Introduction of Low Cadmium Brazing Alloys

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ABSTRACT

Silver brazing alloys are generally divided in TWO categories, one with Cadmium where Cadmium contain is about 18 to 24% & other without Cadmium. In India, the practice was to use Cadmium Containing alloys, however, in order to comply with RoHS directives, many industries shifted for without Cadmium alloys. In this case either they have to increase Silver percentage to match the melting range with there existing alloys or train operators to work with high melting range without Cadmium alloys of same silver percentage. For such industries we have designed an alloy with Cadmium percentage of 2 to 4% which is much less toxic. This alloy worked extremely good as far as flow & wet ability was concern. Some companies, who do not have RoHS constraints have even adopted these alloys for regular brazing, as ill effects of Cadmium is reduced drastically. From the manufacturing point, these alloys can be hot rolled, unlike without Cadmium alloys and gives faster production rates. They melt at moderate temperatures and it becomes extremely easy to switch from high Cadmium alloys to without Cadmium alloys by using these as step or practice alloys to smoothen the process of change over.

INTRODUCTION

It was earlier in 1987, while working on Continuous casting proect[1], some Low Cadmium alloys, were cast through Continuous Casting Route. As high Cadmium boils off, it was decided to make Low cadmium alloys[2]. Alloys were designed with the help of Tertiary diagram[3] of Copper -Silver Zinc & Silver-Cadmium-Tin, Both Tin & Cadmium were kept in small percentages like 0.5 to 2% and 2 to 5% respectively. Studies were conducted from Fluidity & Diffusivity point[4] to establish Brazing alloy character in the newly made alloys. However, when European commission in 2002 declared ban on Cadmium alloys a major drive was taken up to establish a right kind of alloy which can be commercially viable as well as technically proven to match required brazing standards.

The reason for this drive was cost effectiveness, especially in Indian market. Since people were using 30% or 40% silver alloys, in order to match the same melting range in without Cadmium alloy it was required to have a parallel alloy of 38 to 40% (like LAg40Sn) silver or 46% to 55% (like LAg55Sn) silver or higher & still could not bring down melting point in range of 630C to 650C. Also it is necessary to use ample flux, like in the form of pre fluxing for better results, which may require additional man power or extra time, both are scarce for higher production units.

EXPERIMENTAL PROCEDURE

Brazing alloys with 40% Silver & 30% silver were chosen and named as SILLOY 40 LCD & SILLOY 30 LCD

Brazing Alloys were made using cold mould castings & also billets were made followed by Extrusion. Some samples were made using Continuous casting, however, longer hold in crucible, reduced Cadmium in the alloy, hence those CC Cast samples were rejected.

In order to establish Diffusivity of alloy, Copper / Brass / Mild Steel boats were made, specific amount of brazing alloy was kept on it with thermocouple embedded within the boat and it was kept in oven at desired temperature or tested over flame like we do in wet-ability test.

Flow test of the brazing alloy on parent metal was also tested and metallo-graphic study was done to see diffusivity.

SILMUX (T series) Flux was used in above brazing trials, which are standard fluxes available in India. These fluxes were well suited for Mild Steel, Copper &

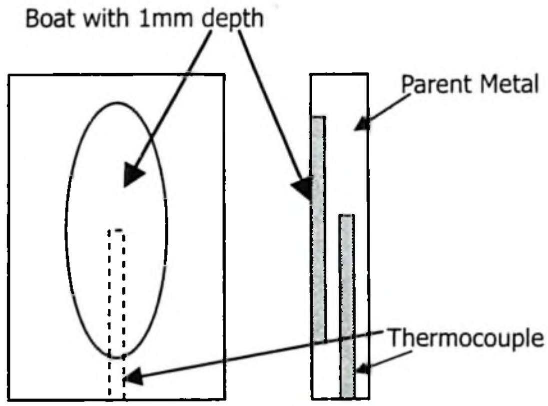

Fig. 1 Schematics of test boat.

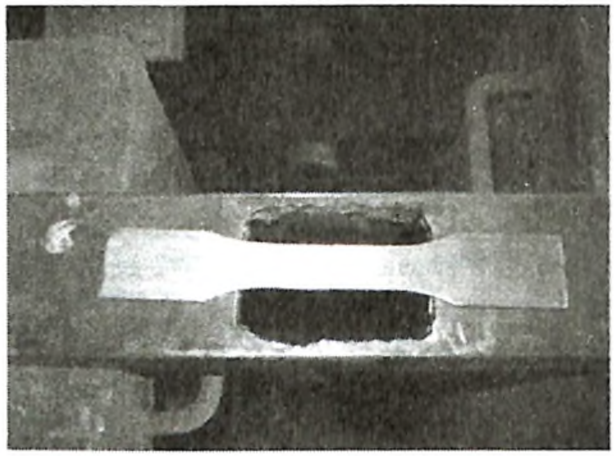

Fig. 3 : Tensile specimen with two different parent metal before brazing.

