Design for solder and brazed assembly

One of the most common joining processes, Brazing, works on the principle of capillary action. It uses a filler metal that is melted and distributed between the faying surfaces by capillarity. The process ensures that only the filler metal melts and the base metals are unaffected. This is because the filler metal has a melting temperature lower than that of the base metal that is to be joined.

The most common brazing metals are alloys of silver or of copper. Filler metals of these materials have a melting point greater than 425°C.

Following are some of the heat sources via which the filler metal is melted:

- Heated iron (solder only)
- Gas torch
- Furnace
- Induction coils
- Dipping in either molten filler metal or a molten salt bath
- Electrical resistance (of the work piece itself)
- Infrared lamps

Brazing has several advantages over welding. These are:

1. Any metal including dissimilar metals can be joined
2. Thin wall parts that cannot be welded can be brazed
3. Less heat and power required than that in fusion welding
4. As the working temperature is low, problems in the heat affected zone in the base metal are reduced
5. Joint areas that are inaccessible by many welding processes can be brazed

Some disadvantages and limitations of brazing include:

1. Joint strength is less as compared to that in a welded joint.
2. Joint strength is less than that of the strength of the base metal.
3. The brazed joint is weakened by high service temperatures.
4. Sometimes color of the brazed surface and base metals are dissimilar.
Uses of the Brazing process

Some of the industries that use brazing on a large enough scale include automotive (joining tubes and pipes), electrical equipments (joining wires and cables), cutting tools (brazing cemented carbide inserts to shanks), and jewelry marking industries.

Soldering

Somewhat similar to brazing, soldering is a joining process in which the filler metal has a melting point less than 425°C and is melted and distributed by capillary action between the faying surfaces of the metal parts being joined. The filler metal is called solder and is added to the joints, which distributes itself between the closely fitting parts.

Common materials which act as solders are based on lead and tin (for higher temperatures) or on brass and silver. Details of soldering are similar to brazing.

Advantage

1. Low energy input relative to brazing and welding
2. Variety of heating methods available
3. After soldering the joint has good electrical and thermal conductivity.
4. Capable of making air-tight and liquid tight seams for containers
5. Rework and repair are easy.

Disadvantage

1. Low joint strength unless reinforced by mechanical means
2. Possible weakening or melting of the joint in elevated temperature service

Application

1. Wide applications in the electronics industry.
2. Used for mechanical joint but not for joints subjected to elevated stresses or temperature

TYPICAL CHARACTERISTICS

Usually brazed and soldered assembly types are recommended if either the configuration with single piece is not possible or it is not economical to make from a single piece. Such situation arises when:
1. Metals are dissimilar

2. The requirement is an intricate lightweight assembly

3. Machining is not feasible on parts that are very thin and that have a high chance of breakage

4. Faced with leak proof joints of hollow shapes such as tanks, floats and evaporators

Soldering and brazing are used in sheet metal assemblies, machined parts, forgings, and in some cases, castings where the size of the assemblies are small. It is to be noted that for large sized parts, these methods are uneconomical.

When capability of disassembly, electrical conductivity and fluid sealing are important and strength requirements are not of concern, soldered assemblies are recommended. On the other hand, if strength requirement is of concern, brazing type is employed. In addition, brazed joints provide good corrosion resistance and a neat appearance.

**SUITABLE MATERIALS**

**Soldering**

Various forms of solders available are - bar, wire (solid or flux-cored) and paste forms. Solderable metals in the order of decreasing solderability are listed below.

1. Tin  
2. Cadmium  
3. Silver  
4. Copper  
5. Brass  
6. Bronze  
7. Lead  
8. Nickel  
9. Monel  
10. Zinc  
11. Steel  
12. Inconel  
13. Stainless steel  
14. Chromium  
15. Nichrome  
16. Silicon bronze  
17. Alnico  
18. Aluminum

**Brazing**

Application of brazing process is found on wide variety of base metals such as: carbon and alloy steel, copper, brass, aluminum, cast iron, nickel, and nickel alloys.

**DETAILED DESIGN RECOMMENDATIONS**

**Joint Design**

1. Lap joint is the recommended form for these assemblies. Generally, the area of overlap in the joint is kept large in order to make it stronger than the weakest member of the assembly.
2. A common thumb rule: Allow an overlap of at least three times the thickness of the thinnest member. (See Fig. M6.3.1.)

![Figure M6.3.1: Lap joint (recommended).]

