BRAZING CHARACTERISTICS BETWEEN CEMENTED CARBIDES AND STEEL USED BY AG-IN BRAZING FILLER

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ABSTRACT

As a general rule, the brazing process between cemented carbides and steel used by Silver (Ag) type brazing filler. The composition of Ag type filler were used Ag-Cu-Zn-Cd type filler mainly. But, the demand of Cadmium (Cd)-free in Ag type filler was raised recently. The reason why Cd-free in Ag brazing filler were occurred to vaporize as a CdO_2 when brazing process, because of Cd element was a most low boiling point of all Ag type filler elements. And, CdO_2 was a very harmful element for the human body. This experiment was developed Cd-freeing on Ag type filler that was used Indium (In) instead of Cd element. In this experiment, there were changed from 0 to 5% In addition in Ag brazing filler and investigated to most effective percentage of Indium.

As a result, the change of In addition instead of Cd, there was a very useful element and obtained same property only 3% In added specimens compared to Cd 19% added specimens. These specimens were obtained same or more deflective strength. In this case, there were obtained 70 MPa over strength and wide brazing temperature range 650～800℃. A factor of deflective strength were influenced by composition and the shape of β phase and between β phase and cemented carbides interface. Indium element presented as α phase and non-effective factor directly, but it's occurred to solid solution hardening as α phase. β phase were composed 84～94% Cu-Ni-Zn elements mainly. Especially, the presence of Ni element in interface was a very important factor. Influence of condensed Ni element in interface layer was increased the ductility and strength of brazing layer. Therefore, these 3% In added Ag type filler were caused to obtain a high brazing strength.

KEY WORDS

Brazing characteristics , cemented carbides , Ag-In brazing filler, Cd-freeing , β phase in interface

1. Introduction

By the problem of bonding technique between cemented carbides and steel, the difference of physical and mechanical properties on both materials were occurred and never bonded any method. Therefore, the brazing process between cemented carbides and steel used by hard soldering method mainly. This hard soldering filler was used Ag type filler as a general[1)]. The reason why this type Ag brazing filler has a low melting point, high strength of brazing part and a good fluidity compared to another brazing filler. The composition of Ag type filler were used Ag-Cu-Zn-Cd type mainly. But, the demand of Cd-free in Ag type filler was raised recently, its composition was Ag-Cu-Zn-In-Ni type filler. In present, it was used mainly Cd type filler, because of strength of brazing area, restrict of brazing operation's condition. When the heating process of Ag type filler included Cd element, Cd element was a most low boiling point and easy vaporized element. CdO_2 was a very harmful element for human body.[2)] Thus, the development of Cd-free type Ag brazing filler was a very important theme on brazing research. Role of Cd in Ag type brazing filler was obtained to lower melting point, harmless of the plastic working and a good wettability of base metal. Therefore, this type filler was a very useful filler .[2)] The purpose of this research, development of Ag type filler of non-included Cd element. But the characteristics of many properties must obtain it or more value. In this experiment, the change of In element instead of Cd were investigated. In addition percentage were changed from 0 to 5% In of Ag brazing filler and investigated to most effective percentage of In. Especially, the crystallized morphology and composition β phase (Cu+Zn+Ni+Mn) in brazing filler was investigated. Furthermore, segregated interface phase elements between cemented carbide and brazing point were investigated.

2. Experimental Procedures

Table 1 shows the chemical composition, solidus and liquidus line of Cd-free Ag brazing filler. These filler was composed Cu: 22% Zn: 25% Ni: 2% Mn: 0.7% constant and In addition was changed from 0 to 5%, corresponded to change Ag percentage. As a result, the tendency of liquidus temperature increased by added Indium element percentage, but these data were a small scattered. Cemented carbide used G-2 type on JIS standard. The composition of G2 was showed WC: 93~95% and Co: 5~7%. On the other hand, carbon steels used this test use usually shank, and S55C type steel on JIS standard. The shape of specimens was worked 45°

Table 1 Chemical compositions of silver brazing fillers

(mass%)