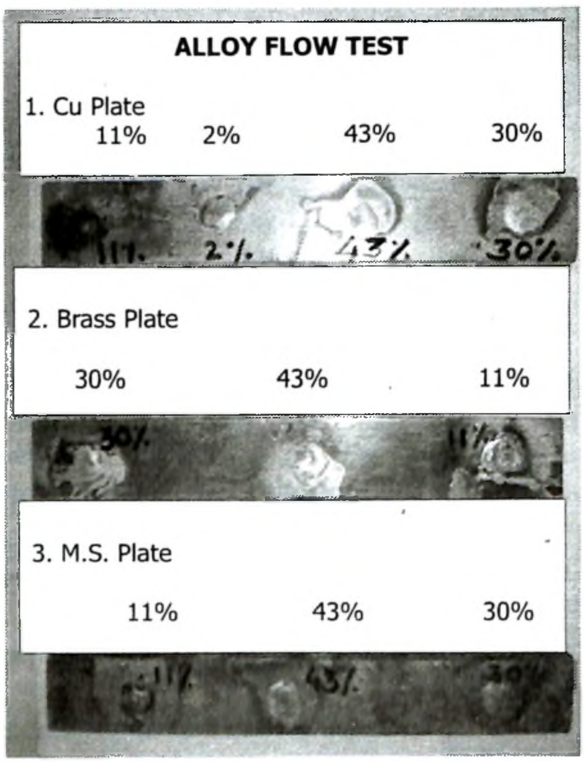

Fig. 2 : Flor test of Brazing alloy on different parent metals

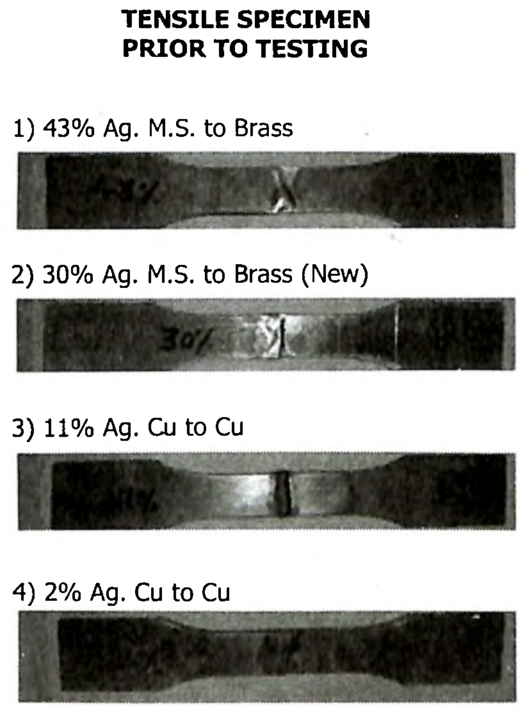

Fig. 4 : Brazed tensile specimen before testing

Brass brazing for Silver alloy & for Copper Phosphorous alloys.

Tensile as well as Impact test piece samples were made and brazed in pairs like Copper-Copper, Copper-Brass, Copper-Mild Steel, Mild Steel Brass, Mild Steel -Mild Steel.

RESULTS AND DISCUSSION

In all cases it was found that the Brazing alloys SILLOY 40 LCD & SILLOY 30 LCD are extremely well behaved for hot rolling as well as cold rolling giving near about 10 to 13% reduction in each pass & requires attending after such 3 passes.

Alloys were drawn to 2 mm & 1.6 mm sizes and were made in forms of rods as well as rings.

Brazed samples were then tested metallographic way to see the diffusion of brazing alloy in parent metal.

