FEASIBILITY OF BRAZING AS "JOINING PROCESS"

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ABSTRACT

Brazing is a joining process, which produces coalescence of materials by heating to a suitable temperature and by using a filler metal (often referred to as braze) having a liquids temperature above 4600C and below the solidus temperature of the base material. The filler metal is drawn into the gap between the closely fitted surfaces of the joint by capillary action. Brazing is a joining technique which is commonly used in many industrial applications.

This paper gives a general view of the feasible work carried out on brazing as:

- ✓ *Introduction to allied welding processes,*
- ✓ *Welding brazing comparative study,*
- ✓ *Different methods of brazing and machine tool,*
- ✓ *Defects and applications brazing.*

I. INTRODUCTION

Brazing doesn't melt the base metals. So the brazing temperatures are lower than the melting points of the base metals. Also, it will always be much lower than the welding temperatures for the same base metals. Brazing creates a metallurgical bond between the filler metal and the surfaces of the two metals being joined.

Some of the prominent types of brazing techniques are Torch brazing, Dip brazing, Induction brazing, Furnace brazing, Resistance brazing and Laser brazing.

1.1 Basic Steps in Brazing

The basic steps involved in brazing can be classified as follows. Proper care has to be taken in each of the steps to avoid a wrong joint upon brazing operation.

a) Ensure proper fit and clearance
b) Clean the metal
c) Flux prior to brazing
d) Fixture of parts
e) Brazing the assembly
f) Cleaning the new joint

II. BRAZING PROCEDURES

The metal needs to be cleaned by either chemical, mechanical or a combination of both methods to ensure good bonding. Edge preparation is essential in braze welding. The edges of the thick parts can be beveled by grinding, machining, or filing. It is not necessary to bevel the thin parts (one-fourth inch or less). The metal must be bright and clean on the underside as well as on the top of the joint. The two pieces must be fitted properly and supported to prevent voids in the joint or accidental movement during brazing and cooling operations.

2.1 Surface Preparation

The surfaces of the metal must be cleaned for capillary action to take place. When necessary, chemically clean the surface by dipping it in acid. Remove the acid by washing the surface with warm water. For mechanical cleaning, you can use steel wool, a file, or abrasive paper. Do not use an emery wheel or emery cloth, because abrasive particles or oil might become embedded in the metal.

2.2 Work Support

Mount the work in position on firebricks or other suitable means of support, and if necessary, clamp it. This is important because if the joint moves during the brazing process, the finished bond will be weak and subject to failure.

2.3 Fluxing

The method of application varies, depending upon the form of flux being used and the type of metal you are brazing. Refer to the material on fluxes previously described. It is extremely important that the flux is suitable for your job.

2.4 Brazing

This step is to heat the parts to the correct brazing temperature. The best way to determine the temperature of the joint, as you heat it, is by watching the behavior of the flux. The flux first dries out as the moisture (water) boils off at 212°F. Then the flux turns milky in color and starts to bubble at about 600°F. Finally, it turns into a clear liquid at about 1100°F. That is just short of the brazing temperature. The clear appearance of the flux indicates that it is time to start adding the filler metal. The heat of the joint, not the flame, should melt the filler metal. When the temperature and alignment are proper, the filler metal spreads over the metal surface and into the joint by capillary attraction. For good bonding, ensure the filler metal penetrates the complete thickness of the metal. Stop heating as soon as the filler metal has completely covered the surface of the joint, and let the joint cool slowly. Do not remove the supports or clamps or move the joint in any way until the surface is cool and the filler metal has completely solidified.

Finally, clean the joint after it has cooled sufficiently. This can be done with hot water. Be sure to remove all traces of the flux because it can corrode the metal. Excess metal left on the joint can be filed smooth.

The above described procedure is a general one, but it applies to the three major types of brazing: silver, copper alloy, and aluminum. The differences being the base metals joined and the composition of the filler metals.

III. KINDS OF BRAZING PROCESSES

3.1 Torch Brazing

In case of torch brazing, flux is applied to the part surfaces and a torch is used to focus flame against the work at the joint. A reducing flame is used to prevent the oxidation. Filler metal wire or rod is added to the joint. Torch uses mixture of two gases, oxygen and acetylene, as a fuel like gas welding.

3.2 Furnace Brazing

In this case, furnace is used to heat the work pieces to be joined by brazing operation. In medium production, usually in batches, the component parts and brazing metal are loaded into a furnace, heated to brazing temperature, and then cooled and removed. If high production rate is required all the parts and brazing material are loaded on a conveyer to pass through then into a furnace. A neutral or reducing atmosphere is desired to make a good quality joint.

3.3 Induction Brazing

Induction brazing uses electrical resistance of work piece and high frequency current induced into the same as a source of heat generation. The parts are pre-loaded with filler metal and placed in a high frequency AC field. Frequencies ranging from 5 to 5000 kHz are used. High frequency power source provides surface heating; however, low frequency causes deeper heating into the work pieces. Low frequency current is recommended for heavier and big sections (work pieces). Any production rate low to high can be achieved by this process.

