Development of low silver content brazing filler metal

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Silver based brazing filler metals have been used in a wide range of fields as the easiest brazing material. Therefore, the type of silver brazing filler metals is the largest among brazing filler metal. In recent years, ISO Ag156 has been the most widely used silver based brazing filler metal with low melting point and easy to use since the use of Cd was prohibited from environmental problems. However, silver based brazing filler metals have become expensive brazing filler metal due to price increase of silver compared to before, so that low price brazing filler metal containing less silver becomes market demand. In this study, brazing filler metal with 40wt% of silver content and below 700 degrees C of melting point was developed.

1 Introduction

Silver based brazing filler metals have a relatively low melting point, excellent workability and excellent brazing characteristics, so it is widely used among a number of brazing filler metals. In particular, silver based brazing filler metal containing Cd represented by BAg-1 (Ag345) has been widely used in general because it has low melting point, excellent wet and flow characteristics and strong joint strength. However, in recent years the use of Cd has been restricted due to environmental problems. The silver brazing filler metals containing Cd are almost not used except for a part of military purpose. Currently, BAg-7 (Ag156) having a relatively low melting point is the most widely used silver brazing material not containing Cd.

BAg-7 has relatively low brazeability compared to BAg-1, but it is the most excellent in brazability in existing Cd -free silver brazing filler metals. On the other hand, the price of silver has increased about four times as compared with the mid-1990s, and the price is still high at present, so silver brazing filler metals are recognized as expensive material. Nevertheless, although silver brazing filler metals have been used for many products due to its excellent properties, the price of the brazing material itself affects the product price. For this reason, a brazing material has same performance as silver based brazing filler metal and low price are required in the market.

In this research, we developed a silver based brazing filler metal which contains 40wt% of Ag for low price material and which has similar brazing characteristics as BAg-7.

Considering the actual work, we developed new brazing filler metal has the melting point of 700 degrees C or lower and the liquidus/solidus temperature range is as narrow as possible.

2 Experimental Procedures

2.1 Alloy Design and Development

As a goal of brazing material design and development, the silver content is 40wt% or less, the melting point is 700 degrees C or less, the range of liquidus/solidus temperature ΔT is 50 degrees C or less, and sufficient processability in actual brazing filler metal production.

2.2 Wet and Spreading Test

Brass (C2801P), carbon steel (SS400), oxygen free copper (C1020P) were selected as a base material for the wet and spreading test. The shape of specimen had a shape of 40 x 30 x 1 (mm). 0.1 g of brazing filler metal was set at the center of the test piece, an appropriate amount of flux (TB-610) was applied and heated from the back of the plate with a torch. Figure 1 shows the appearance of the wet spreading test. The heating time was preliminarily measured on each base metal and heated to 750 degrees C. The wet spreading area was measured, and the wet and spreadability of each base metal was evaluated. The new brazing filler metal was compared with BAg-7.

Figure 1 The appearance of the wet spreading test

2.3 Mechanical Testing

The joint strength was evaluated by tensile shear test. Tensile shear strength test was conducted using JIS Z 3192 No. 3 test piece. Schematic diagram of the shear strength test piece is shown in Figure 2. The crosshead speed was set to 1.5 mm/mm, and the test was performed at room temperature.
Brass (C2801P), carbon steel (SS400), oxygen free copper (C1020P) were selected as a base material for the tensile shear strength test. A tungsten wire of 100μm was sandwiched between the joints of the test piece, and the gaps at the joints were controlled. The overlap margin of the test piece was fixed at 2 mm. Amount of the brazing filler metal was fixed at 0.1g and an appropriate amount of flux (TB-610) was applied and heated with a torch.

