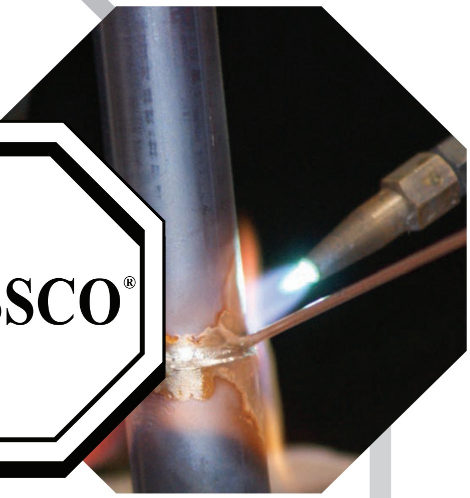

Hand Torch or Flame Brazing Principles

Introduction

Hand-torch brazing is inexpensive and flexible, making it ideally suited to small production batches or production runs involving differing components. However, it is dependent upon the skill of the operator to produce consistent joint quality.

Torches

Most torches are provided with a means of controlling the amount of fuel-gas and air (or oxygen) fed to the nozzle. Consequently, the composition of the mixture burning at the nozzle is capable of wide variation, and this is also under the direct control of the operator. Too high a proportion of fuel-gas will result in the production of a carburising flame, while too low a proportion results in the production of a highly oxidising flame. Both conditions can lead to severe problems of joint quality.

The flame should be adjusted to be marginally gas-rich, except in cases where oxygen containing tough pitch copper is being brazed. In this case, a neutral or marginally oxidising flame is needed to avoid possible hydrogen embrittlement. The same setting is recommended where the components being brazed are to be electroplated or polished.

For best results, the flame size should be adjusted so that it has sufficient capacity to raise the parts to brazing temperature within 30-45 seconds. If this cannot be achieved by a single torch, then some form of multiple torch pre-heating will be required.

Gas mixtures in common use

When considering the time taken to raise a particular component to brazing temperature, several important factors need to be taken into account. Among these are the thermal capacity of the flame, the flame speed, the efficiency at which the heat contained in the flame can be transferred to the component, and the quantity of gas being burnt. These four factors are all inextricably interrelated, and from them can be determined the 'specific flame capacity' which is a broad measure of the heating capability of a given flame.

About 85% of all hand-torch brazing operations are carried out using either oxygen/acetylene or butane/propane with compressed air. For safety reasons, the use of natural gas and compressed air/oxygen is declining and hydrogen/oxygen is rarely used due to the difficulty in seeing the flame, which is virtually invisible.

Torch brazing technique

As with all capillary brazing processes, it is essential that the parts comprising the assembly should be designed to provide good fits and proper clearances in the joint area. Surface irregularities such as burrs must be removed prior to the assembly of the parts.

i. Cleaning

The parts to be brazed should be free from oil, grease, excessive oxide scale and dirt. Oil, grease and most dirt can be removed by rinsing the parts in asolvent or an aqueous cleaning solution. If an aqueous solution is used, it is essential that the parts are properly rinsed and dried. If the parts are scaled with oxide, or are excessively dirty, mechanical abrasion or chemical treatment will have to be used.

Grinding or shot-blasting can be used, but in the latter case, care must be taken to choose the right abrading medium. While iron and steel grit is ideal, the use of sand or alumina should not be considered because particles may become embedded in the surfaces to be joined. Since both these materials are refractory oxides, both of which are extremely difficult, if not impossible, to wet with molten brazing alloys, joint quality will be affected. Brazing should be undertaken as soon as possible after joint cleaning has been completed.

ii. Fluxing

Flux paste should be evenly applied with a brush to the mating surfaces of the joint and the area immediately surrounding the joint.

The flux chosen should become active at least 50°C below the solidus of the brazing alloy being used, and remain active for at least 50°C above the liquidus of the brazing alloy.

Where a flux coated rod is used, it is imperative that the rod has sufficient flux for the brazing process. If not, supplementary flux may be required.

iii. Assembly

If brazing alloy preforms are to be used, they should be located in their correct position in relation to the joint. Once assembly has been completed, a further quantity of flux should be lightly applied to the joint. An adequate coating of flux must be applied to any edges or sharp corners.

Whilst self-jigging parts are to be preferred, this is not always possible to achieve. Where internal jigging is used, careful consideration must be given to the external design of the jig. The ideal jig will meet all the following requirements. It must be:

(a) easy to load and unload
(b) designed to provide minimum contact with the parts to be brazed so as not to act as a thermal sink
(c) designed to support the parts as far from the joint area as possible
(d) of low thermal mass
(e) not rigid, but arranged so that correct alignment of the parts throughout the brazing cycle is maintained by the use of counterweights and/or springs
(f) made of heat-resistant material
(g) designed not to obstruct access by the flame to the joint area

iv. Heating

When brazing, the rate of heat input to the parts is a critical consideration. It might be possible that a part that needs 15 seconds to reach brazing temperature with compressed air/propane, could be made to reach that temperature faster with oxygen/acetylene. However, it is not necessarily good brazing practice to reduce the heating time to, say, 10 seconds by using the much hotter flame provided by oxygen/acetylene. In terms of productivity, the higher heating rate has obvious attractions, but it must be remembered that the faster the rate of heating, the higher the probability of operator error.