3.4 Resistance Brazing

In case of resistance welding the work pieces are directly connected to electrical rather than induction of electric current line induction brazing. Heat to melt the filler metal is obtained by resistance to flow of electric current through the joint to be made. Equipment for resistance brazing is same that is used for resistance welding, only lower power ratings are used in this case. Filler metal into the joint is placed between the electrode before passing current through them. Rapid heating cycles can be achieved in resistance welding. It is recommended to make smaller joints.

3.5 Dip Brazing

In this case heating of the joint is done by immersing it into the molten soft bath or molten metal bath. In case of salt bath method, filler metal is pre-loaded to the joint and flux is contained in to the hot salt bath. The filler metal melts into the joint when it is submerged into the hot bath. Its solidification and formation of the joint takes place after taking out the work piece from the bath. In case of metal bath method, the bath contains molten filler metal. The joint is applied with flux and dipped to the bath. Molten filler metal, fills the joint through capillary action. The joint forms after its solidification after taking it out from molten metal bath. Fast heating is possible in this case. It is recommended for making multiple joints in a single work piece or joining multiple pairs of work pieces simultaneously.

3.6 Infrared Brazing

It uses infrared lamps. These lamps are capable of focused heating of very thin sections. They can generate up to 5000 watts of radiant heat energy. The generated heat is focused at the joint for brazing which are pre-loaded with filler metal and flux. The process is recommended and limited to join very thin sections.

3.7 Braze Welding

This process also resembles with welding so it is categorize as one of the welding process too. There is no capillary action between the faying surfaces of metal parts to fill the joint. The joint to be made is prepared as 'V' groove. a greater quantity of filler metal is deposited into the same as compared to other brazing processes. In this case entire 'V' groove is filled with filler metal, no base material melts. Major application of braze welding is in repair works.

IV. BRAZING MATERIALS

4.1 Selection of Filler Metal

The following factors must be considered when selecting a brazing filler metal Compatibility with base metal and joint design.

Service requirement for the brazed assembly Compositions should be selected to suit operating requirements, such as service temperature, thermal cycling, and stress loading, corrosive conditions and so on. Filler metals with narrow melting ranges less than 280C between solidi to liquids can be used with any heating method.

Filler metals used in brazing are nonferrous metals or alloys that have a melting temperature below the adjoining base metal, but above 800°F. Filler metals must have the ability to wet and bond with the base metal, have stability, and not be excessively volatile. The most commonly used filler metals are the silver- based alloys. Brazing filler metal is available in rod, wire, preformed, and powder form.

Brazing filler metals include the following eight groups:

Base Metal	Filler Metal
Aluminum	Aluminum and Silicon
Nickel-	Copper alloys Copper
Copper	Copper and phosphorus
Steel and cast iron	Copper and zinc
Stainless steel	Gold and silver

Silver-base alloys
Aluminum-silicon alloys
Copper
Copper-zinc (brass) alloys
Copper-phosphorus alloys
Gold alloys
Nickel alloys
Magnesium alloys

- ✓ Aluminum-silicon—used for brazing aluminum and aluminum alloys.
- ✓ Copper-phosphorus—used for joining copper, copper alloys, and other nonferrous metals.
- ✓ Silver—Used for joining almost all ferrous and nonferrous metals. The exceptions for use include aluminum and other metals with low melting points.
- ✓ Copper and copper-zinc—Suited for joining both ferrous and nonferrous metals. This compound is used in a 50/50 mixture for brazing copper. A64% copper/36% zinc compound is used for iron and steel.
- ✓ Nickel—Used when extreme heat and corrosion resistance is needed. Applications include food and chemical processing equipment, automobiles, cryogenics, and vacuum equipment. Flux.

4.2 Fluxes

Brazing processes require the use of a flux. Flux is the substance added to the metal surface to stop the formation of any oxides or similar contaminants that are formed during the brazing process. The flux increases both the flow of the brazing filler metal and its ability to stick to the base metal. It forms a strong joint by bringing the brazing filler metal into immediate contact with the adjoining base metals and permits the filler to penetrate the pores of the metal.

The following factors must be considered when you are using a flux:

Base metal or metals used
Brazing filler metal used
Source of heat used

Flux is available in powder, liquid, and paste form. One method of applying the flux in powdered form is to dip the heated end of a brazing rod into the container of the powdered flux, allowing the flux to stick to the brazing rod. Another method is to heat the base metal slightly and sprinkle the powdered flux over the joint, allowing the flux to partly melt and stick to the base metal. Sometimes, it is desirable to mix powdered flux with clean water (distilled water) to form a paste.

Flux in either the paste or liquid form can be applied with a brush to the joint. Better results occur when the filler metal is also given a coat.

The most common type of flux used is borax or a mixture of borax with other chemicals. Some of the commercial fluxes contain small amounts of phosphorus and halogen salts of either iodine, bromine, fluorine, chlorine, or astatine. When a prepared flux is not available, a mixture of 12 parts of borax and 1 part boric acid may be used.