	Ag	Cu	Zn	In	Ni	Mn	Solidus Temp(℃)	Liquidus Temp(℃)
In 0%	50.42	22.13	24.66	0	2.17	0.62	641	646
In 1%	48.68	21.73	25.67	0.97	2.11	0.84	661	662
In 2%	48.04	21.71	25.42	2.03	2.10	0.70	655	657
In 3%	47.28	22.10	25.16	2.67	2.12	0.67	650	666
In 4%	46.13	21.84	25.16	4.18	2.07	0.62	642	649
In 5%	45.26	22.01	25.05	4.82	2.12	0.74	635	700

Ag+In=50% Cu+Zn+Ni+Mn=50%

V type groove between cemented carbide and carbon steel , because it's shape could make to increase brazing area and brazing strength.[3] Ag brazing filler was worked 0.2 ㎜ thickness as a plate, inserted to V type groove and heated till brazing temperature. In this experiment, for oxidation removal treatment of interface between cemented carbide and carbon steel was used $ZnCl_2$ type flux. This reason why Zinc was reacted O_2 in oxidation layer and diffused in the air. As a result, this flux was revealed of oxidation layer, and obtained a good fluidity.

3. Experimental results and discussions

Fig.1 shows the relation between deflective strength and brazing temperature obtained by 6 types silver brazing filler (In 0～5%). Deflective strength of non-added In specimens as a) graph were show lower tendency when brazing temperature raised. Its tendency showed the dependence of temperature. On the experimental brazing temperature, deflective strength of commercial value (70MPa over)[4] couldn't obtain. Deflective strength of 1% In added specimen as b) graph showed to obtained 70MPa value, but suitable range of brazing temperature was a limited 50K. Brazing filler of 2% In added specimens as c) graph were same

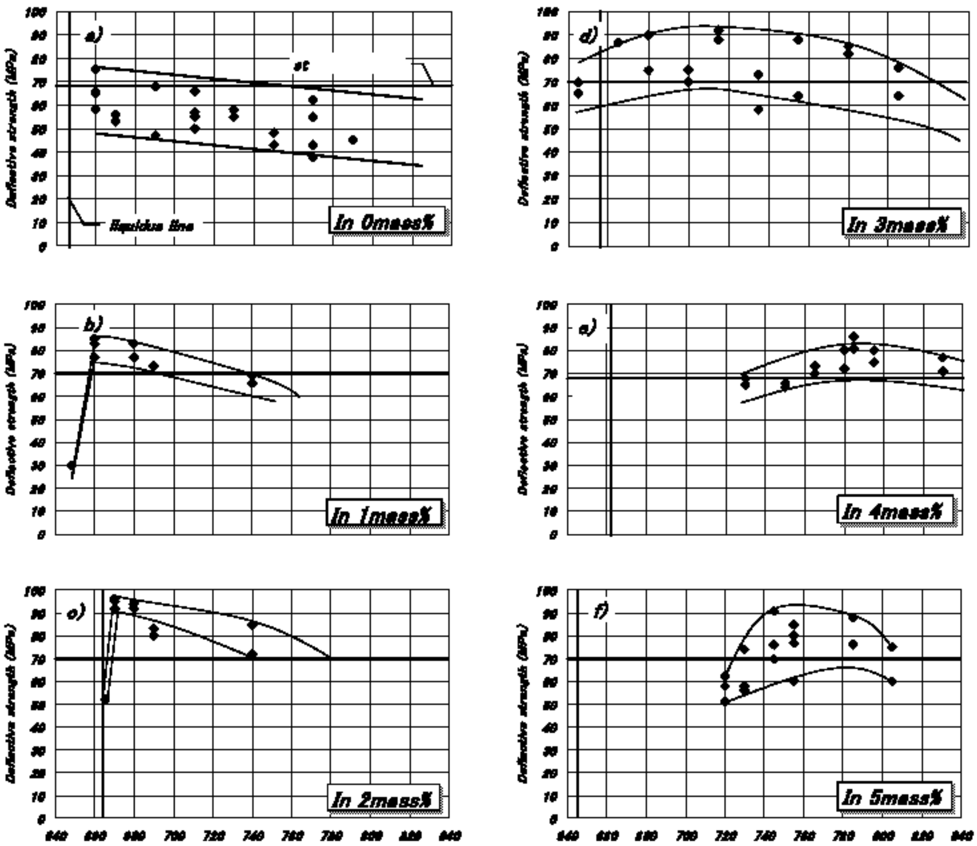

Fig.1 Relation between deflective strength and brazing temperature obtained by 6 types silver brazing filler (In addition from 0 to 5%)

