UNIT 6 SOLDERING AND BRAZING

Structure

6.1 INTRODUCTION

Soldering and brazing provide permanent joint to bond metalpieces. Soldering and brazing process lie some where in between fusion welding and solid state welding. These processes have some advantages over welding process. These can join the metal having poor weldability, dissimilar metals, very less amount of heating is needed. The major disadvantage is joint made by soldering and brazing has low strength as compared to welded joint.

Objectives

After studying this unit, you should be able to

- introduction to allied welding processes,
- welding soldering and brazing comparative study,
- different methods of soldering and brazing and machine tool, and
- defects and applications of soldering and brazing.

6.2 PRINCIPLE OF BRAZING

In case of brazing joining of metal pieces is done with the help of filler metal. Filler metal is melted and distributed by capillary action between the faying surfaces of the metallic parts being joined. In this case only filler metal melts. There is no melting of workpiece metal. The filler metal (brazing metal) should have the melting point more than 450°C. Its melting point should be lesser than the melting point of workpiece metal. The metallurgical bonding between work and filler metal and geometric constrictions imposed on the joint by the workpiece metal make the joint stronger than the filler metal out of which the joint has been formed.

6.3 PRINCIPLE OF SOLDERING

Soldering is very much similar to brazing and its principle is same as that of brazing. The major difference lies with the filler metal, the filler metal used in case of soldering should have the melting temperature lower than 450°C. The surfaces to be soldered must be pre-cleaned so that these are faces of oxides, oils, etc. An appropriate flux must be applied to the faying surfaces and then surfaces are heated. Filler metal called solder is added to the joint, which distributes between the closely fitted surfaces. Strength of soldered joint is much lesser than welded joint and les than a brazed joint.

6.4 DIFFERENT TYPES OF SOLDERS

Most of the solder metals are the alloy of tin and lead. These alloys exhibit a wide range of melting point so different type of soldering metal can be used for variety of applications. Percentage of lead is kept least due to its toxic properties. Tin becomes chemically active at soldering temperature and promotes the wetting action required for making the joint. Copper, silver and antimony are also used in soldering metal as per the strength requirements of the joint. Different solder their melting point and applications are given in the Table 6.1.

Table 6.1 : Common Soldering Alloys and their Applications

Filler Metal Compositions					Melting Point	Applications
Tin	**Lead**	**Silver**	**Zinc**	**Antimony**		
–	96	04	–	–	305°C	Joint making at elevated temperature
60	40	–	–	–	188°C	Electronic circuits
50	50	–	–	–	199°C	Wire joining
40	60	–	–	–	208°C	Automobile radiators
91	–	–	09	–	200°C	Joining of aluminium wires
95	–	–	–	05	238°C	Plumbing, etc.

A solder is selected on the basis of its melting point. If metals to be joined have higher melting point solder of higher melting point is generally selected. Solder of high melting point provides better strength of the joint.

6.5 TYPES OF SOLDERING FLUXES

Soldering fluxes can be classified as :

(a) Organic, and

(b) Inorganic fluxes.

Organic Fluxes

Organic fluxes are either rosin or water soluble materials. Rosin used for fluxes are wood gum, and other rosin which are not water soluble. Organic fluxes are mostly used for electrical and electronic circuit making. These are chemically unstable at elevated temperature but non-corrosive at room temperature.

Inorganic Fluxes

Inorganic fluxes are consists of inorganic acids; mixture of metal chlorides (zinc and ammonium chlorides). These are used to achieve rapid and active fluxing where formation of oxide films are problems.

Fluxes should be removed after soldering either by washing with water or by chemical solvents. The main functions performed by fluxes are :

(a) remove oxide films and tarnish from base part surfaces,

(b) prevent oxidation during heating, and

(c) promote wetting of the faying surfaces.

The fluxes should

(a) be molten at soldering temperature,

(b) be readily displaced by the molten solder during the process, and

(c) leave a residue that is non-corrosive and non-conductive.

6.6 SOLDERING METHODS

There is a lot of similarity between soldering and brazing processes. The major difference between them is less heat and lower temperature is required in case of soldering. The different processes (methods) used in soldering are touch soldering, furnace soldering, resistance soldering, dip soldering and infrared soldering. All the above methods are common to both soldering and brazing processes. There are some more methods used in case of soldering only, these are hand soldering; wave soldering and reflow soldering. These methods are described below.

Hand Soldering

Hand soldering is done manually using solder iron. Small joints are made by this way in very short duration approximately in one second.

