Metal Joining : Soldering & Welding

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History of Soldering

The word solder is derived from the old french , soudure[1] which originated from latin word solidare meaning to fasten together. Lead was first obtained as a by product of silver production .Lead was used by Mesopotamians to join pieces of copper .

The Romans produced lead separately. solders comprising of lead and tin were almost used during the Iron age .An analysis of soldered joints in Roman artifacts were both tin rich and lead rich alloys. Modern soldering dates back to 20 th century when improved extraction techniques which enabled exotic metals to be available at affordable cost gave rise to diversity of alloys .

Need of Soldering in Dentistry

1- For soldering various types of wires in orthodontics,
2- In fixed prosthodontics.
3- For joining various components of fixed partial prosthesis.
4- For repair of perforations in crown and bridges.
5- To develop contact points in crown.
6- In removable partial prosthesis ,for soldering of clasps.

Basically Metal joining procedures are usually divided into three categories

Welding : The parent metals to be joined are fused in the joint area and there is no addition of another metal.

Brazing : Soldering operation at or above 450 c[2,3] is generally termed as brazing.

Soldering : Joining metals using an intermediate metal alloy .In this process the melting temperature of intermediate alloy is lower to the metals being joined. Having a liquidus temperature of filler below 450 c.

The standard soldering are called freehand and investment soldering[4].

Materials used for Soldering

1. **Investment :** The investment for soldering purpose is similar to casting investments containing quartz and calcium sulfate hemihydrate binder.

Soldering investments are designed to have lower setting and thermal expansions than casting investments, a feature that is desirable so that the assembled parts do not shift position.

2. **Solder :** Solder is a filler which flow by capillary attraction between the parts.

Requirements of a Solder-

Should melt at low temperature. When melted ,should be wet and flow freely over the parent metal. It's colour should match that of metal being joined. Should be resistant to tarnish and corrosion. Should resist pitting during heating and application.

Types of Solders

Soft Solders

Hard Solders

Soft Solders : Have a low melting range of about 260 c. Should be applied by hot soldering iron. Lack corrosion resistance, so are not suitable for dental use. Eg- lead-tin.

Hard Solders : Have higher melting temperature. Greater strength and hardness. Melted with help of gas blow torches or occasionally in electric furnace. Eg- silver solders, gold solders.

Gold Solders(Hard solder)

Composition : Gold- 45.81%, Silver-8.30%, Copper-7.20%, Tin-2-4%, Zinc-2-4%. Have high fusion temperature. Tin is added to lower fusion temperature.

Silver Solders(Hard solder)

Composition : Silver-10-80%, Copper-15-50%, Zinc-4-35%. Used when low fusing solders as required for soldering on stainless steel or other base metal alloy.

Properties of Hard solders

1- Fusion temperature - Should be atleast 56 c lower than the parent metal. Gold solders-690-870c . Silver solders-620-700 c.

2- Flow- A good flow and wetting of the parent metal by the solder is essential to produce a good bond.

Flow of solder can be affected by certain factors-

a. Melting range
b. Composition of parent metal.
c. Oxides
d. Surface tension of solder.

Microstructure of soldered joint-

Well formed soldered joint shows that the solder alloy does not combine excessively with the parts being soldered. There is well defined boundary between solder and soldered parts. If heating is prolonged diffusion takes place and the new alloy formed has inferior properties. Lavoris, green mint, cepacol mouth rinses and prepared saliva substitude all exhibited corrosive degradational reactions with silver solders[5].

Flux- Means flow, we need few compounds to assist solder to flow properly and they are called fluxes. For a solder to wet and flow properly the parent metal must be free of oxides.

Function-To remove any oxide coating.

To protect metal surface from oxidation during soldering.

Types of Fluxes-

Divided according to their primary purpose.

a. Surface protective: They Prevents access to oxygen.

b. Reductive – They reduces any oxide present.

c. Solvent-They dissolves any oxide present.