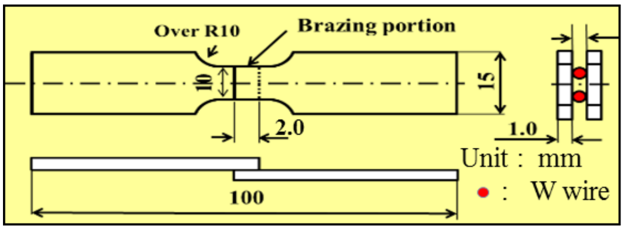


Figure 2 Schematic diagram of tensile shear test piece

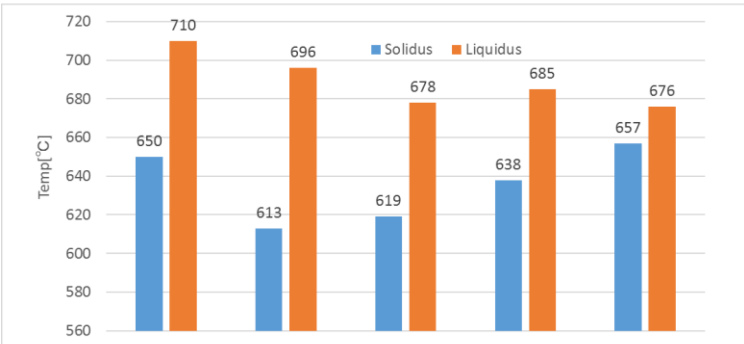
2.4 Microstructural Observation

Cross-section of the brazed joints was observed by optical microscope. Elemental distributions at the brazed joint were analyzed by electron probe micro analyzer (EPMA) examinations.

3 Results and Discussions

3.1 Composition of Developed Brazing Filler Metal

In order to reduce the silver content to 40wt%, we attempted to lower the melting point by increasing the amount of Sn added based on the composition of BAg-28 (Ag140) which is Ag-Cu-Zn-Sn system. As a result, the liquidus temperature became lower than 700 degrees C, but the liquidus/solidus temperature range became wider. Therefore, by adding additive elements to this system, attempting to narrow the liquidus/solidus temperature range and keep the liquidus temperature at 700 degrees C or lower. Mn and Ni were selected as additive elements. By adding Mn, the liquidus/solidus temperature range became narrow. Then by adding Ni, the solidus temperature was increased, and the liquidus/solidus temperature range became narrower. However, since the workability in brazing filer metal production was poor, the compositions of this Ag-Cu-Zn-Mn-Ni-Sn system was modified. Finally, the composition of 40Ag-26Cu-23Zn-5Mn-4Ni-2Sn was obtained. Figure 1 shows development history of new brazing filler metal, liquidus and solidus temperature, and its liquidus/solidus temperature range.

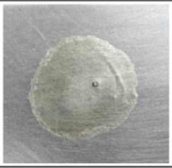
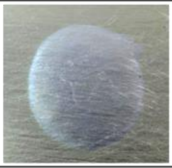
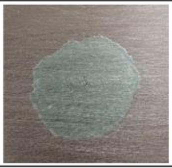


Δt	60℃	83℃	59℃	47℃	19℃
Ag	40	40	40	40	40
Cu	30	25	25	23	26
Zn	28	30	24	25	23
Sn	2	5	6	5	2
Mn	-	-	5	5	5
Ni	-	-		2	4

Figure 3 Development history of new brazing filler metal, liquidus and solidus temperature, and its liquidus/solidus temperature range

3.2 Result of Wet and Spreading Test

The results of the wet and spreading test are shown in Figure 4. The new brazing filler metal exhibited a constant wetting and spread to each base metal. In particular, it showed excellent wetting and spreadability to carbon steel. Comparing the wet spreadability with BAg-7, the new brazing filler metal showed excellent wet and spreading properties to carbon steel. On the other hand, it was found that the wetting and spreadability to brass and copper was relatively poor.

Base Metal	Brass	Carbon steel	Cu
New brazing alloy			
Spread area	122.9 mm²	148.5 mm²	118.2 mm²
BAg-7			
Spread area	234.8 mm²	114.9 mm²	148.5 mm²

5mm

Figure 4 The results of the wet and spreading test

3.3 Result of Tensile Shear Test

The tensile shear strength test results of the new brazing filler metal are shown in figure 5. Compared with the test result of BAg-7, almost equal strength was obtained in each base metal.

