The Influence of a Belt Furnace on the Brazing Process

Introduction

"Brazing" refers to a process that is joins metals together. By using a braze alloy or filler metal to unite individual pieces, a strong metallurgical bond is created without melting or changing the essential structure of the original materials. With proper technique, the connection between the metals is often stronger than the actual metals themselves, which ensures the longevity of the bond. While brazing is one of the oldest processes for joining metals, technological progress has opened the door for brazing other materials such as ceramic or glass together. Brazing is considered to be essential to many industries, including automotive, aircraft, aerospace, electrical, and more. Additionally, brazing serves four major purposes for electronics: mechanical, electrical, hermetic and thermal. Although there are different techniques for brazing, furnace brazing specifically allows for high rates of commercial-scale production.

Furnace brazing has many specific advantages. The metals being joined do not have to be the same; dissimilar metals with varying thicknesses can also be united. This allows for complex arrangements of different parts, without distorting the original metals. Multiple joints can also be brazed at the same time. Moreover, superior products can be achieved by brazing in a furnace, as furnaces allow for premium reproduction. Furnace atmosphere can be precisely controlled, and this automation is significant. The consistency and quality that brazing in a belt furnace produces cannot be paralleled.

The brazing process is straightforward. Typically, filler metals have a melting temperature above 450° C, but their melting point is always less than that of the actual metals being joined. This protects the integrity of the original metals and prevents warping. Once the filler metal reaches its melting point, it flows into the space between the original material to form an alloy at the brazed joint, as Figure 1 depicts.

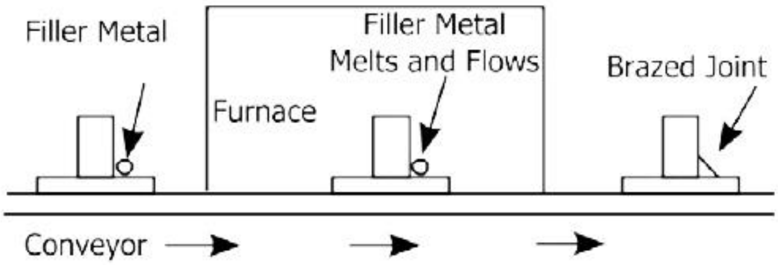

Figure 1: *Schematic for brazing with a belt furnace, as depicted on http://en.wikipedia.org/wiki/Brazing*

Parameters of Brazing Process

Because brazing has certain requirements, brazing furnaces must be able to support these parameters. Components get heated, joined, and cooled inside of a furnace, and this entire process is heavily dependent on temperature. The determining factor for the brazing temperature is based on the melting point of the filler metal. Furthermore, temperature control has a strong influence on success. Usually, there are five steps to a typical brazing process cycle: 1) an optional pre-heat, including holding; 2) ramp to temperature; 3) brazing; 4) cool down; and 5) exit, as illustrated in Figure 2. During the thermal brazing cycle, the temperature needs to be precisely controlled by the furnace.

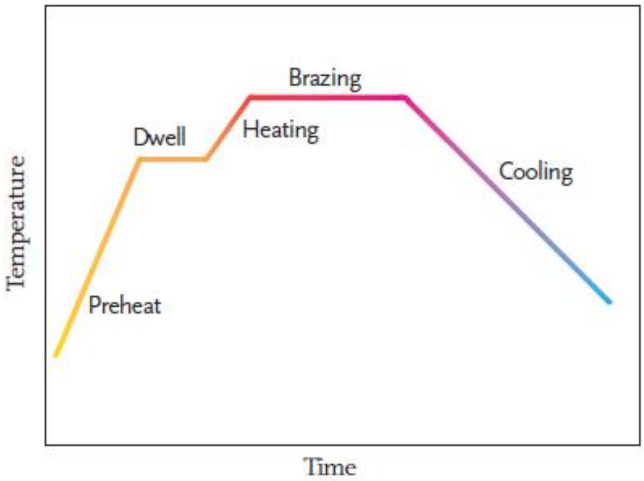

Figure 2: *Schematic of a typical brazing process cycle, as seen in "Furnace Materials #4: Brazing of Metals" by Andersson, Holm, Wiberg, and Astrom.*