tendency that compared 1% In added specimen as b) graph. c) In 2% added specimens were obtained more good deflective strength, these data were about 98MPa at 670℃ conditions. From these results, effect of In addition was a very high sensitivity but a small amount added compared Cd type filler. Especially, d) In 3% added specimens were obtained 70 MPa over value at 650~800℃ (150℃) that a very wide temperature range. e) In 4% added specimens and f) In 5% added specimens was obtained 70 MPa over too, but suitable range of brazing temperature was narrow range compared to c) specimens. Peak of deflective strength were a higher tendency of temperature leaving from liquidus line. As a result, a small added In specimens were difficult to work the brazing operation why near the liquidus line. Both 2% added specimens were obtained a best strength and 3% In added specimens were obtained a wide temperature range of 150℃ plus 70 MPa over strength, and was recognized a good brazing characteristics in this experiment.

Photo.1 shows SEM photographs of In 3% added brazing interface at 720℃ obtained by specimens after deflective test. Crack occurring position were observed cemented carbides or interface of cemented carbide and Ag brazing filler, but didn't present in carbon steel. Crack occurring reason of cemented carbides were caused a porous and brittle material. And, crack occurring reason of Ag brazing area were caused to lower strength compared both cemented carbide and carbon steel.

Photo.2 shows COMPO photograph and EPMA analysis of α phase (Ag, In and Zn) on In 3% added brazing interface at 720℃. Upper part of COMPO photograph was showed cemented carbide, center part was showed Ag brazing area, and lower part was showed carbon steel. From observation of COMPO photograph, brazing area was clearly separated between matrix (α phase) and crystallization phase (β phase). By EPMA analysis, Ag and In of solid solution were observed to present matrix. Zn element was observed both matrixand crystallization phase, but crystallization phase in Zn was rich tendency compared by matrix.

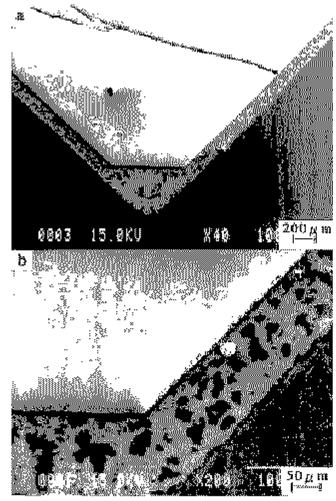

Photo.1 SEM photograph of 3% added brazing interface (720℃)

Photo.3 shows COMPO photograph and EPMA analysis of β phase (Cu, Zn and Ni) on In 3% added brazing interface at 720℃ as same as photo. 2. Crystallization phase (β phase) was observed Cu, Ni and Zn element. These 3 elements were observed to segregate and diffuse on interface of carbon steel and cemented carbide. 3% In added specimens were obtained a maximum value of deflective strength. From considering to fracture position of interface on cemented carbides and brazing area, segregated interface of the β phase were indicated to effect strongly brazing strength.

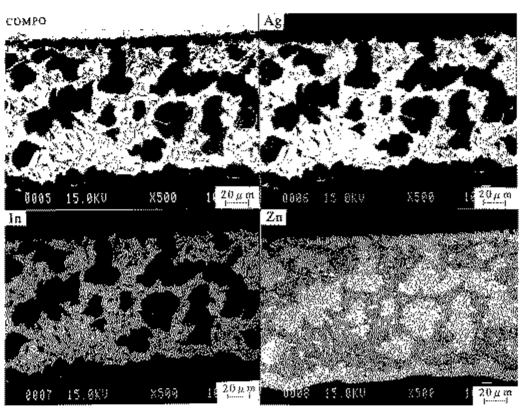

Photo.2 COMPO photograph and EPMA analysis of α-phase on In 3% added brazing interface (720℃)