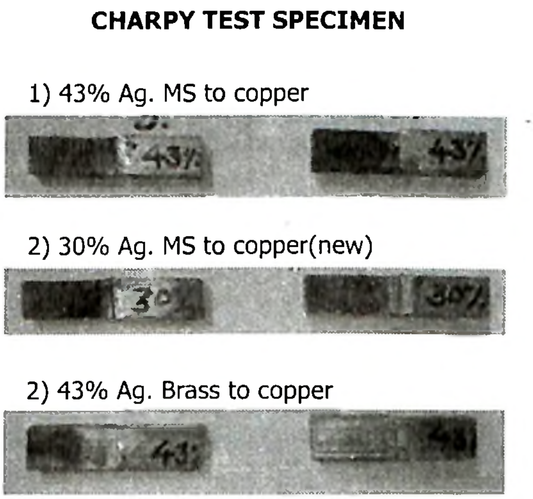

Fig. 5 : Brazed impact - Charpy Test Samples

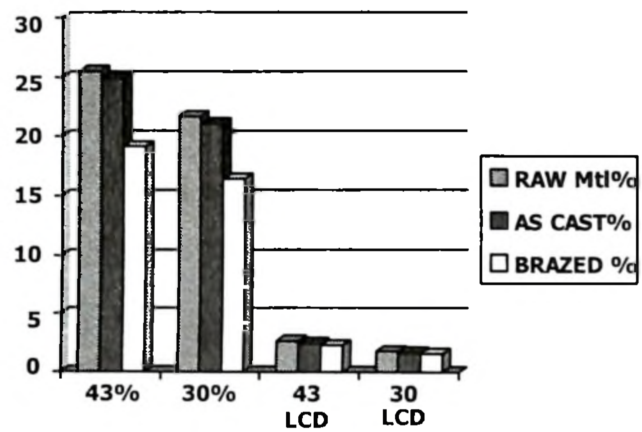

Fig. 7 : Variation in Cd% in alloy during three stages (a) In Raw material form (b) After casting in billet (c) After brazing

Fig. 6. Diffusion Boundary

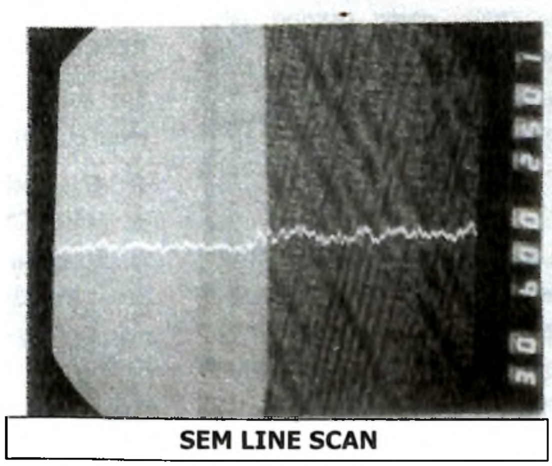

Fig. 8 : SEM line scan across joint showing difusion of Copper in Mild Steel

Tensile test pieces and impact test pieces were also made and checked for bond strength results. It was observed that in case of SILLOY 43 Tensile/Shear strength is almost 400/155 N/mm2 and for SILLOY 43 LCD, it is 460/155 N/mm2. In case of SILLOY 30 same was observed as 525/155 N/mm2 and for SILLOY 30 LCD it was 500/145 N/mm2.

Experiments on Boat showed that alloys are melting within the range of 650C to 720C for SILLOY 40 LCD and680C to 750C for SILLOY 30 LCD, which is lower temperature range than No Cadmium alloys, but slightly higher than Cadmium containing alloys.

Atomic absorption analysis[5,6] of residual Cadmium showed that loss of cadmium in case of low Cadmium alloy is far less than regular high cadmium alloys, by almost 60%. It was found that alloy having as cast 24.9% cadmium in case of SILLOY 43 alloy has residual cadmium of 19.1 (loss of 23.29%) as compared with Low Cadmium alloy SILLOY 43 LCD having 2.5% is having 2.3% as residual Cadmium (loss of 8%). Similarly 30% silver brazing alloy (SILLOY 30) having 21.1% Cd is having residual as 16.4% (loss of 22.27%), where as SILLOY 30 LCD is having 1.7% and it is residual Cadmium after brazing is 1.6% (loss of 5.88%).

Fuming and air sampling of the brazed area also showed almost 70 to 80% reduction in fuming of toxic Cadmium Oxide and with better ventilation they were controlled within limit of 0.05 mg/m3.

Trial at some refrigeratin industry revealed that operators were extremely comfortable using these LCD alloys, as compared to shift from with Cadmium to without Cadmium, with same Silver percent and brazing time or tack time difference was of almost 1.5 sec more than their regular SILLOY 30 (with Cadmium alloy) almost same was observed for SILLOY 40 LCD.

CONCLUSION

Introduction of Tin & Cadmium together does behave well. It probably reduces fuming of Cadmium and also lowers the melting point.

The study showed that it is possible to use this Low cadmium brazing alloys for regular production without any issues, as the brazing joints produced by this are equally good and within acceptable limit. However, as some Cadmium does goes out as a part of fumes during brazing operation, although very low in concentration, but it does require good exhaust system in order to comply with RoHS requirements.

These alloys can also work as intermediate alloys during change over from high Cadmium alloys to No Cadmium alloy.

ACKNOWLEDGEMENTS AND REFERENCES

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BIOGRAPHY

Author has done his M.Phil from Dundee Institute of Technology, Scotland in 1991 and was recipient of SERC & SED scholarships. During his research on Bimetallic Composites of Precious Metals with Rautomead & Johnson Matthy jewelry section, he did extensive study on diffusivity of brazing alloys and worked on many continuous casting projects. After his return to India, besides working as Brazing Consultant, he also introduced many new brazing alloys and fluxes to Indian Industry, especially refrigeration, tools and automobile. He is recipient of many prestigious awards and is also socially active through Rotary and other SSI associations.