Timing is also very important to the brazing process. Brazing requires a minimum duration to ensure that the filler metal can flow through the whole joint to make a strong bond. Generally, one or two minutes is enough for this. Too much processing time will yield undesired effects. Typically, the duration of the contact between liquid filler metal and the base metals must be minimized to prevent excess flow of the filler metal. However, in some cases, greater processing time can produce a modified braze alloy that has a higher melting temperature, which could be advantageous in situations where a second brazing may take place.

The atmosphere must be neutral for both the base metal and the braze alloy to avoid oxidation carburizing, decarburization and nitriding. This ensures that no reactions can occur between the metal, alloy, and the atmospheric elements. In addition to oxygen and carbon, it is possible for nitrogen and hydrogen to also trigger reactions in some circumstances. Likewise, many metals can oxidize rapidly when heated. To avoid this, the brazing atmosphere inside of a furnace must be controlled by utilizing a reducing gas such as hydrogen, forming gas, or cracked ammonia. Controlling the furnace atmosphere is the best way to offset the risk of oxidation and other unwanted issues.

Atmosphere Control in a Belt Furnace

The amount of oxygen and moisture levels in a furnace have a direct influence on the behavior of the filler metal as it melts. For example, when there are low levels of oxygen and moisture in a furnace, the filler metal has a greater ability to melt and navigate into tight joints and create a stronger bond. High levels of these elements can produce the opposite effect, which is adverse to brazing. Maintaining strict control of the furnace atmosphere will significantly improve the quality of the brazing process and prevent physical defects.

Furnace atmospheres contain both neutral and active gases, and these gases can encounter a multitude of reactions. If parts have not been cleaned before entering the furnace, surface contaminants can interact with the gases and cause unexpected results. Additionally, gases can also react with each other, as well as with vapors from the filler metal. Brazing furnaces allow for precise adjustments within the atmosphere composition in order to produce a balance between the two types of gases. This equilibrium helps to control oxidizing and reducing, as well as carburizing and decarburizing. The atmosphere also has an inevitable effect on the rate of heat transfer within a furnace's heating and cooling phases.

It is important for atmosphere control systems in brazing furnaces to include both a system to analyze gas, and also a flow and gas mixture control system in order to control the balance of gases and maintain atmospheric precision. Continuous brazing furnaces are specifically advantageous for accurate control, in that different furnace zones can accommodate diverse atmosphere composition set points, as shown in Figure 3.

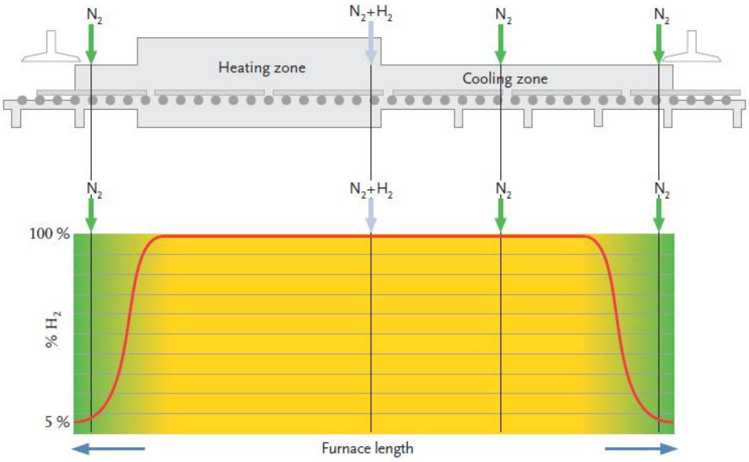

Figure 3: *Atmosphere control in belt furnace, from "Furnace Materials #4: Brazing of Metals" by Andersson, Holm, Wiberg, and Astrom.*

Selecting a Furnace for Brazing

A high quality furnace is essential for in order to produce top-quality results from brazing. The type of products being brazed, characteristics of the materials, production volumes, and schedule can all influence the furnace that is best suited for the task. A continuous brazing furnace is best for production if a perpetual flow of parts is desired, regardless of whether the parts need to be placed in a tray or basket. A brazing furnace has a metallic muffle, which ensures precise control of the atmosphere while minimizing contamination. This guarantees reliable quality.

