

SPC-1 Thin Copper late Brazing by using Cu-P-Ni-Sn Brazing Filler Metal Foil
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Introduction

The radiator for the car was previously made of copper and/or copper alloy, because of good electric conductivity, good heat conductivity and good cost-effectiveness. Afterward, copper radiator was been converted to aluminum radiator, because of lightweight. In recent years, copper radiators have received again much attention, because of downsizing and excellent cost-effectiveness as compared with aluminum radiator.

In this case, copper and / or copper alloy are brazed by using Cu-P brazing filler metal to fabricate copper radiators for the car. So that braze-ability of Cu-P brazing filler metal influenced the performance of the product. Homogeneous Cu-P brazing filler metal foil was produced by using rapidly solidification technology because of liquation of Cu-P brazing filler metal containing Sn, which is melting point depressing element.

In this study, braze-ability of new type Cu-P brazing filler metal foil and conventional Cu-P brazing filler metal to copper was investigated by fabricating copper radiators for the car.

Procedures

Base metal and brazing filler metal

Thin pure copper plate was employed as base metal and a few kinds of Cu-P brazing filler metal (foil and wire) was used in this study. Thin pure copper plate size was 30mm length and 10mm width. And thickness of plate was 0.5mm, 1.0mm or 1.5mm. Chemical compositions and temperature characteristic of the brazing filler metal were shown in Table 1. Braze-ability of new type Cu-P brazing filler metal was estimated by mechanical properties and cross-sectional microstructures at the brazed joint.

Table 1. Chemical composition and temperature characteristic of filler metal

Filler metal	Chemical composition (mass%)					Solidus Temperature □□□	Liquidus Temperature □□□
	Cu	Ni	Sn	P	Ag		
MBF2005	Bal.	5.7	9.7	7.0	—	591	643
BCuP-2	Bal.	—	—	7.0	—	705	805
BCuP-3	Bal.	—	—	6.0	5.0	640	805
BCuP-5	Bal.	—	—	5.0	15.0	640	805

Single lap specimen

Mechanical properties of bonded specimens were tested using procedures similar to those recommended in ANSI/AWS C3.2-92R specification for the single lap type joint configuration. The specimen was tested in a standard tensile test machine and the crosshead speed was made to be 1mm/min. Schematic diagram of the specimen is shown in Fig. 1. The same type specimens were also used to prepare metallographic specimens.

According to ANSI/AWS C3.2 specification, after testing, for each specimen, the joint shear strength in the bonded layer at failure was computed using equation (1).

$$\text{Joint shear strength} = \text{Breaking load} / (A \times W) \quad (1)$$

And the joint shear strength in the bonded layer at base metal was computed using equation (2).

$$\text{Joint tensile strength} = \text{Breaking load} / (W \times T) \quad (2)$$

Cross-sectional microstructures at the bonded joint were observed by optical microscope and a field emission type scanning electron microscope (FE-SEM). Elemental distributions at the brazed joint were determined by an electron probe micro-analyzer (EPMA) and energy dispersed X-ray analyzer (EDX). Overlap ratio of joint overlap (A) to thickness (T) for the specimens was 2.00, 4.00 or 6.00. Brazing was done at 700°C and 800°C in electric heated furnace in an Ar gas atmosphere. Brazing time was 10min.

