Copper Development Association

"BRASS in focus"

Press Information

PR675 issued: 29/10/2004

Starts…….

BRAZING - THE 'MAGIC MOMENT'

"…..an ingenious thing, but of great usefulness."

Vannoccio Biringuccio "Pirotechnica" 1540

A Joint is Formed

"*At room temperature the socket in the cast-brass bush had been a force fit for the steel tube about to be joined to it as an integral part of an oxy-acetylene cutting torch (Fig 1). Now, due to the differential expansion of the two materials at the brazing temperature of 700°C, the gap had developed to precisely 0.050 mm, ideal for the brazing alloy to melt and wick into."*

This example illustrates that such is the precision of the preparation if a perfect joint of optimum properties is to be the result. The design of the joint-gap at temperature is crucial.

In the case of brass-to-steel brazing the choice of filler material would probably have been one of the range of cadmium-free, silver based products such as Johnson Matthey 'Silver-flo 40', a 40% silver copper-zinc alloy with a small addition of tin.

Differing completely from welding, where the mating parts are melted and joined either with or without added filler, brazing has a process requirement that the melt temperature of the filler alloy be significantly below the melt temperature of the mating parts. It is the lower melting point of the components to be joined that determines the type of brazing filler metal that can be chosen. The final adhesion is caused by a complex interaction of macro-surface dendrites in the crystal structure formed by the molten filler as it cools.

Had the joint to be brazed been steel-to-steel then the brass (60/40 copper/zinc) alloy known in the range from Johnson Matthey as Argental No1, melting in the range 875 to 895^{o}C and widely used in industry, would have been another option, or perhaps one of the bronze alloys (high copper with a trace of nickel) melting at just under 1100^{o}C.

Anyone who has ever had the experience of brazing will know the feeling of the 'magic moment' when the brazing medium flows. If the choice of material and flux is correct and the joint designed properly, it is almost instantaneous once the critical temperature is reached.

Immediately preceding that moment, the metals to be joined will have been subjected to gas flame, radiation or induction heating. They are brought as rapidly as the design permits from ambient up to the melt temperature of the filler metal. The flux does its one and only job of removing and preventing oxide formation, and suddenly the filler flows. The surface tension of the melt drops and the binding alloy capillaries its way into the carefully designed joint gap to form a neat interface, in some cases using its surface energy to flow upwards in the gap, appearing to defy gravity itself.

After the joint gap is filled there is no point in continuing to apply heat, it is neither necessary nor desirable. The job is done, usually in a small number of seconds.

On production lines the whole process from start to finish is typically achieved within 30 seconds, making it respectful of the integrity and properties of the components joined and ideally suited to industrial automation.

The cooled joint usually requires little or no post brazing operations beyond the removal of traces of water-soluble flux and, subject to configuration, can in many cases be stronger than the materials joined. Seldom in correct brazing practice is the finished joint the weakest link.

For small components, it is often convenient to heat the whole item homogeneously to the brazing temperature but, for bulkier items, the heat is applied locally to the joint area and it is the thermal conductivity of the item bulk that determines the quantity of heat energy required to sustain temperature at the joint-to-be for the critical melt period.

The brass material Argental No1, mentioned earlier, is also widely used in rod form for a form of brazing sometimes historically termed brass or bronze 'welding' using a hand torch for heating. This should not be confused with high temperature, molten-component welding, since the only material to melt is the filler rod and strength is built up partially by interstitial capillary bonding, and partly by material addition via filler melt.

How long has man been Brazing

In the history of thermal joining it is interesting to note that there are a variety of meanings for the word 'brazing'. Some relate to the French ***braser***, to heat or to burn, some to the application of thin layers of brass and some to the actual joining of metals using alloys of lower melting point than two parent pieces.

It is in this latter etymological version that brazing is now well accepted as an engineering process. A technique of which Vannoccio Biringuccio, one of the earliest engineering metallurgists to write on this subject in his work 'Pirotechnica', stated in 1540, ***"This seems to me to be an ingenious thing, but of great usefulness."***

He could not have said a truer word since the technique is invaluable to all industries involved in metal fabrication.

It is extremely likely that some accidental examples of brazing occurred several millennia earlier during the first furnacing of metals, but certainly an early example would be the analysis of the Sumerian Bronzes dated at approximately 2000 BC which showed them to have been brazed using a fusible chemical flux, remarkable sophistication for the time.

The material 'brass', interpreted as a range of alloys comprising various ratios of copper and zinc with small additional elements, has always been, and remains, a very significant brazing feedstock, particularly in the economical and strong bonding of steels.

Not so long ago, outside of specialist applications such as jewellery, where the cost of silver and gold alloys has always been acceptable since the components to be joined were also precious metals, 50/50 brass was 'Hobson's Choice' for general industrial usage.

Technological demands, however, led the almost 200-year-old Johnson Matthey company to form its Metal Joining business 70 years ago, developing both the sophisticated range of some 200 thoroughly proven formulations comprising ingredients:
……….silver, gold, palladium, nickel, copper, zinc, cadmium, indium, tin and, in some cases, traces of silicon……….. also the parallel development of equally complex chemical fluxes, without which the process would not work.