The HSA series belt furnace seen below in Figure 4 is designed to excel at the brazing process. This furnace uses ceramic heater boards to achieve elevated temperatures. The HSA series furnace comes with a refractory heating chamber that is equipped with ceramic fiber FEC (fully enclosed coil) heating board. The heating works to give fast thermal response. The furnace is equipped with a temperature profiling system and a computer monitoring system. Moreover, it can achieve precise atmosphere control for hydrogen, nitrogen, and oxygen by using a dew point and oxygen monitoring system.

Forced air or water cooling are used in the cooling section of the furnace. The muffle is located within the furnace, and helps to control atmospheric conditions as well as to maintain a clean environment inside the furnace. As a standard feature, this furnace is equipped with a steel brush for cleaning the conveyor belt, and ultrasonic belt cleaning is available as an extra option.

Figure 4: *Hengli HSA series belt furnace*

The HSA series furnace has a microprocessor based PID controller to manage the furnace. Type K thermo-couples are used in determining the zone temperatures, and controls are located on the right side of the furnace, which can be viewed from the entrance. The central processing unit (CPU) is located at the exit table and is paired with a Windows operating system for ease of use. The computer system is preinstalled with a program for controlling the furnace parameters, including the belt speed, zone temperatures, and atmospheric conditions. Temperature profiles can be stored and retrieved as well for future purposes. The furnace has parameters in the software for capturing, storing, displaying, and printing the furnace profile. Thermocouple ports are located at the entrance table for connecting the profiling thermocouple directly to the microprocessor. This feature allows for monitoring and recording of actual temperatures that are experienced by parts. Additionally, this furnace is equipped with a redundant overheat safety protection system, which incorporates an additional type "K" thermocouple in the center of each controlled zone and the multi-loop alarm. The specifications for a HSA7503-082N belt furnace are shown in Table 1.

Specification	HSA7503-08ZN
Rate Temperature	900 deg. C max, Normal operating: 850 deg C
Belt Width	30" (750mm)
Effective Above Belt Clearance	1" (25mm)
Control Zones	8
Conveyor Speed	2-8 IPM (40-200mm/min)
Loading Table	59" (1500mm)
Unloading Table	59" (1500mm)
Belt	Balanced V Weave, SUS314
Heating Elements	FEC Heater Board
Insulation	High quality ceramic fiber
Temperature Controller	Intelligent PID Shimaden Controller
Alarm	Thermocouple, Over Temp, Belt Stop. Audio and Visual Alarm
Atmosphere	6 pipes of dry clean air or N2. 2-6 m3/h, 1.1-3.3 CFM
Cooling	Forced Air cooling
Across Belt Temperature Uniformity	+/- 4 deg C
Overall System Width	60.5" (1540mm)
Overall System Length	343" (8705mm)
Overall System Height	54" (1,350mm)
Net Weight	2500kg
Power	Three-phase, 480VAC, 60Hz, 38 KVA MaxNormal operating power draw is about 15 KVA

Table 1: *Specifications of HSA7503-082N belt furnace*

Conclusion

Brazing in a belt furnace offers an economic opportunity to join complex parts together while creating a high quality bond. Continuous furnaces are extremely versatile, in that they allow for both small and large-scale operations, as well as reliable results. Maintaining control of the furnace temperature, atmosphere, and processing time is imperative if an efficient brazing process is to be achieved. Precise time control helps to ensure product quality, so that defects aren't discovered after brazing. Furthermore, brazing furnaces should offer rapid heating, cooling, and temperature stability in order to produce desired results. Once these requirements are fulfilled, a consistent brazing process can be achieved.