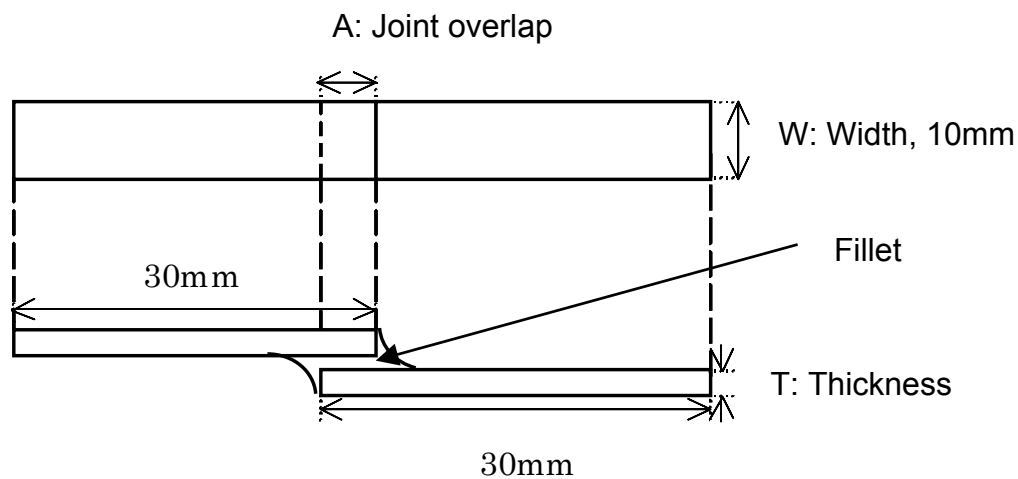


Figure 1. Schematic diagram of the single lap specimen.

Pipe on plate specimen

New type specimen for estimation of fabricating-ability of car radiator by using thin copper plate and brazing filler metal foil is proposed. Figure 2 shows the schematic diagram of the new type pipe on plate specimen. The same type specimens were also used to prepare metallographic specimens. Brazing was done at 700°C and 800°C in electric heated furnace in an Ar gas atmosphere. Brazing time was 10min. The specimen was tested in a standard tensile test machine and the crosshead speed was made to be 1mm/min.

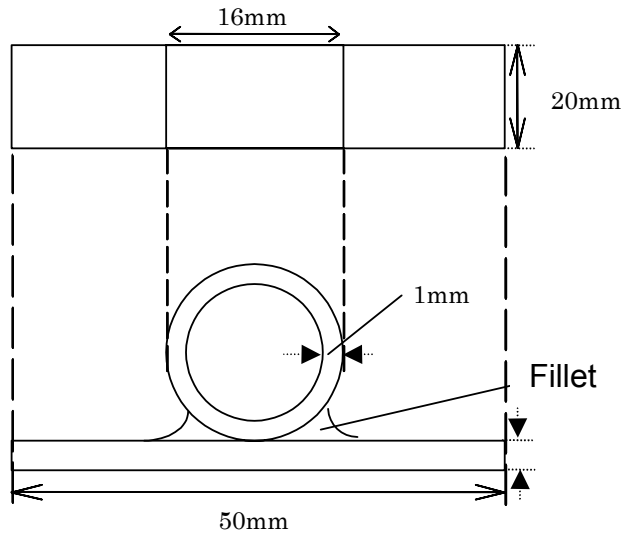


Figure 2. Schematic diagram of the pipe on plate specimen

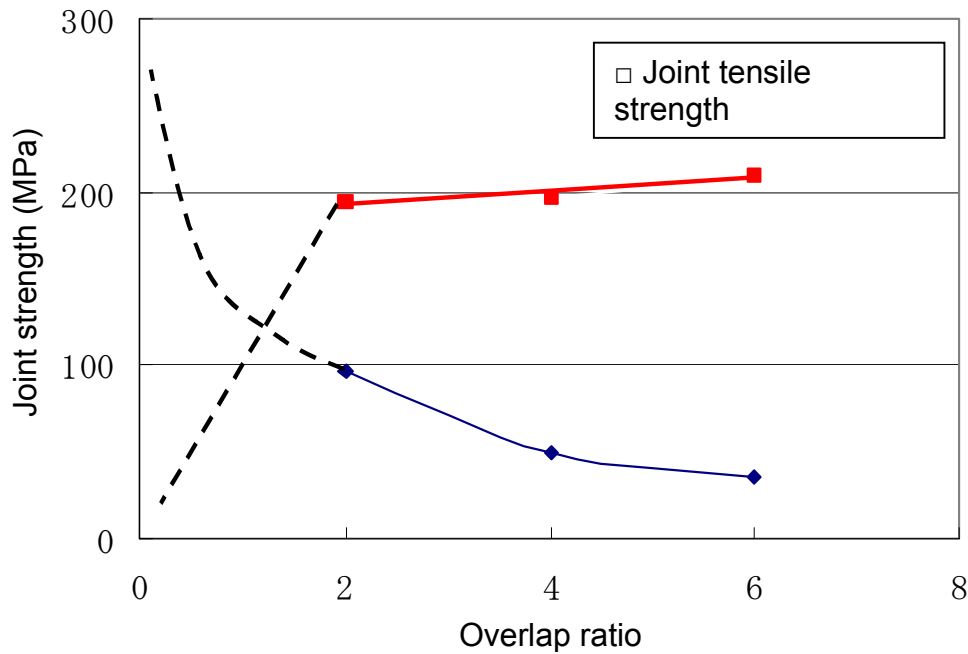


Fig. 3. Effect of overlap ratio on joint strength
Base metal (copper plate) thickness: 0.5mm
Brazing temperature: 700°C, Brazing time: 10min