Wave Soldering

Wave soldering is a mechanical and technique that allows multiple lead wires to be soldered to a Printed Circuit Board (PCB) as it passes over a wave of molten solder. In this process a PCB on which electronic components have been placed with their lead wires extending through the through the holes in the board, is loaded onto a conveyor for transport through the wave soldering equipment. The conveyor supports the PCB on its sides, so its underside is exposed to the processing steps, which consists of the following :

(a) flux is applied through foaming, spraying, brushing, and

(b) wave soldering is used pump liquid solder from a molten both on to the bottom of board to make soldering connections between lead wire and metal circuit on the board.

Reflow Soldering

This process is also widely used in electronics to assemble surface mount components to print circuit boards. In this process a solder paste consisting of solder powders in a flux binder is applied to spots on the board where electrical contacts are to be made between surface mount components and the copper circuit. The components are placed on the paste spots, and the board is heated to melt the solder, forming mechanical and electrical bonds between the component leads and the copper on the circuit board.

6.7 SOLDERING TOOLS

The main tool used for soldering is the soldering iron. In addition to soldering some consumable are also used in the process of soldering like fluxes, solder wire or stick and spelter. These are described below.

Soldering Iron

It consists of a copper bit attached to iron rod at its one end, and a wooden handle at the other end. It is used to melt the filler metal and paste it to make the joint. A soldering iron can be a forge soldering iron which is heated in a furnace to have sufficient temperature to melt the filler metal or it can be electric solder iron. Electric solder iron is heated by passing electric current through it. Use of electric solder iron is popular and cost effective. It is used in making very precise joints in electronic and electrical equipment.

Spelter

Spelter is an alloy of zinc and copper in equal proportion. This is one of the filler metal with low melting point with other desirable properties to make good quality solder joint.

Different types of solders and fluxes, which are common consumables used in soldering have already been described. Some precautions are to be followed to keep the soldering tools as described below.

(a) Selection of correct tool according to the process. A defective tool should not be used.

(b) Electrically heated solder iron should have proper earthing.

(c) Hot solder iron, when idle, should be placed on its proper stand.

(d) Tip of the solder iron should be cleaned before, its use.

(e) Solder iron should be gripped at its handle while in use.

6.8 SOLDERING PROCEDURE

Following sequential steps should be carried out as soldering procedure.

Work Preparation

Workpieces which are to be joined together should be perfectly clean. There should not be any dirt, dust, rust, paint or grease. This is so that the solder or spelter can stick to the joint with proper strength. Cleaning is done with the help of a file or sandpaper. In case of joining of conducting wires, insulation of portion to be joined should be perfectly removed. Sometimes chemicals are used to clean the workpieces. De-scaling (removal of scaling) is done by dipping the workpieces into dilute HCl.

Preparation of Joint

After cleaning workpieces should be kept together in correct position to make the final joint. Workpieces should be clamped to avoid any relative movement between them that may disturb the joint making. At the joint smaller grooves are made on the workpieces to facilitate better flow of molten solder and so good strength of the joint. There may be the two objectives of joint :

- to bear load, and
- to make electrical contact.

In case of load bearing joints lap joint or butt joints are preferred. It is important to note down that strength of a soldered joint can not be compared with welded joint. If electrical contact is to be made the solder should be so selected that resistance of joint should match with the resistance of the conductor.

Fluxing

Fluxing includes selection of appropriate flux and its application to the joint. Selection of flux depends on the material of workpiece keeping its purpose in view. It is applied to the joint with the help of a brush before soldering. It avoids oxidation of molten metal, helps in flow of molten solder into the joint and so maintains strength of the joint.

Tinning

In this step of soldering procedure, the bit of solder iron is cleaned, application of flux is done over it. It is brought in contact of solder wire so the bit carries sufficient amount of molten solder over it. After that it is used to make tags of solder at various process through out the joint. If soldering is done to make electrical contacts of conductivity wires the complete joint is made by tagging few times. In case of long joint, after tagging the molten solder is filled to the joint by bringing hot bit of solder iron and solder wire together in contact with the joint. Filling the joint with molten solder and allowing to solidify is the last step of the procedure called soldering.

6.9 SOLDERING DEFECTS AND THEIR REMEDIES

Some of the common soldering defects are discussed below :

(a) Granular formation at the surface of the joint of solder is one of the common soldering defects.

