Brazing, soldering and Friction Stir Welding

This chapter presents the basic concept of brazing and soldering processes and fabrications conditions where these joining processes are found suitable. Further, brazing filler, flux and temperature have also been described. A solid state a newly developed friction stir welding process has also be presented briefly.

Keywords: Brazing, soldering, joint design, clearance, brazing flux, brazing filler, brazing temperature, friction stir welding and processing

18.1 Basics of Brazing and Soldering

Brazing and soldering both are solid liquid processes primarily involve three steps a) heating of plates to be joined using suitable heat source, b) placing and melting of solder or brazing materials followed by heating to the molten state and c) filling of molten filler metal between the faying surfaces of the components to be joined by capillary action and then solidification results in a joint. These three steps are schematically shown in Fig. 18.1 (a-c). An attractive feature of these processes is that a permanent joint produced without melting of parent work pieces. Owing to this typical feature of developing a joint, brazing and soldering are preferred under following situations.

1. Metallurgical incompatibility: Joining of metals having entirely different physical, chemical and mechanical characteristics
2. Poor Weldability: Joining of metals of poor weldability in fusion welding due to cracking tendency, chemical reactivity to ambient gases etc.
3. Unfavorable HAZ: Heat affected zone formed in metal being welded by fusion welding process due to weld thermal cycle causes excessive hardening or softening thus making it not acceptable
4. Odd position welding: Locations of joint which do not allow application of conventional fusion welding technique due to working difficulties like melting of faying surfaces, placing molten metal in places where it is required.
5. Light service conditions: Joint is not expected to take high load & temperature, other adverse atmospheric conditions.