For example, an increase of only 1 or 2 seconds in the heating time when using an oxy-acetylene torch can result in gross overheating of the parts. If this happens, several highly undesirable side-effects may result. Breakdown of the flux may occur, the residues being 'burnt on', causing difficulties in their subsequent removal. Depending on the nature of the parts themselves, overheating may cause the parts to melt.

Generating the correct heat pattern is vital to the production of a sound brazed joint. To achieve this in hand-torch brazing, a 'bushy' rather than a concentrated, extremely hot flame should be used.

It is essential that both parts comprising the joint reach brazing temperature simultaneously. A few moments spent studying the components prior to heating, is time well spent and will assist in producing a sound joint.

Keeping the torch continually on the move promotes even heating and, where natural gas/compressed air is to be used, the nozzle should ideally be some 75-100mm from the work. Where one component is much larger than the other, it will usually require preferential heating. This is also true when one component has lower thermal conductivity than the other.

Since a molten alloy will always flow towards the hottest part of the joint, the objective during heating should be to develop a heat pattern such that the point at which the alloy is to be applied is the last part of the joint to achieve brazing temperature. The alloy will then flow through the joint due to the combined effect of capillary attraction and the temperature gradient.

Wherever possible, joints should be designed so that gravity can assist the flow of the molten brazing alloy. Where this is not feasible, good results will always be obtained if due attention is paid to developing the proper heat pattern in the joint during the heating cycle. The molten brazing alloy will then be drawn vertically upwards through the joint.

As heating continues, it will be noticed that the flux settles down to become a thin, clear liquid.

If the correct flux has been selected, the presence of this clear liquid will indicate to the operator that the parts are now approaching brazing temperature and application of the alloy can be carried out. The alloy should be placed in firm contact with the joint, which should be at the temperature at which the brazing alloy will melt and flow into and around the joint.

Feeding of the alloy should be continued until the joint is slightly overfilled so as to allow the formation of a small fillet which can act as a ‘feeder’ for the shrinkage which will occur as the alloy solidifies.

It cannot be over-emphasised that where hand-torch brazing is concerned, the brazing alloy should be melted by conduction of heat from the components and, most definitely not by direct heating with the torch flame. If melting by the flame is found to be necessary, it is a sign that the parts are not up to brazing temperature and, inevitably, a poor joint with little or no alloy penetration will result. For this reason, the use of alloy preforms located inside the joint, which are thus shielded from direct flame impingement, is to be preferred.

v. Quenching

Once heating has been discontinued, the component should be allowed to cool freely in air until the alloy has solidified in the joint. The component may then be force-cooled either by means of an air blast or, preferably, by warm-water quenching. Watch quenching will give the best results, since the resulting thermal shock provided by sudden immersion in water causes most of the flux residue to flake off.

Water quenching should be avoided where the parent materials have widely differing coefficients of expansion. Similarly, in cases where one or both of the parent materials have large, or sudden, changes of section, water quenching may produce stress-induced cracking of either the parent metals or of the joint itself and so should be avoided.

vi. Post-braze cleaning

Flux residues should always be removed, not only to produce a clear finish, but because the majority of fluxes leave residues which absorb moisture. This encourages corrosion of the parent material and the brazing alloy.

Final cleaning is best carried out by soaking the work in hot water using, if necessary, a wire brush to remove the remaining flux.

Where residues prove particularly difficult to remove, the parts should be immersed in a warm 5-10% solution of sulphuric acid for 2-3 minutes, or in hot, 75°C, 10% solution of sodium hydroxide, for a similar period, followed by rinsing in running water and further brushing if required.

Thessco Flux-Coated Rods

The technique to adopt when carrying out hand-torch brazing with Thessco flux-coated rods, is generally the same as that already described. As the flux is present on the rods, pre-fluxing of the components prior to their assembly is unnecessary.

During the heating stage, the Thessco rod should be applied to the joint periodically until a small quantity of the flux coating at the tip of the rod has melted and flowed onto the work. Melting of the flux must be induced by conduction of the heat from the parts, and not by direct impingement of the torch flame.

When melting of the flux has occurred, the Thessco rod should be brought into contact with the mouth of the joint and then twisted through about 180° in order to melt more flux off the rod. The rod should then be removed from the work and heating continued for 5-6 seconds. The flux-free tip of the rod should then be brought into contact with the mouth of the joint, which will now have attained sufficient temperature to cause the alloy to melt and flow into and around the joint.

Quenching and post-braze flux residue removal procedures for Thessco flux-coated rods are identical to those described earlier.

Self-Fluxing Silver-Copper-Phosphorous 'Phos' Alloys

There are some torch brazing applications, where the addition of a separate flux is not required, such as the joining of copper to copper, with one of the Thessco Phos Series of self-fluxing brazing alloys. Although the self-fluxing properties of these alloys are completely satisfactory for most applications, where prolonged heating or extended penetration of the alloy through the joint is needed, fluxing action can be augmented by the application of a small amount of Thessco 'F' flux paste to the parts prior to assembly.