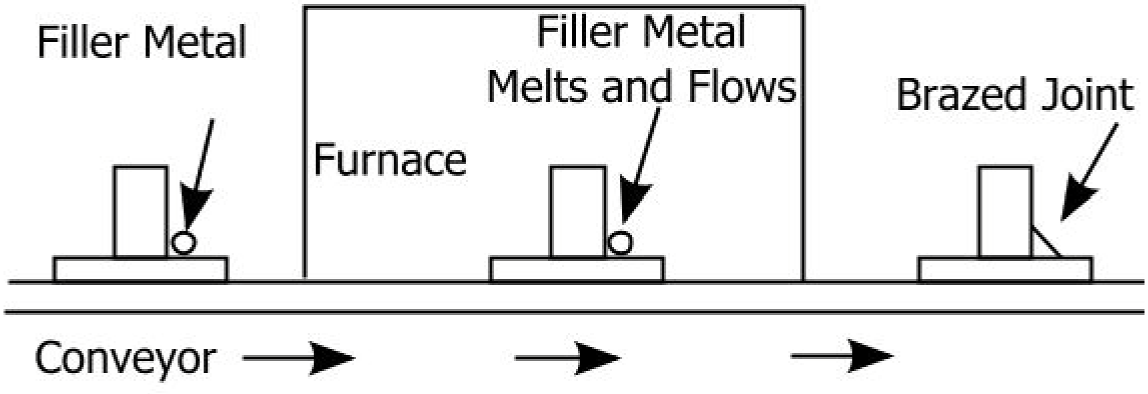
COMPONENTS FOR COPPER BRAZED ASSEMBLY





## Exothermic Continuous Belt Brazing

The requirements for a successful furnace brazing are essential in order to produce high quality brazed parts.  The conveyor furnace must be well designed and maintained.  The process requires an atmosphere which will be free of air and water vapor. The goal is to protect the parts during the brazing & cooling process against oxidation or decarburization.



## Why Furnace Braze?

**Nickel Brazed Stainless Steel Detector Tube**

**Brass to Stainless Silver Brazed Valve Caps**

There are varied reasons which makes furnace brazing preferable over other brazing methods.
These are:

- The process is highly repeatable and capable of high quality
- The process is a semi-automatic process used due to its adaptability to mass production
- The use of semi skilled labor is practical and cost effective
- Main advantage is the ease with which it can produce large numbers of parts per hour
- The parts are uniformly heated under tight process control
- Simultaneous joining of multiple braze joints is usual
- Components to be brazed can be designed for self alignment without the need for fixturing.
- Braze Filler metal can be preplaced in contact with the braze joints
- A controlled heat cycle minimizes or eliminates distortion.
- No need for post braze cleaning operations

## Brazing Fundamentals

**Stainless Fuel Filter Lids**

**Nickel brazed tube bundle heat exchanger**

In order to obtain high-quality brazed joints, parts must be designed for furnace brazing by a braze engineer. Parts must be closely fitted, and the base metals must be exceptionally clean and free of dirt, grim, oils or oxides. In most cases, joint clearances of 0.03 to 0.08 mm (0.002 to 0.003 in) are recommended for the best capillary action and joint strength. However, in some braze joint designs it is not uncommon to have joint clearances on the order of 0.61 mm (0.024 in). Cleanliness of the brazing surfaces is also of vital importance, as any contamination can cause poor wetting. The two main methods for cleaning parts, prior to brazing are: alkaline or chemical cleaning and abrasive or mechanical cleaning. In the case of mechanical cleaning, it is of vital importance to maintain the proper surface roughness as wetting on a rough surface occurs much more readily than on a smooth surface of the same geometry.

# Furnace Brazing – Exothermic, Pure Hydrogen, Vacuum or Hydrogen/Nitrogen Atmospheres

The process also offers the benefits of Common atmospheres used include: inert, reducing or vacuum atmospheres all of which protect the part from oxidation. Some other advantages include: low unit cost when used in mass production, close temperature control, and the ability to braze multiple joints

**Furnace Brazing - Equipment**

At Hi TecMetal Group furnaces are typically heated using  electric depending on the type of furnace and application. However, some of the disadvantages of this method include: high capital equipment cost, more difficult design considerations and high power consumption.

