

MicroWelding

by Geoffrey Walker

Microwelding has sparked quite some interest in conservation circles recently. It would appear to be the ideal solution to the problem of worn clock and watch components, by enabling the replacement of metal lost by wear. It sounds absolutely perfect! In the interests of conservation, absolutely no more metal than is absolutely essential should be removed from any part of the clock. As much original metal should be left as is possible. For example, seriously worn teeth, which are beyond the realms of giving useful service, should be replaced with a ring of teeth fitted to the original wheel, having turned the old teeth off. Bore out the new wheel until it fits the rim. It is much easier than you think, and the repair can be virtually invisible if done with care. I cannot understand why it may be thought that the cure for parts that have worn, is to remove even more metal.

Microwelding is exciting because it offers the possibility of keeping many more original parts intact.

This article was prompted by seeing the reference to the welder in the *HJ April 2008* report about the Inhorgenta Trade Fair, and aims to offer an insight into the practical aspects of owning a Lampert PUK 3 Professional model jewellery welder.

Unfortunately laser welding machines are very expensive, around the £12,000 mark, adding VAT will push that up to £14,100, and there is the gas supply to think of as well.

With this in mind, I bought the Lampert PUK 3 Professional Plus Jewellery Welder, in June 2007, and since then I have managed to recover many items.

The welding procedure is to touch the work-piece onto the electrode tip, and hold it still, whilst the Argon gas flows out of the nozzle to form an inert shield around the component. After about a second the electronics trigger a current pulse, and simultaneously the electrode retracts, and the gas flow is shut off. Filler wire can be used to fill grooves, gaps and hollows.

The work is held under the microscope, which is supplied with the machine. Magnification is X10, and built in to the optics of the microscope is a shutter, which is operated by the electronics in the machine. It is the liquid crystal type that is readily available with standard welding helmets. Experiencing one of these welding helmets for the first time is definitely strange. It goes completely against the grain to strike an arc whilst you can clearly see the electrode. Instinct makes you hesitate, but the switching time of the filter is of the order of a millisecond, so your eyes won't experience any of the arc without protection.

Altogether there are three settings on the welder. Standard mode, Silver mode and Micro mode. The micro setting has the same pulse shape as the standard, apart from the lower time and power settings, but the silver mode has a slowly decaying current pulse shape. This helps to stop the heat disappearing so quickly, and gives the molten metal time to settle into a smooth pool or bead.

Electrodes are made of tungsten and they need to be kept to a sharp point. On lower power and time settings the point will keep sharp quite well, and as TIG welders will appreciate, keeping the electrode sharp is essential. A sharp electrode focuses the heat more effectively. As the electrode tip becomes less sharp, it is tempting to turn up the power setting to compensate. This will work to a limited extent. It is better to change the electrode. They are supplied in packs of ten, so before starting a job, ensure they are all sharp, and work can continue smoothly by just changing as required. It takes less than 10 seconds to change.

Welding current pulse width of the Lampert welder is variable from 4mS to 30mS, (0.004S to 0.03S).

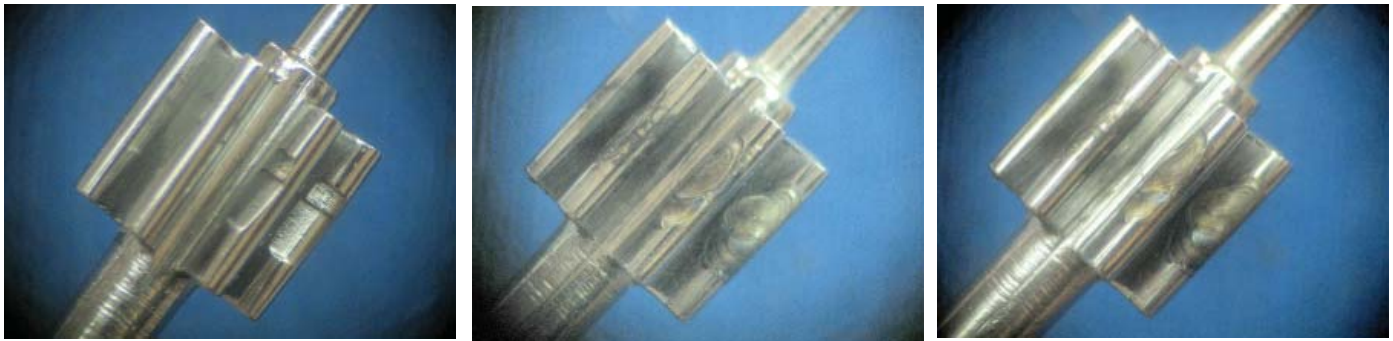
The cooling rate of the weld pool is estimated to be in the order of 6,750 degrees per second. (1,350 degrees appears to cool in about 200 mS). This means that the weld bead is as hard as it is possible for the material to be. In practice it seems the only thing that can touch it is a diamond tool. A typical figure for the cooling rate to harden carbon steel is 200 degrees per second. Gauge plate has other metals added in its manufacture to enable it to be cooled a bit more slowly, at 50 degrees per second, and still harden. As a result, items can be quenched in oil to achieve a lower cooling rate and thus reduce the degree of distortion.