(b) Formation of spheroids at the surface of soldering joint is also similar defect. This happen due to under heating or over heating of solder iron, insufficient use of flux. Formation of spheroids make the joint ugly and week in strength.

(c) Improper or uneven application of flux may make the joint of weaker strength.

(d) Proper coordination between flux application and soldering makes the joint of good quality.

6.10 SAFETY PRECAUTIONS IN SOLDERING

(a) Keep solder iron always on its stand.

(b) All electrically operated instruments/equipment should have proper earthing.

(c) Sometimes emission of (smoke) soldering operation may be poisonous due to a particular type of flux. Operator should have protection from the same.

(d) Flux should be applied gradually while soldering.

(e) While diluting HCl, water should not be added to HCl but HCl should be mixed into the water drop by drop, to avoid accident.

(f) Work place should have enough ventilation and smoking should be strictly prohibited during the operation. Work place should have the facility of first aid.

(g) It should be noted down good quality surface preparation always contributes to good quality joint.

6.11 BRAZING PROCESSES

All the processes covered here can also be applied to soldering processes. These common processes are being described below.

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.

Furnace Brazing

In this case, furnace is used to heat the workpieces 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.

Induction Brazing

Induction brazing uses electrical resistance of workpiece 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 is used. High frequency power source provides surface heating, however, low frequency causes deeper heating into the workpieces. Low frequency current is recommended for heavier and big sections (workpieces). Any production rate, low to high, can be achieved by this process.

Resistance Brazing

In case of resistance welding the workpieces 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.

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 workpiece 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 workpiece or joining multiple pairs of workpieces simultaneously.

Infrared Brazing

It uses infrared lamps. These lamps are capable of focused heating of very thin sections. They can generate upto 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.

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 as shown in the Figure 6.1, 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.

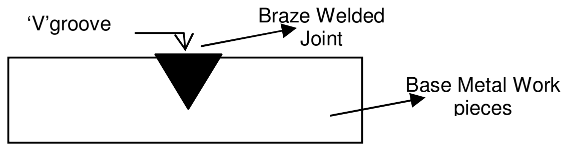

Figure 6.1 : Braze Welding

6.12 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. This are demonstrated in Figure 6.2. The extra processing makes the alignment of parts, during brazing, slightly difficult.

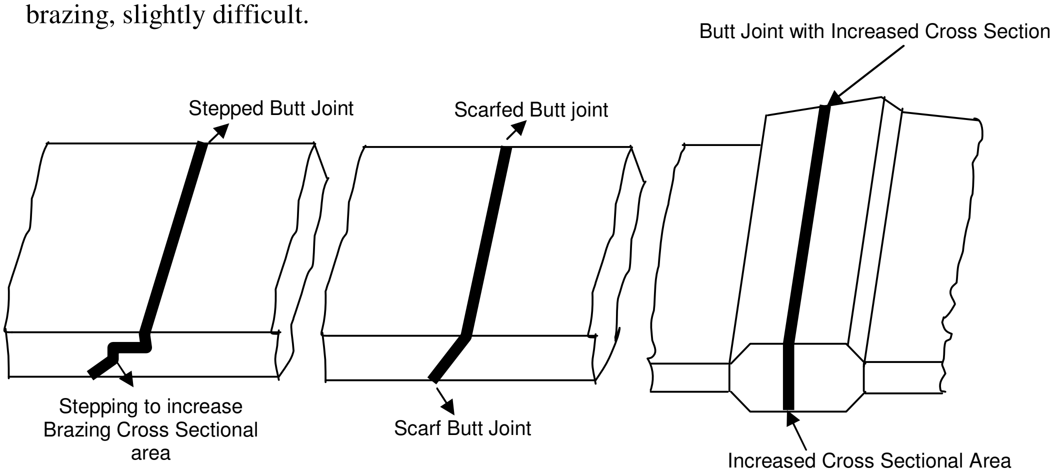

Figure 6.2 : Brazed Butt Joints

The other type of joint used in brazing is lap joint. Lap joint can provide relatively larger overlapping area and so better strength. The parts (workpieces) to the joined are kept so that some of their contact area should remain overlapped. Brazing is done on the overlapped edges of both the parts. Some examples of lapped brazed joints are shown in Figure 6.3.

