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Laser Brazing of Zinc-Coated Steel and Al Alloy by Ag Alloy Filler Metal

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Abstract

Dissimilar metal joint of zinc-coated steel and 6000 series Al alloy can be successfully made by a diode laser brazing process with Ag-Cu alloy brazing filler metal. Defects of cracking and porosity were not formed by optimizing the laser brazing conditions of laser power, traveling speed, laser beam diameter, laser beam offset, filler metal feed rate and shielding gas flow rate. Microstructures of the joint interfaces of braze metal at steel and Al alloy sides were evaluated by SEM with EDX. No Al-Fe brittle intermetallic compound was formed, but Al-Ag-Cu eutectic layer at Al alloy side were formed. From tensile test, fracture position of the joint occurred in the HAZ of Al alloy, which corresponded to the position with the lowest hardness in the joint.

Key words : laser brazing, aluminum, zinc coated steel, dissimilar joining, silver alloy brazing filler metal

1.Introduction

It is difficult to join steel and aluminum directory by fusion welding because of the formation of hard and brittle intermetallic compounds (IMC) at the interface . From the past study on the dissimilar metal joining of steel and aluminum among fusion methods, brazing has high potential to prevent the formation of thick IMC layer. There is increasing interest in laser brazing of steel and aluminum by filler metal of zinc-alloy

In this paper, the joining of zinc-coated steel and Al alloy sheets by laser brazing process using a Ag alloy brazing filler metal has been investigated and the joint strength was discussed associated with microstructures of the brazed joint.

2.Experimental Procedure

The materials used in this study were Al alloy A6061-T6 and zinc-coated steel GA with a thickness of 1.2mm and 1.0mm, respectively, and their chemical compositions are shown in

Table1 Chemical compositions of Al alloy zinc-coated steel.

	Chemical composition (mass%)				
Steel (GA)	C	Mn	P	S	Fe
	0.05	0.15	0.016	0.013	Bal.
Al alloy (A6061)	Si	Mg	Cu	Cr	Al
	1.04	0.57	0.01	0.01	Bal.

Table2 Laser brazing condition used.

Laser	LD(λ: 840nm)
Laser power(kW)	2.5~4.0
Wire feed rate(m/min)	1.5~2.5
Travel speed(m/min)	1.0
Shielding gas(L/min)	Ar : 15
Laser had angle	40°

Table1. As a filler wire Ag alloy brazing filler metal BAg-8 (Ag72mass%, Cu28mass%) was used. Nocolock brazing flux CsF was coated on the surface of the joint before laser brazing.

A diode laser was used for laser brazing, of which conditions are summarized in **Table2**. The specimens were brazed at a flare flange joint as shown in **Fig.1**. The mechanical properties of the laser brazed joint were evaluated by the tensile shear test.

Microstructural and chemical composition examinations were carried out using a SEM equipped with EDX detector and XRD. Vickers hardness profile was measured on the cross-section with a load of 0.49N, loading time of 15s.

3.Results and Discussions

3.1 Microstructures of brazed joint

Fig.2 shows typical photo of cross section of the resulting braze welded zone. It shows that

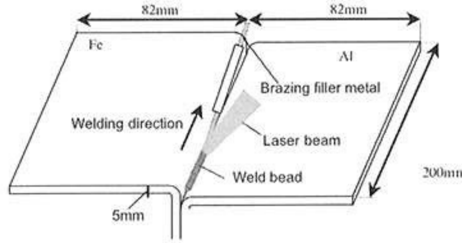

Fig.1 Schematic illustration of laser brazing setup.

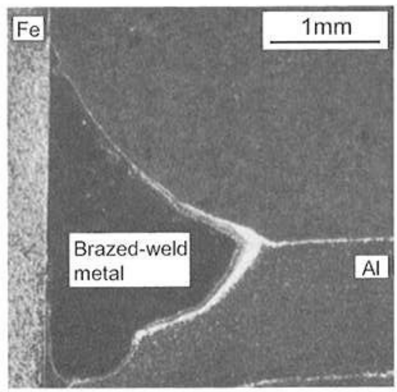

Fig.2 Microstructure on cross section of laser brazed joint.

by using Ag alloy filler metal, good brazed joint without cracking and porosity and good wettability for both base metals can be obtained at the wide condition range. Macroscopically, steel was not melted, but Al alloy was melted, and thus brazed weld metal consisted of the mixture of Ag alloy filler metal and Al alloy.

Fig.3 shows SEM image and EDX analysis of interface at steel and brazed-weld metal. No IMC layer was formed at the interface. Brazed metal contains a little aluminum due to the melting of Al alloy base metal.

