Troubleshooting Continuous Controlled Atmosphere Brazing Furnaces

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Figure 1. Controlled Atmosphere Brazing Furnace.

Controlled atmosphere brazing furnaces of the continuous type are some of the most common furnaces used in brazing. The goal of a brazing furnace is to provide a time, temperature, atmosphere relationship that is accurate, repeatable and economical in meeting the requirements of the brazing process. Although the general operation of this equipment is fairly straight forward, the troubleshooting that can often accompany a brazing issue can be frustrating. A methodical approach and good diagnostic tools can make this a minor event and provide a great deal of understanding of the equipment used to braze.

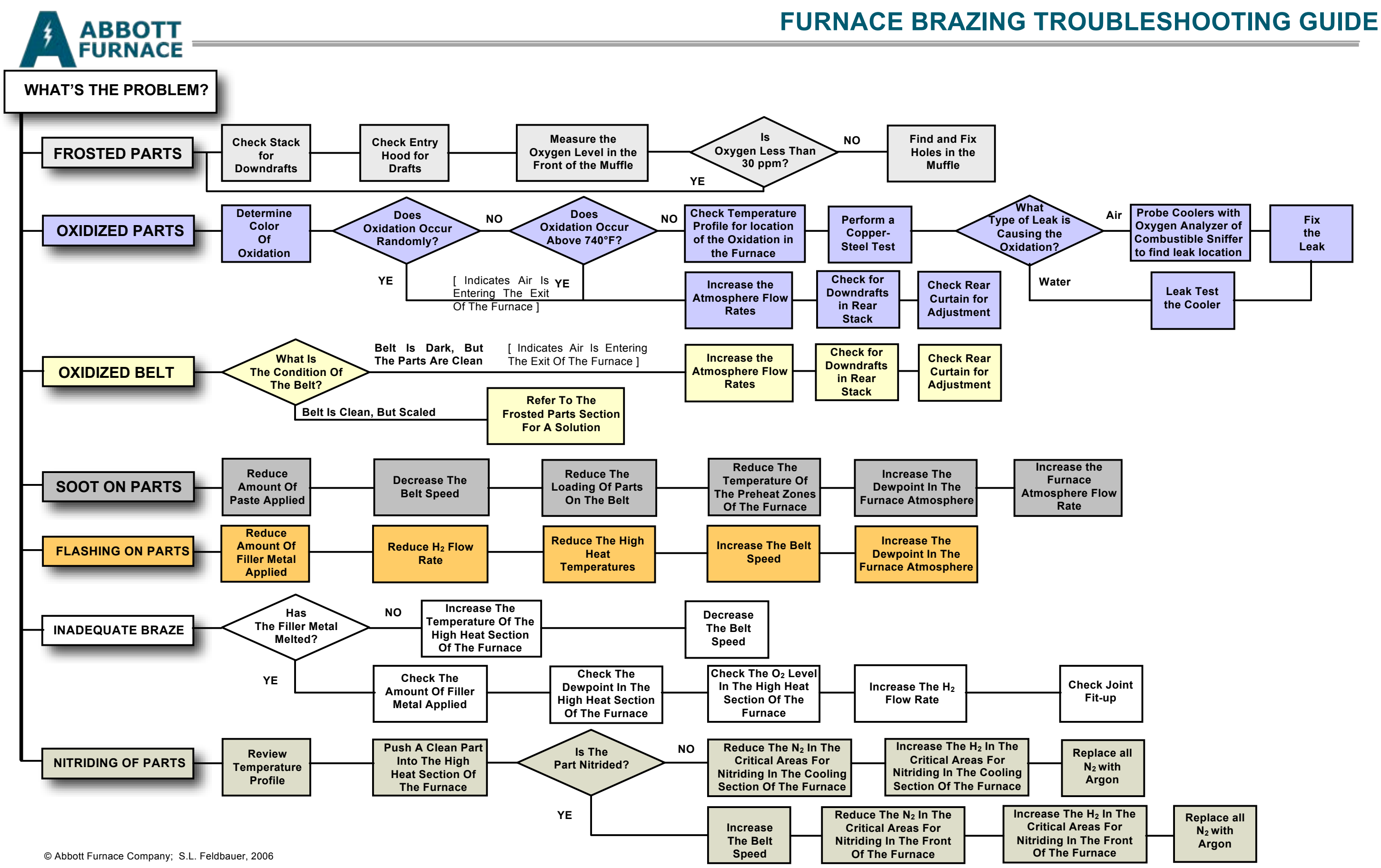
Defining the Problem

The first step in troubleshooting any issue is to define the problem. The seven most common problems that arise related to continuous, controlled atmosphere brazing are:

1. Frosted Parts - A cosmetic defect that results in a brazed component with a dull surface appearance.
2. Oxidized Parts - A discoloration of the parts ranging in color from a light straw color to black. The parts may or may not braze successfully.
3. Oxidized Belt - The stainless steel belt used to convey the parts through the furnace is discolored.
4. Soot on Parts - Black Carbon deposits are found around the joint and on the part. The deposits can be easily cleaned by wiping the deposit away.
5. Flashing on Parts - Filler metal wets the part and covers portions of the part other than the region near the joint.
6. Inadequate Braze - A strong braze connection does not form throughout the joint. In some cases the filler metal appears to have melted, but has not flown into the joint.
7. Nitriding of Parts - Stainless steel parts appear dull in appearance and lacks corrosion resistance. Parts may braze on the first pass through the furnace, but brazing on a second pass through the furnace may not be successful.