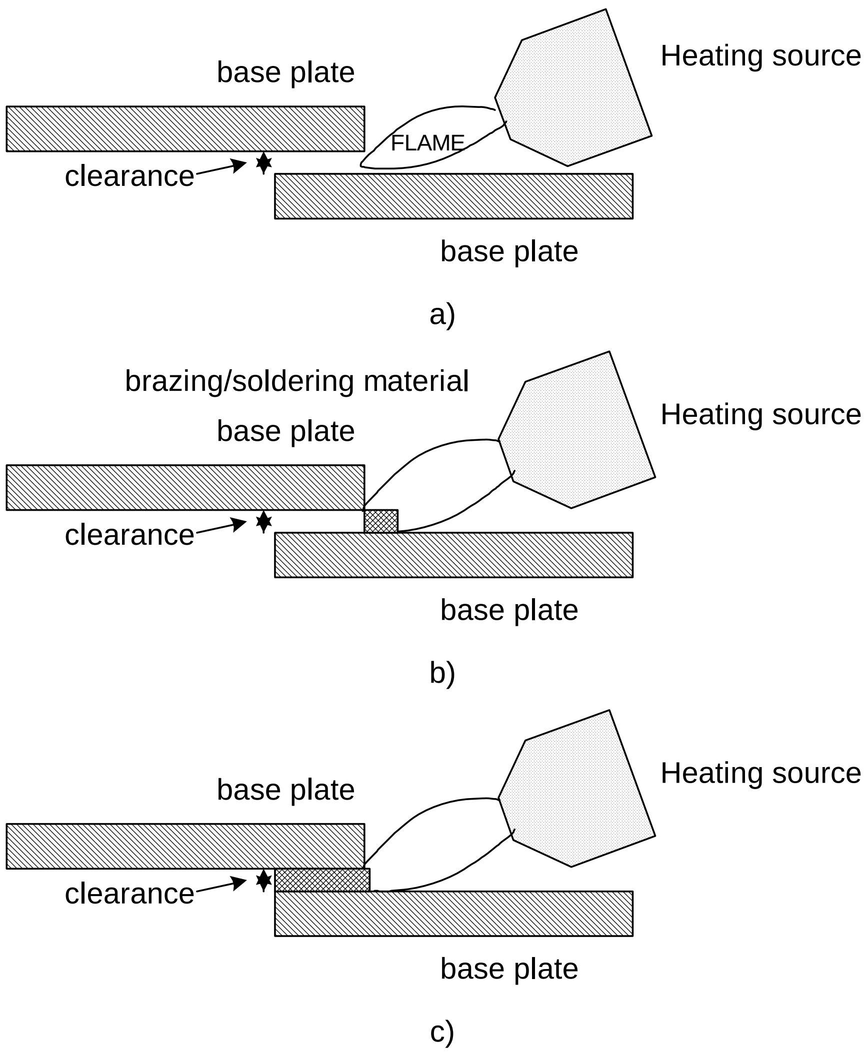

Fig. 18.1 Schematic of Step used for brazing and soldering process a) heating of plates, b) placing brazing/soldering metal and heating and c) filling of molten metal by capillary action followed by solidification

18.2 Joints for Brazing and Soldering

Lap joint is commonly developed using both the techniques. Clearance (0.075-0.125mm) between the plates to be joined is of great importance as it affects the capillary action and so distribution of joining metal between the faying which in turn affects the strength of joint (Fig. 18.2a). Both too narrow clearance and too wide clearance reduce sucking tendency of liquid joining metal by capillary action. To ensure good and sound joint between the sheets, surfaces to be joined must be free from impurities to ensure proper capillary action. Butt joint can also be developed between the components with some edge preparation primarily to increase the contact area between the plates to be joined (Fig. 18.2b).

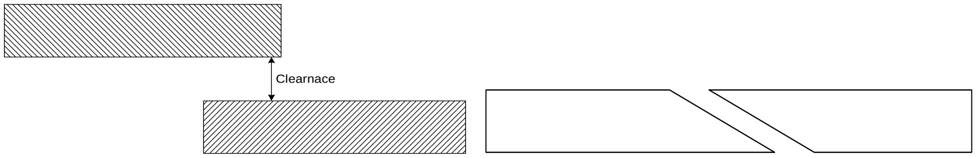

Fig. 18.2 Schematic of lap joint for brazing and soldering

18.3 Comparison of brazing and soldering

Both these solid/liquid joining processes can be compared in respect of various factors such as melting point of filler and strength of joint, ability to withstand at high temperature, heating source for developing joint and their applications.

18.3.1 Melting point of filler

Soldering uses the filler metal system having low melting point (183-275^0 C generally than 450^{0}C) called solder (alloy of lead and tin) while brazing uses comparatively higher melting point (450-1200^{0}C) filler metals (alloys of Al, Cu and Ni).

18.3.2 Strength of Joint

Strength of solder joint is limited by the strength of filler metal. In general, brazed joints offer greater strength than solder joints. Accordingly, brazed joints are used for somewhat higher loading conditions than solder joint.

18.3.3 Ability to withstand under high temperature conditions

In general, braze joints offer higher resistance to thermal load than soldered joint primarily due to difference in melting temperature of solder and braze metal. Therefore, solder joints are preferred mainly for low temperature applications.

18.4 Application

Soldering is mostly used for joining electronic components where they are normally not exposed to severe temperature and loading conditions during service. Brazing is commonly used for joining of tubes, pipes, wires cable, and tipped tool.

Common filler metals with brazing temperatures and applications

Filler metal	Al-Si	Cu	Cu-P	Cu-Zn	Au-Ag	Ni-Cu
Brazing temperature (^{o}C)	600	1120	850	925	950	1120
Parent metal	Al	Ni & Cu	Cu	Steel, cast iron, Ni	Stainless steel, Ni	Stainless steel, NI

Common soldering fillers and their applications

Solders	Applications
Tin-Lead (Sn-Pb)	General Purpose
Tin-Zinc (Sn-Zn)	Aluminum
Tin-Silver (Sn-Ag)	Electronics
Tin-Bismuth (Sn-Sb)	Electronics
Lead-Silver (Pb-Ag)	Strength at Higher Temperatures
Cadmium-Silver (Cd-Ag)	Strength at Higher Temperatures
Zinc-Aluminum (Zn-Al)	Aluminum; Corrosion resistance

18.5. Source of Heat for Joining

Soldering can be carried out using heat from soldering iron (20-150W), dip soldering and wave soldering. Brazing can performed using gas flame torch, furnace heating, induction heating, and infrared heating methods.