Results and Discussions

Typical mechanical properties results in that case of single lap specimen were shown in Fig.3. Figure 3 shows the relationship between overlap ratio of joint overlap to thickness and joint shear strength or joint tensile strength in this case of 0.5mm thickness thin pure copper plate and 700°C brazing temperature. Other mechanical properties results were similar to this result. Joint tensile strength was increased with increasing overlap ratio of joint overlap to thickness until overlap ratio 2.0 and joint tensile strength was almost unchanged above 2.0. Above 2.0, fracture of the specimen

during mechanical testing occurred at the base metal and the fillet area as shown in Fig.4. It appeared that joint tensile strength was almost unchanged above 2.0 because fracture area contained base metal.

According to these mechanical properties results, fillet size influenced hardly joint strength. And brazing temperature influenced hardly joint strength in that case of 0.5 and 1.0 mm thickness. On the other hand, joint strength was increased slightly with increasing brazing temperature in that case of 1.5 mm thickness.

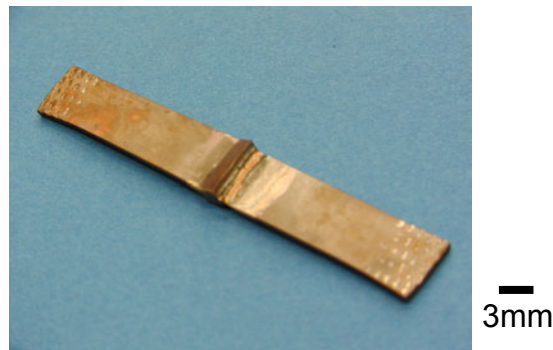


Figure 4. Typical specimen appearance after tensile shear test

Figure 5 showed the typical cross-sectional microstructure at the brazed joint brazed by MBF2005 brazing filler metal foil for 10min at 800°C in that case of 0.5mm copper plate thickness. According to Fig. 5, it was recognized that excellent brazed joint was obtained because of homogeneous microstructure and no void & crack at the brazed joint and no liquation of Cu-P brazing filler metal.

Figure 6 showed the elemental distributions at the brazed joint because the fracture of the specimen during mechanical testing occurred at the base metal and the fillet area as shown in Fig.4. According to area 1, 2 and 5 analytical results at Fig. 6, it appeared that Cu solid solution containing Sn mainly was formed at the fillet and formation of the Cu solid solution influenced mechanical properties at the brazed joint by using MBF2005 brazing filler metal foil.

It was recognized that estimation of fabricating-ability of car radiator by using thin copper plate and brazing filler metal foil was possible through use of the pipe on plate specimen. Cross-sectional microstructure at the brazed joint in that case of the pipe on plate specimen was similar to the single lap specimen.

Conclusions

1. Good thin copper plate brazed joint made by Cu-5.7Ni-9.7Sn-7.0P brazing filler metal foil (MBF2005) for fabricating of car radiator was obtained.
2. It appeared that Cu solid solution containing Sn mainly was formed at the fillet and formation of the Cu solid solution influenced mechanical properties at the brazed joint by using MBF2005 brazing filler metal foil.
3. It was recognized that estimation of fabricating-ability of car radiator by using thin copper plate and brazing filler metal foil was possible through use of the pipe on plate specimen.