Solving the Problem

Once the problem has been defined, the root cause of the problem can be identified. Methodically work through each potential cause of the problem is the key to ultimately solving the problem. The "Furnace Brazing Troubleshooting Guide" can be followed to aid in this process.



Frosted Parts

"Frosted Parts" are produced when the surface of the part is oxidized within the preheat portion of the furnace. The Oxygen of this newly formed oxide is then removed by the reducing atmosphere that is present in the high heat section of the furnace. The result is a modeled structure to the surface that reflects light differently than before and appears dull.

The solution to "Frosted Parts" is to eliminate the source of Oxygen that comes in contact with the part as it enters the furnace and begins to heat up. Potential sources for this Oxygen are stack downdrafts, entry hood drafts and holes in the front portion of the muffle. A good indicator of a hole in the muffle is an Oxygen level of more than 30 ppm and many times a flame in the location of the hole can be seen.

Oxidized Parts

Oxidized parts are caused by the part coming in contact with a source of Oxygen while at an elevated temperature. The sources of this Oxygen can be water or air coming from cooler leaks, air infiltration up the back of the furnace, holes in the muffle, and air leaks in flanges or atmosphere plumbing.

Examining the color of the parts, the approximate temperature of the part at the time when it came in contact with the source of Oxygen can be determined.

OXIDATION COLORS

Temperature °F	Color
400	Faint Straw
440	Straw
475	Deep Straw
520	Bronze
540	Peacock
590	Full Blue
640	Light Blue
640 – 730	Gray to Black

When the oxidation color chart is used in conjunction with a temperature profile, the location of leaks in the cooling section can be determined. The type of leak in the cooling section can further be determined by performing the copper – steel test.

COPPER – STEEL TEST

1. Set all zones of the furnace to 1900°F.
2. Place a piece of bright copper strip and steel side by side on the belt.
3. Pass both metal strips through the furnace.
4. Copper is oxidized by Oxygen but not water.
5. Steel is oxidized by both Oxygen and water.

Oxidized Belt

An oxidized belt is the result of a source of Oxygen coming in contact with the belt while at an elevated temperature. This may occur in the front of the furnace. However, instead of appearing as a frosted dull color, the belt will begin to scale due to the repeated oxidizing and reduction that destroys the surface of the belt.

The oxidation of the belt may also occur as a result of air entering the rear of the furnace. In this case, the belt may be discolored; but the parts may not be oxidized.

Soot on Parts

All brazing paste contains a binder. This binder is made up of various hydrocarbons. Hydrocarbons will dissociate at brazing temperatures to form Hydrogen and Carbon. The presence of this Carbon on the part is what is referred to as “soot”.

Sooting can be avoided by providing more time for the binder to vaporize before and hydrocarbons see the high brazing temperatures and dissociate. The hydrocarbon vapors will be swept away from the part by the flow of the furnace atmosphere.

In cases where production requirements do not allow enough time for the binder to fully vaporize, an oxidizing source may be introduced into the atmosphere to allow for the reaction with the Carbon to form carbon monoxide. As a gas, carbon monoxide will be swept away with the furnace atmosphere and burned to carbon dioxide in the flame at the furnace entrance.

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Flashing on Parts

Flashing refers to the filler metal flowing away from the joint surface to cover the surface of the base metal around the joint. The cause is more filler metal is applied than is required to fill the joint or an increased tendency for the filler metal to wet the surface of the base metal resulting in the filler metal flowing away from the region of the joint.

The amount of filler metal, viscosity of the filler metal, and the cleanliness of the base metal are the primary variables that can be used to control flashing. By reducing the temperature of the high heat section of the furnace and reducing the amount of Hydrogen in the atmosphere, and increasing the dew point of the atmosphere, the reducing tendency in the furnace will be lessened and will not cause the surface of the base metal to be as clean. The lower temperature will also result in the filler metal viscosity being somewhat higher and reduce its ability to flow.

Inadequate Braze

An inadequate braze is formed when the filler metal does not flow through the joint and alloy with the base metal. The first step in determining the cause of an inadequate braze is to establish if the filler metal has melted. If the filler metal has not melted, either the filler metal was not given enough time to melt and flow through the joint or the overall brazing temperature is too low.

If the filler metal has melted, there are a number of other potential sources of the problem. There may not be enough filler metal to fill the joint or the filler metal may be prevented from flowing into the joint. Oxides on the furnace of the base metal or a joint that is too tight or too large will prevent the filler metal from flowing completely.

Nitriding of Parts

Nitriding occurs when the Chromium within the austenitic stainless steel base metals reacts with Nitrogen to form a very stable chromium nitride phase at the grain boundaries of the material. This reaction takes place between 750^{o}F and 1650^{o}F. The temperature window for nitriding occurs during the heating up and cooling down of the parts in the furnace brazing process. Nitriding will appear as a smoky color on the surface of the base metal and can be seen as dark intergranular deposits in a photomicrograph.

A good quality braze is possible on parts that have been nitrided during the cooling stage of the process. However, this nitride will prevent additional brazing and rework. The alloying between the base metal and the filler metal will not take place. In the event of nitriding at the front of the furnace, brazing may not be successful even on the first pass.

Summary

Although not all encompassing, there are seven problems that are most common to the furnace brazing process. The keys to solving these problems are an understanding of the root cause of the problem and methodically working through the potential sources of the cause.

The goal of any brazing furnace is to provide a consistent and repeatable time - temperature – atmosphere relationship. By working with the belt speed, the furnace temperatures, and the composition of the furnace atmosphere and its flow, a solution to these issues can be found.