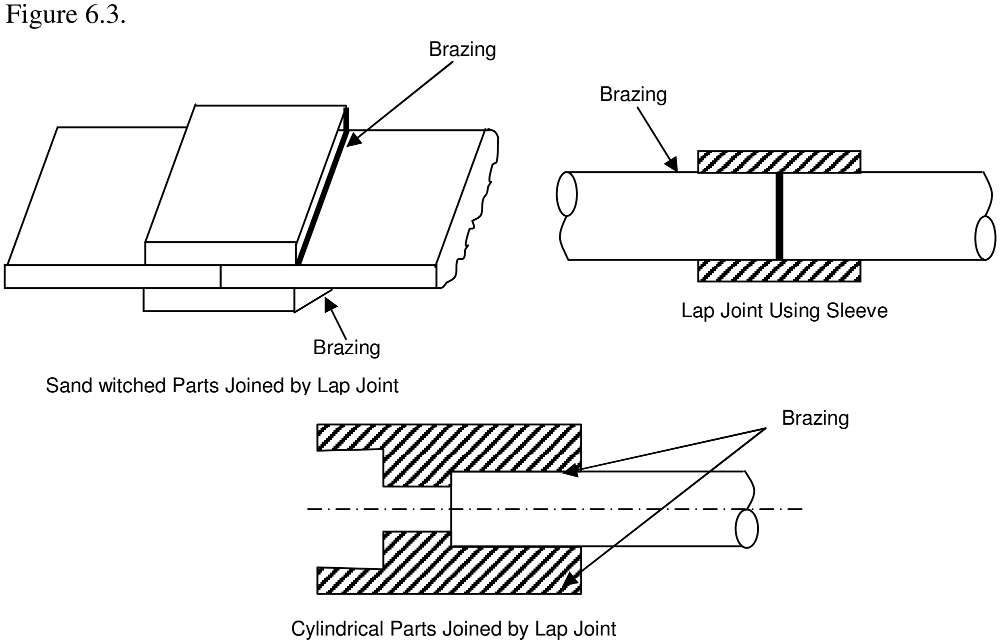

Figure 6.3 : Examples of Lap Joints by Brazing

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 workpieces 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 upto 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.

6.13 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 workepiece metal. Molten filler metal should also be chemically insensitive to the workpiece 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 :

(a) low melting temperature,

(b) less viscosity so that filler metal (molten) can displace it, and'

(c) adhering to the workpiece.

Common fluxes are borax, borates, chlorides and florides.

6.14 COMPARISON OF SOLDERING, BRAZING AND WELDING

The three processes soldering, brazing and welding have similarity that these are bonding processes. All the three uses filler metal, flux and application of heat. These processes also are dissimilar regarding the cost involved, performance, application area, etc. This comparison is tabulated below.

Table 6.1 : Comparison between Welding, Soldering and Brazing

Sl. No.	Welding	Soldering	Brazing
1.	These are the strongest joints used to bear the load. Strength of a welded joint may be more than the strength of base metal.	These are weakest joint out of three. Not meant to bear the load. Use to make electrical contacts generally.	These are stronger than soldering but weaker than welding. These can be used to bear the load upto some extent.
2.	Temperature required is upto 3800^oC of welding zone.	Temperature requirement is upto 450^oC.	It may go to 600^oC in brazing.
3.	Workpiece to be joined need to be heated till their melting point.	No need to heat the workpieces.	Workpieces are heated but below their melting point.

4.	Mechanical properties of base metal may change at the joint due to heating and cooling.	No change in mechanical properties after joining.	May change in mechanical properties of joint but it is almost negligible.
5.	Heat cost is involved and high skill level is required.	Cost involved and skill requirements are very low.	Cost involved and sill required are in between others two.
6.	Heat treatment is generally required to eliminate undesirable effects of welding.	No heat treatment is required.	No heat treatment is required after brazing.
7.	No preheating of workpiece is required before welding as it is carried out at high temperature.	Preheating of workpieces before soldering is good for making good quality joint.	Preheating is desirable to make strong joint as brazing is carried out at relatively low temperature.

6.15 SUMMARY

Soldering and brazing are the two allied processes of welding. The major difference between them is huge amount of heat is required in case of welding, low amount of heat is needed in case of brazing and very low amount of heat is consumed in case of soldering. Welding gives the high strength joints which are capable to hear the heavy load. Joints made by brazing are relatively weak and soldering joints are very weak to bear the load. Generally, soldering is used to make electrical contacts. Different methods of brazing are described in this unit. There are no different varieties of soldering method. Only the soldering material called speltor has its different varieties according to application. Different soldering and brazing defects and methods of their removal are also described in this unit.