3. The clearance between the joint surfaces varies from 0.025 to 0.20 mm with an average value of about 0.10 mm and usually depends on the fluidity of the filler metal.

4. Butt joints are avoided as they are weak due to small joint areas. They (see Fig. M6.3.2) are not recommended unless strength requirements are very low and there is no need for a pressure seal at the joint.

![Figure M6.3.2: Butt joint (not recommended).]

5. To provide a greater joint area, scarf joints (shown in Fig. M6.3.3) are recommended. A thumb rule for the recommendation of the scarf joints is that “if the joint area is three or more times the stock thickness scarf joints are recommended”.

![Figure M6.3.3: Scarf joint (not recommended)]

6. Figure M6.3.4 shows a number of both recommended and not-recommended joint configurations.
Assembly

Parts considered for brazed assemblies process are designed for easy assembly. The most economical soldered and brazed assemblies are those that are self-jigging, i.e., the assembled parts and the filler metal hold together during the heating cycle without any external fixture.

The approaches involved for holding parts together are gravity, spot and tack welding, friction and press fits, staking and peening, swaging, crimping and forming, threading, and riveting. These methods have been illustrated in Figure M6.3.5.

Placement of Braze Metal

Metals used for soldering and brazing can be in a number of forms namely, wire (commonly formed into rings for circular joints), slugs, shims, paste and sprayed or plated coatings and
these permit pre-placement before heating. Sprayed or plated coatings are especially applicable to copper brazing.

1. If filler metal is in shims, the assembly should be such that the parts are free to move when the filler metal melts. This allows a stronger, narrow-gap joint as shown in Figure M6.3.6.

![Figure M6.3.6: Filler metal in shim form is used](image)

2. One of the ways of avoiding gas entrapment in joints is to provide a vent hole in the joint.

Other Considerations

1. In the case of high temperature of brazing (>425 °C), parts can be distorted. Large, unsupported flat areas should be replaced by curved parts which have greater self-supporting capabilities. (Refer Figure M6.3.7.)

![Figure M6.3.7: Use curved areas if possible.](image)

2. A vent must be provided to allow the escape of gases generated due to heating of brazing flux for tanks or other enclosed assemblies.

3. Parts are kept in the correct position by using steps, stakes, or some holding means (See Figure M6.3.5.). Brazing involves multiple metals having different thermal coefficient of expansion and hence part movement or slippage is common in this case.
4. If induction heating is used, the joint must be designed to allow space for the induction coil. (See Figure M6.3.8.)

![Figure M6.3.8: Design allows room for the coil for induction heating](image)

5. Dip-brazed assemblies must be designed in a way that flux from the bath is not trapped in the joint. (See Figure M6.3.9.)

![Figure M6.3.9: Avoid designs that entrap flux for dip brazing](image)

6. Clearances for brazed metal or solder will cause a variation in the location of the parts to be joined. If it is critical, this variation can be controlled by knurling the parts, providing other means of minimizing the clearance before assembly, or swaging or crimping after assembly but before brazing. (See Figure M6.3.10.)
Figure M6.3.10: Knurled part at joint area allowing room for filler metal to flow by capillary action.

DIMENSIONAL FACTORS

Tolerances of brazed and soldered assemblies are controlled by the tolerances of their component parts. Further, to achieve some dimensions to closer limits in the joint assembly, finish-machining operations are possible after brazing.

Dimensional variations are most often caused by thermal effects during brazing (or soldering) operations. There is of course some dimensional variation across-the-joint that shows up as variations in filler metal thickness in the assembly, but this is usually a result of part variation or fixturing factors rather than variations inherent in the solder or brazes metal itself. Fixturing can often control across-the-joint dimensions.

RECOMMENDED TOLERANCES

Across-the-Joint Dimensions

If heat distortion is not involved (with solder and low-temperature brazing alloys), the assembly tolerance should approximately be equal to the stack-up of tolerances of the individual parts and an additional allowance for gap variations. An average value for this is +0.05 mm. If heat distortion is involved (likely if temperatures exceed 700°C), the expected distortion variation is added to this total tolerance.

Concentricity across the Joint

Variations permitted by the tolerances of individual parts are to be allowed except when joining with pre-applied paste filler metal. In this case one of the parts to be joined can be rotated which then distributes the paste uniformly and reduces eccentricity. In this case apply one-half the tolerance that would result from the parts’ spacing. Similar reductions in tolerances can also be made if torch brazing is used: one part can be rotated manually while the filler metal is molten.