Adding Technique to Technology - The Experts

At Johnson Matthey, as one can imagine in a company with probably the longest history of precious metal refining, metallurgy rules. As each technological challenge arises, the resources are at hand to create solutions. The company's informative house magazine 'Assay', so named as a reflection that Johnson Matthey were appointed 'assay' to the Bank of England in 1852, regales the reader with updates on manufacturing achievements by the Group employing around 8000 people world-wide in such high-tech and advanced areas as:

- machined micro-miniature tubes and medical implant components almost too small to find
- fuel cell developments for automotive and other applications
- nanotechnology, combinations of atoms or molecules in small clusters, each around one billionth (1/1,000,000,000) of a metre in size, exhibiting unique properties in science, medicine and advanced applications such as colour pigments and catalysis
- non-polluting recovery of precious metals from the hydrocarbon matrix of catalytic converters without incineration
- natural gas-to-liquid GTL processes in preparation for when the oil supplies of the world become increasingly exhausted.

In the UK, heading up the technical team at the 25 strong Metal Joining business, Jack Willingham, Manager – Quality and Technical Service comments:

"We cover both soldering and brazing, the only difference being the temperature level of the melt. Above 450^{o}C is termed brazing, below this level it is soldering but the principles and techniques are identical. Both techniques often represent the best way of joining metals.

We are also well versed in welding technology, mechanical joining and adhesive techniques so we are in a position to advise on the relative advantages should an alternative be appropriate.

In brazing applications, however, there are some strict rules to follow. It is a common belief that the flux is a cleaning agent, and this is not the case. Oily or contaminated surfaces will not braze satisfactorily. Such contamination will, in fact, prevent the flux from performing its only function, which is to prevent or reduce surface oxidation.

Specifically also, in the case of joining the brasses by brazing, it is the low lead or lead free brasses that produce the best result. Any constituent in a parent component that can melt or evaporate below the melt temperature of the filler is bad news to brazing. Free machining brass should not be brazed for this reason; the component should be manufactured in the correct alloy for the application.

For joining brass and copper alloys it is the silver-based alloys that perform best. There is a further misconception here on the issue of cost and we find that the three factors below tend to balance, making silver brazing both technically attractive and entirely economical:

1. The quantity of filler material needed is very small indeed.
2. The ratio of '*cost of filler vs. overall cost of preparing and making the joint'* is wide making the filler material cost minimal.
3. To skimp on the silver is to degrade the product and, since such joints are usually performance critical to the function and longevity of the product or component, to use a cheaper filler material is false economy.

Further up the temperature scale the brass-based alloys themselves, used as filler materials, display remarkable gap-filling ability. For example, tubular steel structures can be manufactured to less critical tolerances on dimension and ovality and still form acceptably sound joints on brazing, reliant on the strength of the brass itself.

We address hundreds of new applications a year and our advisory/trouble-shooting service is available free of charge to customers and designers alike. We are best used as consultants at the design stage, before the client hits difficulty due to lack of knowledge or experience with metal joining.

With a comprehensive range of products and a wealth of archived knowledge to back up the technical team in the field, we enjoy exploring new markets and applications for brazing. It is an elegant and effective process.

Whether the case is an industrial mass production line or a craftsman with a propane torch and high hopes, we like to think we can make that 'magic moment' happen."

Need to Know More?

Copper Development Association holds several seminars each year on the theme "Brass in focus". Key speakers include Phil Webb of Johnson Matthey, an expert on industrial applications, who covers the techniques and materials of silver brazing in full detail.

Every aspect of design and production in brass from casting, hot stamping, extrusion, investment casting, through to surface finishes, for decorative or protection purposes, is addressed by industry specialists and leading producers.

Covered for the first time in this year's series is the novel development of 'melt overflow' a unique method of producing fine fibres for a variety of applications.

These events, which include a buffet lunch, are free of charge and qualify for CPD. Delegates wishing to attend are advised to book early. For details of seminar programmes and venues and to register visit http://www.brass.org/News/Training/seminars.htm

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Fig 1

Brazing filler added manually.

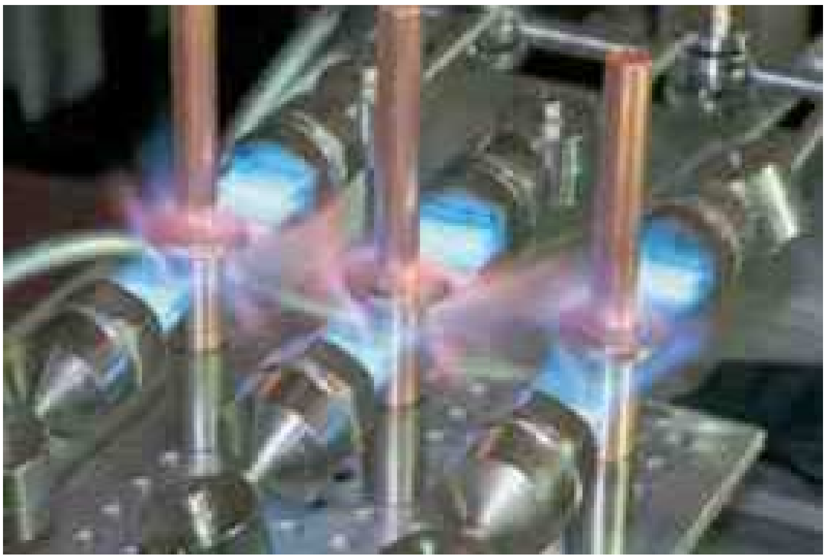

Fig 2

Filler pre-loaded in the exact quantity as a paste to parts of an ornate shower assembly

…………ends.

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