Some useful tips:

- 1: Start with scrap material first and experiment by varying the power and time settings. For filling wear grooves in pallets, try 45% power with 18mS pulse width. The default power and time setting is 7 mS and 27% power.
- 2: Use only minimum pressure to contact the electrode. If you push too hard, the work will follow the electrode as it retracts and it will stick to the electrode.
- 3: Keep electrodes sharpened.
- 4: Excessive gas flow seems to cause turbulence, which draws in oxygen rather than keeping it out.
- 5: If you use too little power you will end up with lumps and a lot of material to grind away before you have another go.
- 6: When repivoting, use a length of blue pivot steel, and make a male centre of about 45 degrees on one end. Then just catch the centre of the arbor with a graver, as if you were going to drill the arbor, and it will help to locate the male centre on the pivot steel precisely. Mount the blue pivot steel in a collet in the lathe. Support the arbor in a female centre in the tailstock to ensure perfect alignment with the pivot steel. Then weld it using filler rod all the way round. Temper the pivot, cut the excess pivot steel to length, turn the shoulder, and polish the new pivot. If you use pivot steel that is one size large than required, then while turning the shoulder, a light cut can be taken to reduce the diameter and ensure precise concentricity of the pivot with the



Left: Worn pinion leaf. Middle: Welded pinion. Right: Pinion worn more than half way through, one leaf is partly welded.



Excess weld on this pinion was removed with diamond tools and polished.

arbor.

7: It seems to help if you use pre heat and post heat treatment. Pre heat drives off contaminants like oil, but don't heat it too much or the hardness and temper of the main material will be affected. Post heat will temper the work. I welded a carbon steel watch spring very successfully, but as soon as it bent it broke. On the next attempt, after tempering, it seemed to do the job. Unfortunately it was a scrap spring and was never put into the watch to endure repeated winding and unwinding cycles.

8: If you make a mess of the job, you can always grind away the excess weld and start again.

9: Do not leave the welded component in any acid based cleaning fluid, such as Envo Turbo, for any longer than is absolutely necessary. Because of the different localised constituents, you will find that electrolytic action will eat in to the weld and leave it looking like chocolate with holes in it that sounds as if you eat in an aeroplane! (I don't think I am allowed to say Aero chocolate). Clean the component thoroughly before welding and it will only need a quick clean afterwards. Perhaps Xylene based or similar cleaning fluids will not cause this problem if it is caused by electrolytic action.

Results

I have had success with about 20 pinions, 8 pallets, 2 delaminated crutches, 2 broken steel hands, and built up a worn tooth on a rack. I have also repaired a broken return bar (435) in a watches keyless work. So far promising, but more practice needed. I have had a little trouble with porosity in the weld bead. This is overcome by re-welding it to fill the hole. Sometimes I have had to break off a newly welded pivot, temper the arbor to blue and re pivot in the normal way because the resulting weld has been too hard to turn the shoulder.

The larger the module of a pinion, and the fewer leaves, the easier it is to weld. It may be very difficult to recover pinions of lower modules than those found in longcase clocks.