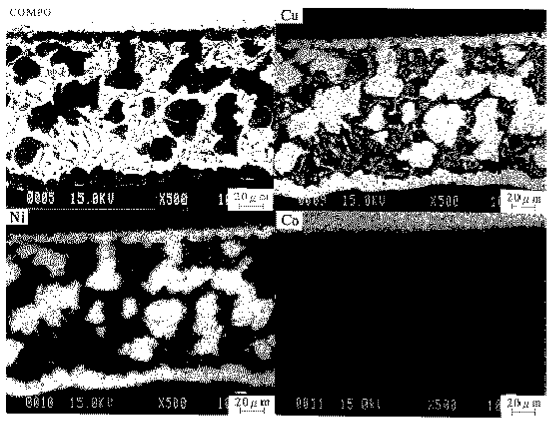

Photo.3 COMPO photograph and EPMA analysis of β-phase on In 3% added brazing interface (720℃)

Fig.2 shows the relation between In addition and each element concentration on brazing interface obtained by cracking specimen. Brazing interface area composed about same β phase compositions. Cu element analysis value was obtained maximum 50% (twice times of brazing filler composition). Zn element analysis value was obtained maximum 33% (1.3 times of brazing filler composition). Ni element analysis value was obtained maximum 8% (4 times of brazing filler composition). These elements were concentrated remarkably compared to initial brazing filler. From the results, effect of In added filler was observed a good solid solution and improve of fluidity, but deflective strength was recognized to controlling factor as a β phase.

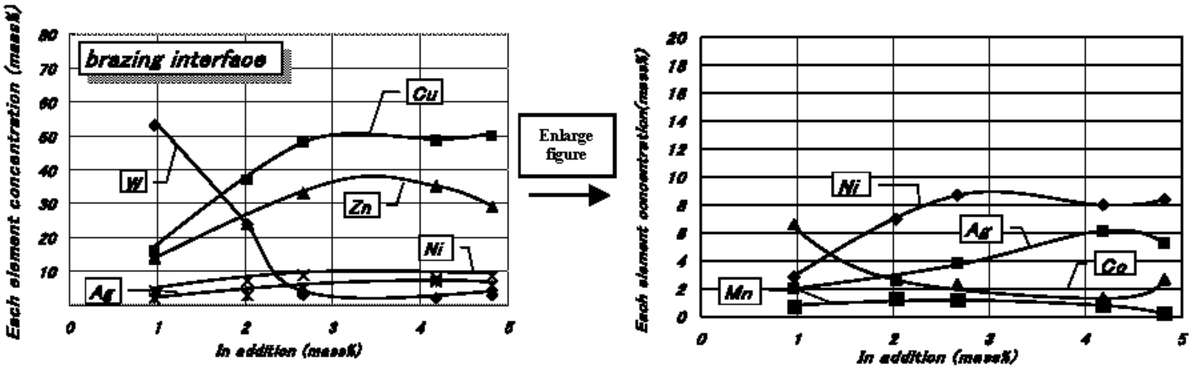

Fig.2 Relation between In addition and each element concentration on brazing filler

3. Conclusions

By the purpose of influence on Indium instead of Cadmium element by Ag brazing filler, we examined to change In addition from 0 to 5%. The behavior of best addition of Indium researched. Amount of β phase of interface and its reacted mechanism investigated too. This experiment was investigated the reaction behavior that made by new In added brazing filler. The results obtained as follows.

1) The brazing treatment between cemented carbides and S55C (carbon steel) used by trial new 6 types Ag filler changed In addition (0～5%) was examined. Brazing strength was obtained all In added specimens. As a result, there could to change In instead of Cd.

2) In 3% added brazing filler obtained the deflective strength 70 MPa over value and brazing temperature range from 650 to 800℃. This obtained result was a best value in this experiment.

3) Controlling factor of deflective strength was showed β phase of brazing area, β phase composition and morphology of interface crystallization between cemented carbides and interface. Composition of β phase was showed 84～94% Cu-Zn-Ni elements. Especially, concentrate of Ni element was influenced remarkably. Condensed Ni in the β phase, it occurred to improve the ductility of brazing area. It caused to improve the deflective strength.

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