Commonly used fluxes-

a. Boric and borate compounds- They are used with noble metal alloys. They act as protective and reducing fluxes.

b. Fluroides- They are used for stainless steel. Same as gold fluxes with the addition of KF. More of boric acid is used than in gold fluxes. Fluxes supplied as- liquid ,paste,powder,fused onto the solder,prefluxed solder in tube form.

Heat Sources

Heat source is needed to melt solder and soldering to happen. Most commonly used heat source is a gas – air or gas- oxygen torch. Other source is electric furnace. Flame must provide enough heat to not only to melt the filler metal but also to compensate for heat loss to surroundings. Flame should have high temperature but also high heat content. Lower heat content

leads to longer soldering time and more danger of oxidation.

Various gases used as heat sources-

Hydrogen- It has lower heat content and therefore heating would be slow.

Natural gas- It has high temperature 2680 c. Heat content 1000 BTU. Normally available gas is non uniform in composition and frequently contains water vapour.

Acetylene- It has Highest flame temperature 3140 c and higher heat content than hydrogen and natural gas. Temperature varies by 100 C from one part of flame to other , therefore positioning of torch is critical. Chemically unstable and readily decomposes to carbon and hydrogen.

Propane- This is the best choice. Highest heat content 2385 Btu[6] . Good flame temperature.

Butane- More readily available in some parts of world. Similar to propane. Both propane and butane are uniform in quality and water free.

Techniques of soldering-

Free hand-

Investment-

Basic Steps in soldering-

1.selection of solder.

2.Cleaning and polishing of components.

3.Assembly of bridge in investment.

4.Application of flux.

5.Placement of solder.

6.Application of hot gas flame to joint and solder.

7.Cooling of assembly followed by quenching in water.

Requirements for successful soldering

a.Cleaniliness-Joints and the filler used should be clean and free from impurities.

b.Gap-The optimal gap is not defined. Stade et al (JPD 1978) atleast .31 mm gap be present but should be less than 0.76m[7] .If the gap is too much then joint strength will be governed by filler metal. If gap is too less then incomplete flow of filler will result in less strength.

c.Selection of solder- This step is important as we discussed it before every type of solder behaves differently with the metal to be joined.

d.Flux- different fluxes are used differently and accordingly to the need.

e.Flame-Flame used should be of neutral or slightly reducing part of heat source. This part has the most efficient burning process and highest heat content.

f.Temperature- This should be minimum to complete the soldering. Higher temperatures result in diffusion between substrate and filler metal. Lower temperatures do not wet the substrate metal.

g.Time- The heat source should be maintained until the filler has flowed into connection ans little more so that flux separate out from fluid filler metal.

Antiflux – There are times when operator does not want solder to flow into a specific area, then we use antiflux. Eg- Graphite ,Rouge[8], Whiting in alcohol and water suspension.

Welding- Few places soldering is not required we use welding procedure.

Indications-

Orthodontics- Join flat structures like bands and brackets.

Pedodontics- Weld bands and other appliances.

Prosthodontics- Joint wrought wire clasps and repair of broken metal partial dentures.

Spot welding- Wires or bands to be welded placed between two copper electrodes, a flexible spring is attached to electrode to apply pressure on metal and on pressing the switch large current passes. The combined heat and pressure fuses the metal at the point.Weld joint are susceptible to corrosion because of precipitation of chromium carbide and consequence of passivation.

Laser and plasma welding- Laser welding unit has a high power neodymium laser with a very high power density. Used mainly to join titanium components , this is because commercially available pure titanium is very reactive in air.

Advantages –

Lower heat generation.

No oxide formation because of inert argon.

Joint made up of same pure titanium as the components , thus reducing galvanic corrosion.

Welding processes-

Gas tungsten arc welding

Plasma arc welding

Friction welding

Laser beam welding

Conclusion

Even though soldering techniques being practiced since antiquity but now modern techniques are introduced which are possible due to introduction of new materials .Soldering , welding and brazing techniques are important part of dentistry and used in many branches. These are sensitive procedures so utmost care to be taken to have good results.

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