So far the results from trials with brass are disappointing. The machine has a setting, which enables it to weld silver. Silver has a very high thermal conductivity, and Lampert have used a pulse of current, which decays, rather than being cut off

instantly. Why this is not so effective with brass I fail to understand at the moment. It is probably due to the zinc, which melts at a much lower temperature, and will vapourise in the attempt. A strip of modern brass sheet however, responds quite well, and the weld pool surface is smooth. But a piece of yellow cast brass looks like a lunar surface. Weldability of a scrap wheel from an alarm clock falls somewhere between the two.

One can never be certain exactly what is in the brass. It is not just copper and zinc; there may well be some lead in it to start with and the possibility of aluminium and or tin. Choice of brass rod to act as filler would be difficult if you didn't know the specification of the parent metal to start with. See the "key to metals" website mentioned at the end.

If brass could be welded, then material could be deposited to replace the broken tooth. This would save filing a piece out of the wheel rim and shaping a dovetail. But unless the strength of the weld is up to the job, the new tooth could fail. Some more work is required in this area.

Heating the material before and after is used in structural welding, and is called Pre-heat and Post-heat respectively.

Preheat will:

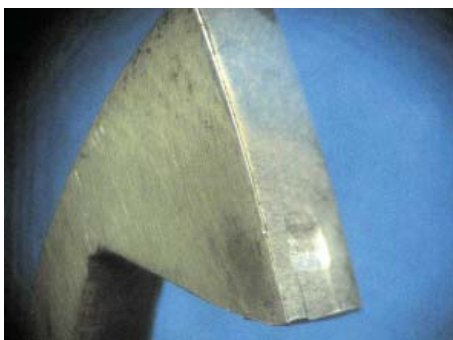
- Reduce thermal stress
- Compensate for high heat losses during welding
- Minimize the rate of weld hardening.
- Reduce porosity in the weld.
- Reduce hydrogen cracking.
- Improve the microstructure of heat-affected zone. (HAZ)
- Drive off moisture, which can break down into hydrogen

Post heat will:

- Relieve stresses thermal and residual, set up in the welds
- Temper the metal to reduce brittleness
- Reduce diffused Hydrogen

Thermal stress is unlikely to be a problem in our applications. But it may be difficult to assess how much the other factors come into play. I suspect that the porosity I have found may be as much to do with contaminants as turbulence in the gas flow drawing in oxygen. For filler rod I use piano wire, and sometimes I have used broken piercing saw blades.

In order to profile pinion leaves as accurately as possible, perhaps ideally I could make a tool blank out of some sort of material to the same form as the pinion, load it with diamond paste and use that to grind the profile back a little more accurately. At present I use a flat disc diamond wheel running slowly in the lathe, and just take off the proud weld. I use MDF discs loaded with valve grinding paste of different grades to smooth and polish out the grinding marks.



An entry pallet. After welding, the surface was so hard I could only dress it with a diamond file. By depositing metal on the sharp edge of the discharge corner of the pallet I was able to reduce the inside drop to a more acceptable level.

Stainless welds very well, but the wire size for filler rod is 0.3mm, and I haven't come across any stainless wire of that diameter yet. Actually I haven't tried that hard, I've been quite busy, but I will get round to try "building up" the worn parts of stainless watchcases.

An extra benefit

I have made another stand for the microscope, which is supplied with the welder, and mounted the microscope over my watchmakers lathe. Apart from things looking green through the filter, it works very well, and it provides its own illumination.

Useful websites

<http://www.lampert.info/english/produkte.php>
Lampert's own website.

http://www.suttontools.co.uk/acatalog/Easi_Welder_2.html
Sutton tools are the agents in the UK.

<http://www.lampertusa.com/forum/index.php?c=2>

This is a Lampert users discussion site. It looks very promising. However, I have so far failed to enter any of the areas on this website, but perhaps by the time this appears, the problem may be solved. Alternatively it may be due to something I am doing wrong! Let me know if you find out how to do it.

<http://www.key-to-metals.com/Article69.htm>

This explains something of how the strength of brass varies with constituents and heat treatment.

Finally

The School of Jewellery at Birmingham occasionally have a 1-day course for £80 and you get the £80 off the price of a welder from Sutton tools. Sutton tools are literally across the road from the jewellery school main entrance.

If anyone would like to try this machine out, they can contact me and arrange a visit, and bring your worn pinions etc!

Geoffrey Walker
mail@geoffreywalkerclocks.co.uk