There are 4 main types of furnaces used in brazing operations: batch type; continuous; retort with controlled atmosphere; and vacuum.

***Batch type furnaces*** heat each part load separately. It is capable of being turned on and off at will which reduces operating expenses when not in use. These furnaces are well suited to medium to large volume production and offer a large degree of flexibility in type of parts that can be brazed. Either controlled atmospheres or flux can be used to control oxidation and cleanliness of parts.

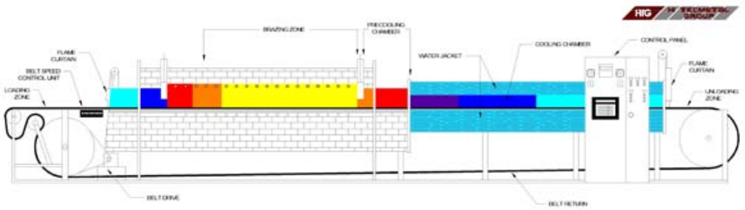
***Continuous type furnaces*** are best suited to a steady flow of similar-sized parts through the furnace. These furnaces are often conveyor fed, allowing parts to be moved through the hot zone at a controlled speed. It is common to use either a controlled atmosphere or pure dry hydrogen in continuous furnaces. In particular, these furnaces offer the benefit of very low manual labor requirements and so are best suited to large scale production operations.

HTG utilizes both straight through and hump type continuous furnaces for both quality and cost considerations.  Both types of furnaces are designed to produce the best type of materials joining technique that offers significant advantages:

- Both processes produce extremely clean brazed parts with superior, flux-free braze joints of high integrity and strength.
- The hump back continuous braze process performed is performed in a -100° degree dew point.
- Temperature uniformity is maintained on the work piece when heating in a either type of furnace.
- Residual stresses are reduced due to slow heating and cooling cycles. This, in turn, can significantly improve the thermal and mechanical properties of the material, thus providing unique heat treatment capabilities.
- The hydrogen furnace has the capability of heat-treating or solution treating the work piece while performing the metal-joining process, all in a single furnace thermal cycle.
- Both furnaces will braze multiple joints at once because the parts reach a uniform brazing temperature.

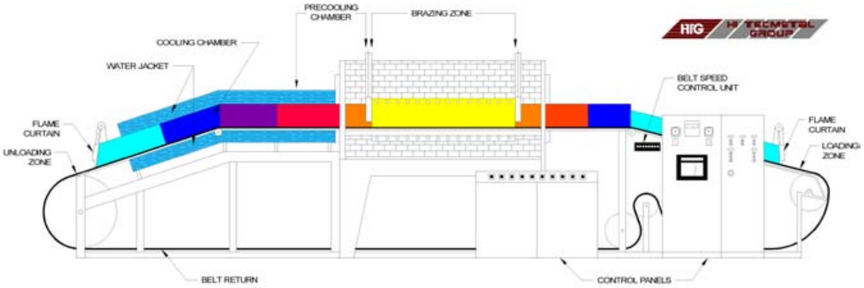
# FURNACE TYPES

## *Continuous type Exothermic Brazing & Annealing Furnace*



A straight through, continuous belt furnace avoids many of the issues presented by the hump in the humpback furnace. However, a straight through furnace is not best suited for brazing stainless steels because of the difficulty of controlling the furnace dew point. With a straight through furnace the belt rides on a horizontal surface throughout the furnace. Product stability and height issues are minimized along with the added maintenance that is seen in the humpback furnace