V. BRAZING FLUXES, EQUIPMENTS AND FILLER METAL

Main property of brazing filler metal is its fluidity, its capability of penetration into the interface of surfaces. Melting point of filler metal must be compatible with work piece metal. Molten filler metal should also be chemically insensitive to the work piece metal. Filler metal can be sued in any form including powder or paste. Purpose of brazing flux is same it is in case of welding. It prevents formation of oxides and other unwanted by products making the joint weaker. Characteristics of a good flux are:

Low Melting Temperature,
Less Viscosity So That Filler Metal (Molten) Can Displace It, And’
Adhering To The Work piece. Common Fluxes Are Borax, Borates, Chlorides And Florides

VI. BRAZING JOINTS AND SURFACE PREPARATION

Common categorization of joint is butt joint and lap joint is also applicable to brazing joints. Normally a butt joint provides very limited area for brazing. We know the strength of the joint depends on the brazing area and so limited brazing area is responsible for week joint formation. To increase the brazing area the mating parts are often scarified or stepped by altering them through extra processing.

In case of lapped joints over lap of at least three times the thickness of the thinner part is recommended. An advantage of brazing over welding while making lap joints in that the filler metal is bonded to the work pieces throughout the entire interface area between the parts rather than only at the edges. Clearance between the mating surfaces should be large enough so that molten filler metal can flow throughout the entire overlapped area. At the same time clearance should be small enough so that capillary action can exists to facilitate the flow of molten filler metal between the overlapped area. Recommended clearance is up to 0.25 mm. Other important instruction for making brazing joint is cleanliness of mating surfaces. The mating surfaces should be free of oxides, oils, grease, etc. to make wetting and capillary action comfortable. Cleaning may be done using mechanical means or by chemical treatments depending on the situation.

6.1 Advantages of braze welding

This process requires less preheating, permits greater welding speed, demands a shorter cooling-off period, and is less likely to crack metals, such as cast iron, during the braze welding operation. There is no splash or weld spatter to worry about and low temperatures minimize distortion. The completed joint requires little or no finishing. Brazing technique does not require as much skill as the technique required for fusion welding. High variety of materials may be joined; Thin wall parts may be joined. Dissimilar materials may be joined.

6.2 Disadvantages of braze welding

If the joint is to be exposed to corrosive media, the filler metal must have the required corrosion-resistant characteristics. All brazing alloys lose strength at elevated temperatures.

If the joint is to be painted, all traces of the flux must be removed. E.g. Torch brazing.

The oxyacetylene flame is perhaps the most common method of heating the parts to be brazed.

VII. APPLICATION OF BRAZING

In Metal- Ceramic Joining

Metal-ceramic joints have wide applications in reactor power system (typically in spacecrafts), thermonuclear power reactors, and heat exchangers. Metal-ceramic joints are produced by two methods:

- Molybdenum-Manganese/Nickel plating method
- Active filler metal brazing

Molybdenum-Manganese/Nickel plating method

Molybdenum-Manganese/Nickel plating method is also known as Molly-Manganese metallization. Depicts various steps initially a coating of molybdenum and manganese particles mixed with glass additives and volatile carriers is applied to the ceramic surface to be brazed. Next, the coating is fired in a wet hydrogen environment leaving a glassy metallic coating. Further a layer of nickel is plated over the glassy metallic coating. Next, the nickel plating is sinter-fired in a dry hydrogen atmosphere leaving a finished metallic surface that can be readily brazed using Standard braze filler metals.

7.1 Active filler metal brazing

Active filler metal brazing is more famous than the Moly-Manganese metallization. The primary for this is that it is very material dependent, active filler metals display good wetting with most ceramic materials. Moreover, this method permits the use of standard brazing techniques when making metal-ceramic basements without the need to apply any metallization to the ceramic substrate. depicts various steps followed in this method to produce ceramic-metal joint. The metal and the ceramic substrates are cleaned, and the active filler metal perform or paste is applied between the faying surfaces of the basement. The brazing operation is usually performed in an inert or vacuum environment.

7.2 Brazing: Quality

It is important to have extremely clean surfaces for the brazed joint. Mechanical surface preparations such as grinding, sandblasting, wire brushing, filing, and machining can be used. The surface must be clean and removed from dust, oil, etc. Troubleshooting hints: If the brazing filler metal does not wet the surface: Increase the amount of flux used Roughen the surface Welding Technology Roughen the surface Change the work position so that the gravity will help the filler metal fill the joint If the brazing alloy does not flow through the joint: Allow more time for heating Heat to a higher temp Apply flux both the base metal and brazing filler metal. If the brazing filler metal melts but does not flow: Coat the filler metal with flux mechanically and chemically clean the filler metal if there are surface oxides present.

VIII. CONCLUSION

Brazing is a highly efficient method for joining and finds an important place in the current industrial scenario especially in aerospace and automotive applications. More methods of brazing are expected to be invented in the near future and this paper provides an insight into the existing brazing techniques and the test methods, so that the researchers can easily understand some of the overall developments.

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