18.6 Limitation of Brazing and Soldering

These processes have major limitation of poor strength and inability to withstand at higher temperature with some possibility of colour mismatch with parent metals.

18.7 Role of flux in brazing

Fluxes react with impurities present on the surface of base metal or those formed during joining to form slag apart from reducing contamination of the joints from atmospheric gases (formation of oxides and nitrides due to atmospheric gases). For performing above role effectively fluxes should have low melting point and molten filler should have low viscosity. Fluxes applied over the surface of work piece for developing joint must be cleaned from the work surface after brazing/soldering as these are corrosive in nature.

18.7 Friction stir welding and processing

The friction stir welding is a comparatively new solid state joining process developed by the Welding Institute U.K. in 1991. This process is based on the simple principle of thermal softening of metal followed by sever plastic deformation to develop a weld joint. The thermal softening is facilitated by heat generation from two sources a) friction between tool and base metal and b) plastic deformation. The development of weld joints is facilitated by transport of metal from one side to another followed by consolidation by forging action (Fig. 18.3). To ensure proper performance of tool, its material must be strong and heat and wear resistant. The typical solid state joining feature of this process lowers undesirable effects of common fusion weld thermal cycle. This process is common applied for developing butt joints. The friction stir-welding has been applied in many ways for producing other weld configuration like T joints and Lap joints. Friction stir spot welding is one of the typical variant of friction stir welding used for producing lap joints. The strength of friction stir spot weld joints is found comparable or even better than spot weld joints in lap weld configuration.

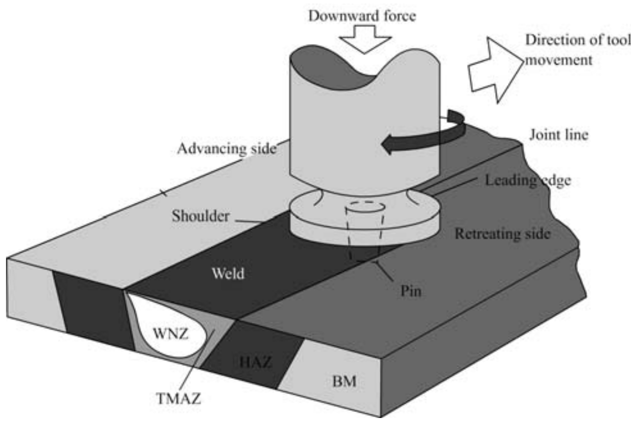

Fig. 18.3 Schematic of friction stir welding showing different parts of tool and zones of weld joints (Steve Hensley, Modern Machine Shop, 2008)

References and books for further reading

- Metals Handbook-Welding, Brazing and Soldering, American Society for Metals, 1993, 10th edition, Volume 6, USA.
- R S Parmar, Welding process and technology, Khanna Publisher, New Delhi
- Richard Little, Welding and Welding Technology, McGraw Hill, 2001, 1st edition.
- Steve Hensley, Editor, Friction Stir Welding—It is Not Just For Aluminum, Modern Machine Shop, (7/1/2008)
- Welding handbook, American Welding Society, 1987, 8th edition, volume 1 & 2, USA.
- http://www.globalsecurity.org/military/library/policy/navy/nrtc/14250_ch6.pdf
- http://www.ignou.ac.in/upload/Unit-6.pdf
- http://www.esabna.com/EUWeb/oxy_handbook/589oxy19_1.htm
- http://www.youtube.com/watch?v=3UBd1HIXegM

- http://www.weldingengineer.com/1soldering.htm
- http://www.silfos.com/htmdocs/product_support/alloy_selection_guide.html
- http://www.mmsonline.com/articles/friction-stir-weldingit39s-not-just-for-aluminum