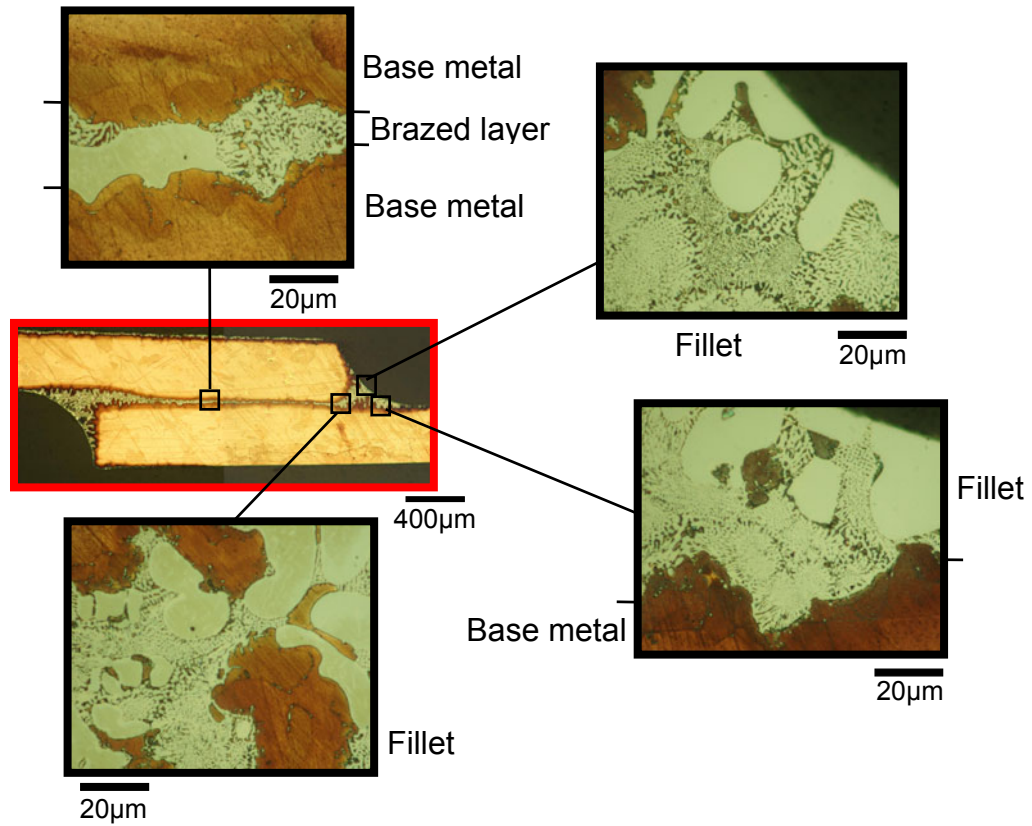


Fig. 5. Typical cross-sectional microstructure at the brazed joint
Brazing filler metal: MBF2005, Copper plate thickness: 0.5mm,
Brazing temperature: 800°C, Brazing time: 10min

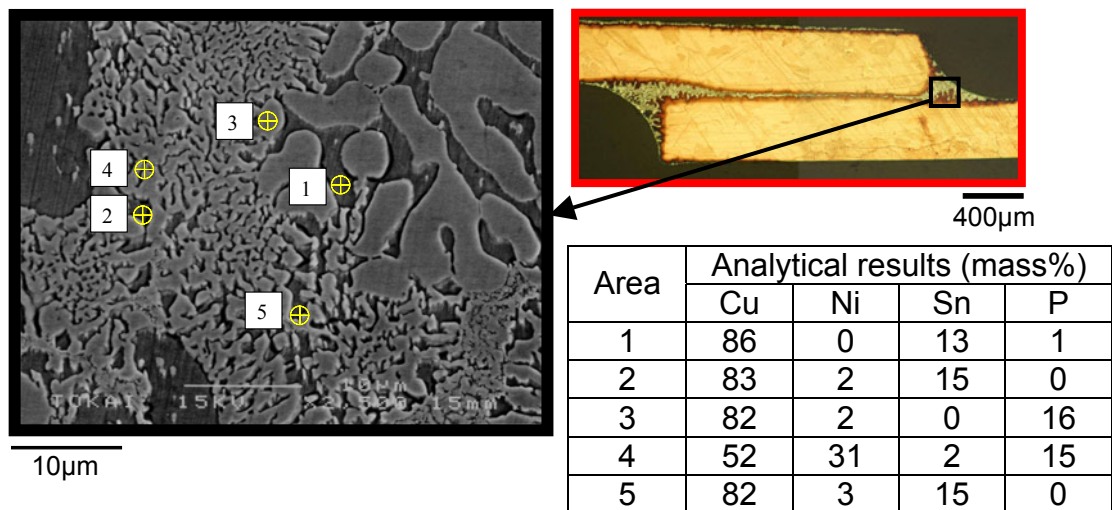


Fig. 6. Elemental distributions at the brazed joint
Brazing temperature: 800°C, Brazing time: 10min,
Copper plate thickness: 0.5mm