Figure 6 shows fracture position of each brazing filler metal on each base metal. As a result of microstructure observation at the cross-section of brazed joint after the strength test, it was found that the fracture of the brass joint by the new brazing filler metal occurred in the center of the brazing filler metal layer. On the other hand, it was found that the fracture occurred in the brazing layer near base metal at interface in BAg-7. It was understood that the fracture position was different between new brazing filler metals and BAg-7. The fracture position of carbon steel joint was in the brazing layer near base metal at interface both new brazing filler metal and BAg-7. All test specimens made of copper broke at the base metal.

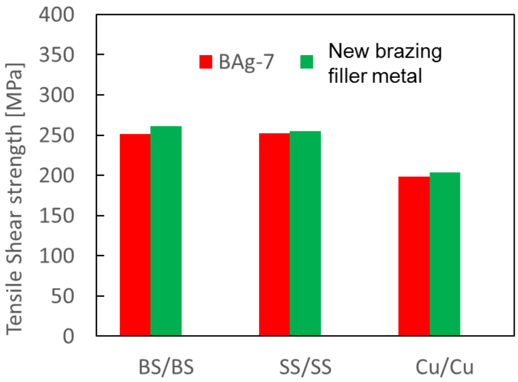


Figure 5 Tensile shear test results

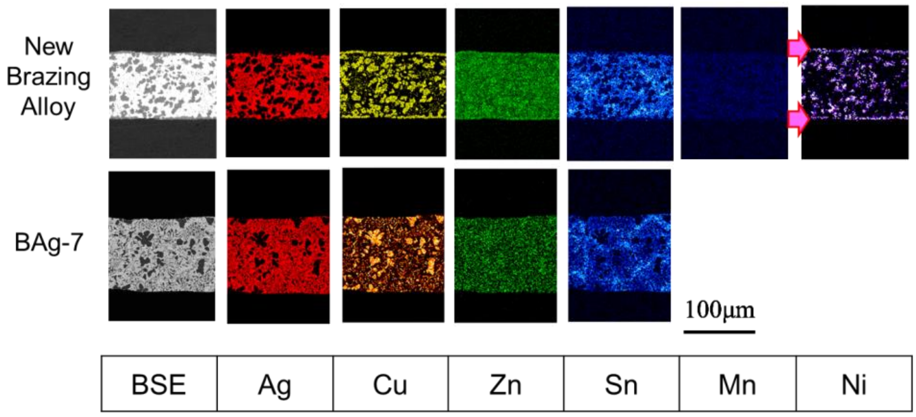
Base Metal	Brazing Alloy	Fracture
BS/BS	New Brazing Alloy	In the middle of brazing alloy layer
	BAg-7	Brazing layer near base metal at interface
SS400/SS400	New Brazing Alloy	Brazing layer near base metal at interface
	BAg-7	
Cu/Cu	New Brazing Alloy	Base metal
	BAg-7	

Figure 6 Fracture position of each brazing filler metal on each base metal.

3.4 Microstructure

As a result of observation of the cross-section of the joint, sound brazing joint without defects such as voids in the brazing filler metal layer was obtained in each base metal. In the new brazing filler metal joint, intermetallic compound layer composed of Cu and Zn was observed at the interface between the base material and the brazing filler metal layer. This compound layer was not observed in BAg-7. SEM image of the joint interface at carbon steel and the EPMA analysis results of each element were shown in Figure 7. Compared with BAg-7, the new brazing filler metal showed particularly good for wetting with carbon steel. The addition of Ni to the new brazing filler metal is the main reason for improving the wettability to carbon steel.

From the EPMA analysis results, Ni rich layer was found at the interface and it was considered to be a compound layer of α-Cu(Zn, Ni).



4 Conclusions

By adding Mn and Ni to Ag-Cu-Zn-Sn system, it was successfully developed new brazing filler metal which is Cd free, Ag content of 40wt%, the liquidus temperature below 700 degrees C, the range of liquidus/solidus temperature ΔT is 19 degrees C and capable of mass production of plastic working.

The new brazing filler metal exhibited a constant wetting and spread to brass, carbon steel and copper. In particular, it showed excellent wetting and spreadability to carbon steel. But compared to BAg-7, the new brazing filler metal showed relatively poor wetting and spreadability to brass and copper.

By adding Ni and Mn improve wetting and spreadability to carbon steel.

Joint strength by tensile shear test showed excellent results which is almost the same as BAg-7.