SOLDERING STAINLESS STEEL

Pete Moses ***MPH 439*** ***Page 31***

1, Stainless Steel, a description
Stainless steels are corrosion resistant steels that have a rather wide variety of compositions, but always with a high percentage of chromium (Cr), typically 12 per cent. To be effective they must contain enough chromium to form a layer of chromic oxide (Cr_20_3) and, maybe, a small amount of $FeOCr_20_3$ This layer is inert and it is also self healing, so the material may be worked without losing its resistance.

2. Fluxes and Cleaning
Difficulties encountered in soldering stainless steel are often caused by the tenacity of the oxide layer. This layer prevents the steel being wetted by the solder. The usual resin-based fluxes are not capable of removing the layer. A flux that can be used effectively is a mixture of zinc chloride ($ZnCl_2$) and hydrochloric acid (HCl), perhaps with a small amount of ammonium chloride (NH_4C1). It is absolutely essential that the soldered joint is cleaned thoroughly to prevent corrosion.

The chloride ion is generally very destructive to stainless steels. This type of attack takes the form of pitting and, with austentic stainless steels, stress corrosion cracking may occur. For stress corrosion to occur there must be tensile stresses at the surface, these may be applied stresses or stresses due to unequal cooling from high temperature. These types of cracks give the impression of a brittle mechanical fracture, but they are because of a local corrosion process. The best known example of stress corrosion cracking is the season cracking of brass. One strange aspect of stress corrosion is that it may take from a matter of minutes to many years for cracking to happen.

Cleaning the chloride-type flux off may be done by washing in water with five to 10 per cent sodium carbonate (Na_2CO_3) and then rinsing in plain water. Another flux, based on phosphoric acid (H_3PO_4) will destroy the oxide layer at higher temperatures, but when cool it is not particularly corrosive and so stringent cleaning is not called for.

3. Too Hot?
If excessive heat is used, the steel may become sensitised, or susceptible to intergranular corrosion. This occurs during exposure to temperatures in the range of 900-1,600°F. The melting point of solders used for stainless steels rarely exceeds about 500°F. Sensitisation is when chromium carbides form at the grain boundaries of the stainless steel and adjacent to the grain boundaries there is a lack of chromium, possibly reduced to nothing in some cases. In this case the poor corrosion resistance of ordinary steel is approached.[1]

4. Solders and Surface Finish
Dave Hills[2] appears to have used the best type of solder, ie, silver solder (96Sn, 4Ag), This has distinct advantages over the usual lead-tin system. Silver solders have a higher corrosion resistance than lead-tin solders, which is important with ferretic stainless steels - so no problems here. Soldering is, however, expedited by a rough surface and not a polished surface. Difficulty will be found with bright annealed stainless steel, because the oxide film is thickened during annealing[3].

5. Summary
Probably most difficulties are due to the use of the wrong flux and inefficient cleaning. I do not see any reason why a silver soldered stainless joint should not be made and I believe that certain stainless steel parts used on some aeroplanes were silver soldered.

The correct temperature for soldering is reached when the solder flows freely into the area of the joint[4] and if a flame is being used for heating, soldering may be made easier by ensuring that the flame is of a slightly reducing nature, ie, a small excess of gas present. With Bunsen-type flames, use the envelope and not the cone tip, in order to reduce any oxidation[5].

I must point out that I am not an expert in these matters, and I only comment by request. These comments may, of course, be rejected ad hoc. I notice that our President is a member of the Institution of Mechanical Engineers, perhaps he can shed some light on the matter.

References

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2. D. Hills, MPH 436, p12-13 (1985).
3. R. A. E. Hoover, Weld Met Fabric, 44, 286 (1976).
4. Machinery's Handbook, 21st Edition, Industrial Press NY (1979).
5. F. J. Camm (Ed), Newnes Engineers Reference Book, 4^{th} Ed. G. Newnes Ltd, London (1951).

John Webber ***MPH 440*** ***Page 4***

I recently had a letter from Geoff Strange, who is Product Manager, Brazepaste and Automation, of Johnson Matthey Metals, who specialise, among other things, in brazing and soldering materials and fluxes. I would like to quote a couple of paragraphs from the letter, as they may be of interest to members

I will not attempt to go into technical 'chat' here, except to say that the phenomena of interfacial or crevice corrosion of stainless steel are still not fully understood despite many years of research. All that can be said is that we have prevention not cure. The selection of the correct brazing alloy is all important (and flux); in fact only one in the silver bearing range will give complete immunity (JMM Ltd. Argobraze 56) with one or two others giving a fighting chance. Brazing in a furnace with copper base alloy is another solution, although not giving a colour match, but generally not available to the 'amateur'.

Dave Hills ***MPH 440*** ***Page 22***

Pete Moses's article entitled "Soldering Stainless Steel" was very interesting and I think I know the probable cause of my registration numbers/ mounting stud failure. Yes, I use the best silver solder (96Sn 4Ag) and phosphoric acid as a flux, but I didn't know that polished, annealed stainless had an extra thick oxide coating and that a rough surface would be best. I also use an acetylene torch with a pointed blue flame which is probably producing a heat area far too small. The failed weather vane was also highly polished before silver soldering, again indicating the probable cause of failure. Of course, it's so much easier to polish before assembly, but I shall have another go and see what success I have. Thank you, Pete, for all that interesting information and I echo your comments, I'd love to hear our President's views.

Dave Hills ***MPH 441*** ***Page 18***

When I first asked about "failed joints" in stainless steel parts that had been silver soldered, I didn't realise that this is an unsolvable problem for plumbers who try to silver solder domestic systems which use stainless steel tubes. Ever since stainless has been used for domestic hot water systems, soldered joint failure has been a problem and the use of compression joints is now almost universal. It is possible to silver solder stainless parts together, but a successful join is dependent on several factor - and one of them is knowing the precise nickel content of the stainless steel parts involved. Fluxes of the right type must be used and also the correct type of silver solder, but the whole procedure is so involved that I am not going to attempt an explanation in *MPH*.

However, my investigations have given me contacts at British Aircraft Corporation at Weybridge and within the research department at British Oxygen and I can offer a "trade-type" leaflet (photostat) to anyone who would like to know more about "crevice corrosion" (the correct term for a failed stainless/ silver soldered join). It seems that the silver soldering of stainless steel was stopped complete during the early 50s at Vickers (now BAC) and other aircraft factories because the exact cause of "crevice corrosion" could not be pinpointed. The ability to produce a silver soldered/ stainless join acceptable to aircraft standards took some years to find. All in all, I am glad I asked the question - I am now much wiser and, hopefully, I can now keep my registration numbers and letters attached to my bike!