SEM image and EDX analysis of the interface at Al alloy and brazed-weld metal is shown in **Fig.4**, in which Al-Ag-Cu ternary eutectic layer with comparably thick thickness of about 20~30 μm was formed at the interface. **Fig.5** shows

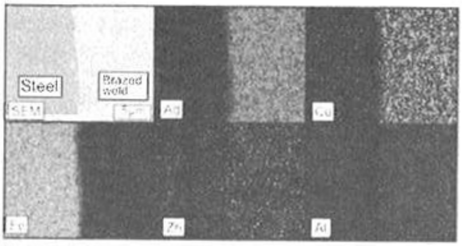

Fig.3 SEM image and EDX analysis of interface at Fe and brazed –weld metal.

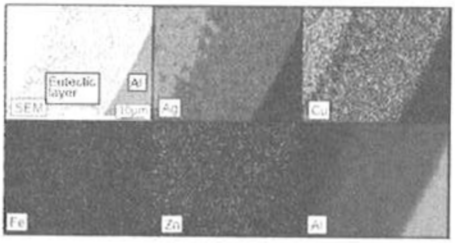

Fig.4 SEM image and EDX analysis of interface at Al and brazed-weld metal.

X-ray diffraction pattern from eutectic layer between Al alloys and brazed-weld metal. From this analysis, the eutectic layer revealed a ternary composition of αAl, Ag_2Al and Al_2Cu, which forms a lamellar structure that consisted of soft α-Al layer and hard IMC layers of Ag_2Al and Al_2Cu.

3.2 Tensile strength of brazed joint

The effect of laser power on the joint strength of laser brazed joint is shown in **Fig.6**. The joint strength decreased with increasing laser power per unit length at each filler feed rate, but increased with increasing filler feed rate. The fracture position of all the joints obtained in present paper was HAZ in Al alloy.

Fig.7 shows the hardness distribution on cross section of laser brazed joint. The hardness of the brazed weld metal is higher than the steel. In addition, the hardness of eutectic layers showed the highest hardness in the joint, about 400HV.

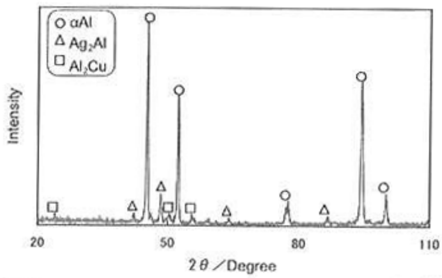

Fig.5 X-ray diffraction of Al and brazed-weld metal.

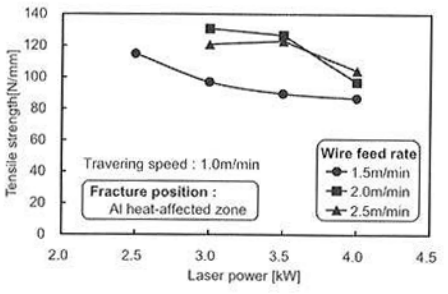

Fig.6 Tensile strength of laser braze welds.

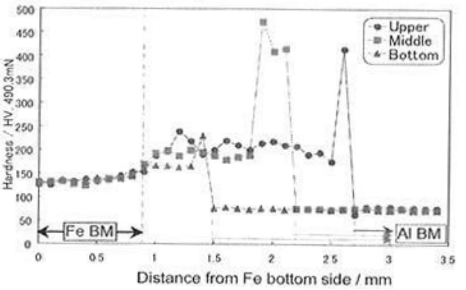

Fig.7 Hardness profiles of laser brazed welds.

On the contrary, the lowest hardness in the joint was obtained at HAZ of Al alloy, and which decreased with increasing laser power and decreasing filler wire rate. Thus, it became clear that tensile strength of the joint depended on the hardness of HAZ of Al alloy. In addition, ternary eutectic structure did not show the joint strength degradation even with relatively thick layer as reported in the case of Fe-Al IMC layer because it is considered that in the eutectic layer soft α-Al phase surrounds hard Ag_2Al and Al_2Cu phases.

4.Conclusions

In this paper, laser brazing of zinc-coated steel and Al alloy by Ag alloy filler metal was investigated. The major conclusions can be summarized as follows.

(1) Laser brazing of zinc-coated steel and Al alloy 6061-T6 by Ag-Cu alloy filler BAg-8 was conducted with variation in laser power and filler wire feed rate. From the result of tensile test, the fracture position of joints was HAZ in Al alloy due to the hardness in the joint.

(2) Ag-Cu filler metal BAg-8 showed good wettability for both base materials. From SEM, EDX and XRD analyses, no Al-Fe brittle intermetallic compound was formed at steel interface, but Al-Ag-Cu eutectic layer at Al alloy interface was formed. The ternary eutectic structure did not show the joint strength degradation even with relatively thick thickness

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