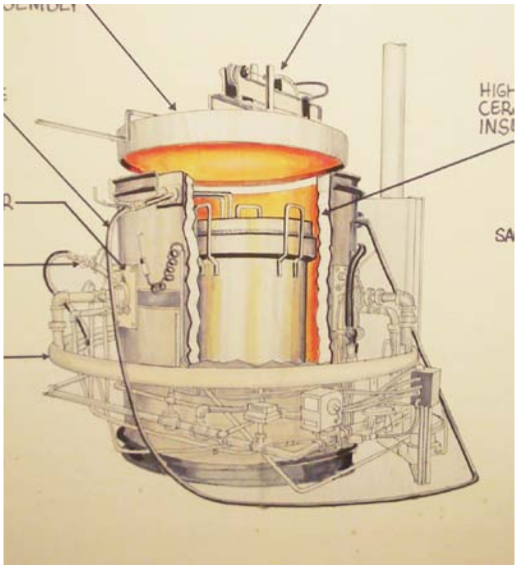
## *Continuous type Pure Dry Hydrogen Humpback Furnace*



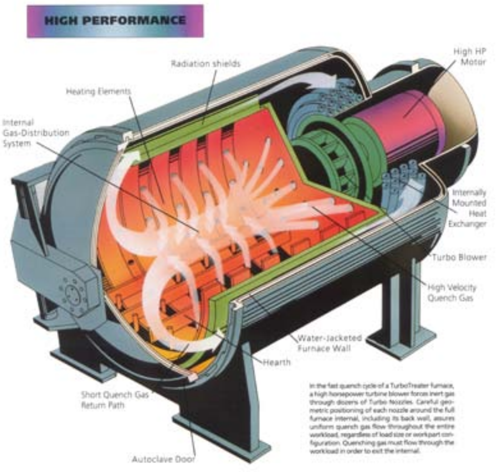
The humpback furnace affords the producer the ability to braze larger volumes of product with equivalent quality, higher production rates, and higher thermal efficiency ***than the vacuum furnace***.

The disadvantages of the humpback furnace are: The height of the product must be restricted to ensure that the hump is effective in maintaining the seal through the stratification of the atmosphere. As well, the hump presents many problems with respect to product tipping and general furnace maintenance.

***Retort-type furnaces*** differ from other batch-type furnaces in that they make use of a "retort". The retort [sealed vessel] is designed with a air tight seal and filled completely with the desired atmosphere. Heat is applied externally by conventional heating elements. Due to the high temperatures involved, the retort is made of heat resistant alloys that resist oxidation. Retort furnaces are classified as a batch process.



**Vacuum furnaces** is most often used to braze to heat treat materials with very stable oxides that cannot be brazed in atmosphere furnaces. Vacuum brazing is also used heavily with refractory materials and other exotic alloy combinations unsuited to atmosphere furnaces. Due to the absence of flux or a reducing atmosphere, the part cleanliness is critical when brazing in a vacuum. Hi TecMetal Group utilizes vacuum furnaces of a cold-wall design. Typical vacuum levels for brazing range from pressures of 1.3 to 0.13 Pascal's ($10^{-2}$ to $10^{-3}$ Torr) to 0.00013 Pa ($10^{-6}$ Torr). Vacuum furnaces are batch-type and they are suited to medium and high production volumes.



In the fast quench cycle of a TurboTreater furnace, a high horsepower turbine blower forces inert gas through dozens of Turbo Nozzles. Careful geometric positioning of each nozzle around the full furnace internal, including its back wall, assures uniform quench gas flow throughout the entire workload, regardless of load size or workpart configuration. Quenching gas must flow through the workload in order to exit the internal.

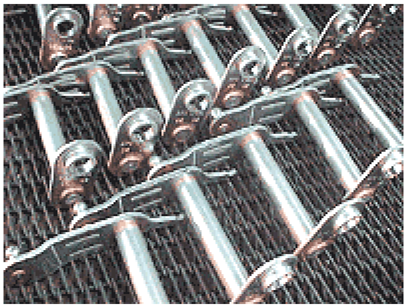
## Furnace Brazing - Process

Furnace brazing defines a process of joining metallic materials using a molten filler metal. The filler metal permeates into the joint by the dynamics of capillary action [attraction]. The filler metal is generally preplaced on the parts before the parts are carefully placed onto the furnace belt. The filler metal has a lower melting point than the parent materials. Furnace brazing is considered best for mass production of parts.

The following additional considerations must be made in order to produce a brazed product with high braze joint integrity:

The effect of temperature and time on the quality of brazed joints is considered with all applications. As the temperature of the braze alloy is increased, the alloying and wetting action of the filler metal increases as well. In general, the brazing temperature selected must be above the melting point of the filler metal.

**Illustrated: Copper Brazed Refrigeration Dryer**



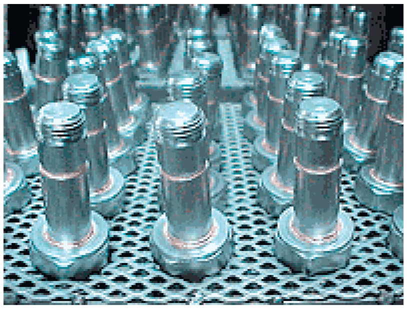
**Illustrated: Copper Brazed Lawn & Garden Equipment Lever**

## Heating and Cooling

The following factors that influence the joint designer's temperature selection are listed below. The best braze temperature is usually selected: (1) to be the lowest possible braze temperature, (2) best practice is to try and minimize any heat effects on the assembly, (3) and try to keep the filler metal/base metal interactions to a minimum, and (4) maximize the life of furnace belt.

A higher temperature may be selected to allow for other factors in the design such as:

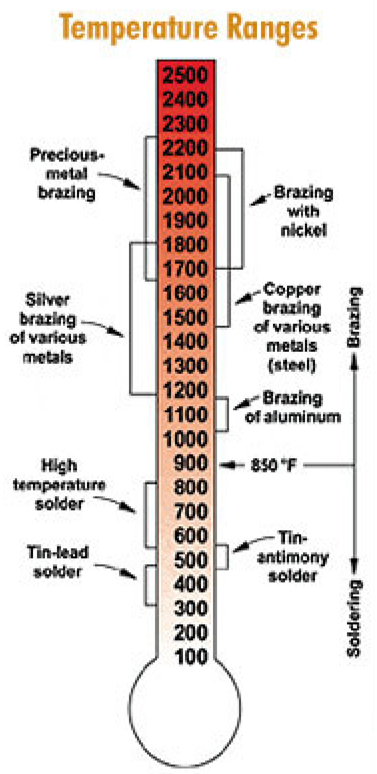
- ✓ Enable the part to be hardened during the heat and cooling process if the parent materials can be air hardened.
- ✓ Enable the use of a different filler metal, or to control metallurgical effects.
- ✓ Or to provide a pre-cleaning process at an elevated temperature, in order to sufficiently remove surface contamination on the parts to be brazed.
- ✓ The effect of time on the brazed joint primarily affects the extent to which the aforementioned effects are present; however, in general most production processes are selected to minimize brazing time and the associated costs. This is not always the case, however, since in some non-production settings, time and cost are secondary to other joint attributes (e.g. strength, appearance).



**Copper**

**Brazed Stainless & LC Steel Solenoid Spool Assembly**

PROPER DESIGN AND MANUFACTURING PLUS CONTOL OF FURNACE ATMOSPHERE, TEMPERATURE AND TIME ARE ESSENTIAL



## *Advantages and Disadvantages of Furnace Brazing*

Furnace Brazing has many advantages over other metal-joining techniques, such as induction or torch brazing and welding. The Furnace Brazing does not melt the base metal of the joint. The process yields tighter control over tolerances and produces clean parts and brazes joints without the need for secondary finishing. Additionally, dissimilar metals and non-metals can be brazed. In general, furnace brazing also produces less thermal distortion than welding due to the uniform heating of a brazed piece. Complex and multi-part assemblies can be brazed cost-effectively.

Furnace brazing is easily adapted to mass production and it is easy to automate because the individual process parameters are less sensitive to variation.

One of the main disadvantages is: that brazed joints require a high degree of base-metal cleanliness. And, all braze applications require design and manufacturing considerations prior to the manufacturing of both the components [pieces and parts] and the final assembly.

## *See also: www.htg.cc*

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