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Corrosion of Aluminum Die-castings Jointed with Rubber

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In automobiles, a suspension bush, a set of aluminum parts connected to each other vie rubber, is mounted into the suspension members to link the body to the wheels, and realizes hard and soft mounts contributing both to the stabilization during high speed driving and to absorbing the shock from the road. However, decohesion of the aluminum part from the rubber occurs occasionally, arising from the interface corrosion of aluminum, which deteriorates the performance of the vehicle directly. In this study, effects of alloy composition and processing route on this kind of corrosion has been investigated. Low durability caused by decohesion of the joint was found in pressure-die-cast ADC12 and ADC3 alloys. In general, small amount of impurity Fe and alloying Cu tended to cause the low durability. In pressure-die-cast ADC12, large fraction of eutectic area adjacent to the surface was deduced to be the cause of the low durability.

Keywords: *Aluminum alloy, Rubber, Corrosion, Joint, Pressure-die-casting*

1. Introduction

Suspension bush where aluminum alloy is jointed with rubber is a most important component in the suspension of an automobile vehicle, and contributes to comfortable and silent riding. Although JIS-AC4CH alloy castings are being used in current suspension bushes, pressure die-castings of JIS-ADC12 is a candidate to be substituted for AC4CH for the purpose of cost reduction. The ADC12, a heat-treatable Al-Si-Cu-based alloy, accounts for 95% of the total aluminum die-casting production because of its excellent casting performance arising from the high Si content. However, preliminary durability examination under corrosive atmosphere showed that joints between the ADC12 and rubber were prone to be peeled off [1]. This might have been caused by the corrosion of the aluminum alloy. The objective of this study is to obtain fundamental knowledge on factors affecting the corrosion of the aluminum alloy jointed with rubber. Durability of some aluminum alloys jointed with rubber will be examined under corrosive atmosphere, and the results obtained will be discussed in terms of alloy composition and processing route.

2. Specimens and Experimental Procedure

Besides pressure-die-cast ADC12, five JIS alloy specimens were prepared: extruded A6N01, gravity-die-cast AC4CH and ADC12, and pressure-die-cast ADC3 and Silafont36. The manufacturing process and the composition of each sample are shown in Table 1. The A6N01 has good corrosion resistance, weldability and extrudability, and hence it is being used widely for extruded shapes with a large dimension and complicated section. The AC4CH and ADC3 are Al-Si base alloys with small addition of Mg resulting in heat-treatability, good castablity and corrosion resistance. The AC4CH is being used for most of the automotive wheels, while the production of ADC3 is limited in late years [2].

The dimension and morphology of the test piece of the aluminum alloy and the whole joint are shown in Fig. 1. The rubber used in this study is NR/BR generally used for protection against vibration. Two aluminum alloy test pieces shown in Fig. 1 (a) were wet-blasted, chemical-conversion-treated, coated with adhesive, placed into a set of dies and finally jointed with the rubber through vulcanization into the shape shown in Fig. 1(b). The whole test piece was then installed to a jig as shown in Fig. 2, which can apply tensile stress to the joints.

Table 1 Chemical composition in mass % and processing route of the specimens

Specimen	Si	Fe	Cu	Mg	Mn
A6N01/Extruded	0.64	0.27	0.23	0.46	0.02
AC4CH/GDC	8.85	0.08	0.02	0.20	0.65
ADC12/GDC/PDC	10.1	0.83	2.44	0.19	0.20
Silafont36	9.93	0.08	0.001	0.20	0.57
ADC3/PDC	7.95	0.17	0.007	0.40	0.39

GDC: Gravity-Die-Cast, PDC: Pressure-Die-Cast

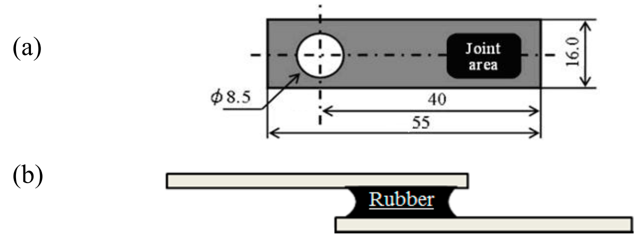

Fig.1 Morphology and dimension of the aluminum alloy test piece(a), and schematic of the joint(b).

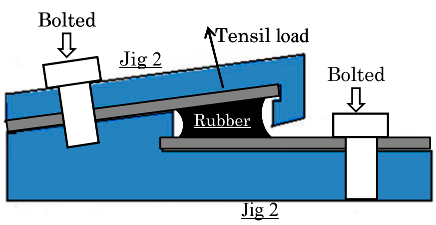

Fig. 2 Device for testing the durability of the joint under corrosive atmospheres.

Two tests, sprayed saltwater test (SST) based on JIS Z 2371 and combined cycle corrosion test (CCT) based on JIS K 5621, were carried out to examine the durability of the joints under corrosive environments. After the specimen was exposed to each environment for the scheduled time or cycle, the whole joint was divided into two aluminum alloy pieces forcibly using a tensile testing machine. The fracture occurs inside the rubbers when the adhesion remains sound and at the aluminum alloy/rubber interface when decohesion takes place. The durability was assessed with the fraction of exfoliated area with no rubber on the fracture surface. In addition, cross section near the interface was observed with an optical microscope and SEM.

3. Results and Discussion

The results obtained in the durability tests (SST and CCT) are shown in Fig. 3 as a function of Fe and Cu contents. High durability (with no decohesion) can be seen in A6N01, AC4CH, ADC3 and Silafont36 that contain about 0.2% Fe and Cu in SST at 280h, while ADC12/PDC shows serious decohesion. The ADC3 results in 80% decohesion in SST at 1000h. In CCT under 50 cycles, A6N01 shows no decohesion. The AC4CH and silafont36 remained sound throughout the whole durability test. In general, the durability is prone to decrease with increasing Fe and Cu content. However, it is to be noted that the occurrence of decohesion changes markedly with the processing route in ADC12 in spite of the same alloy composition.

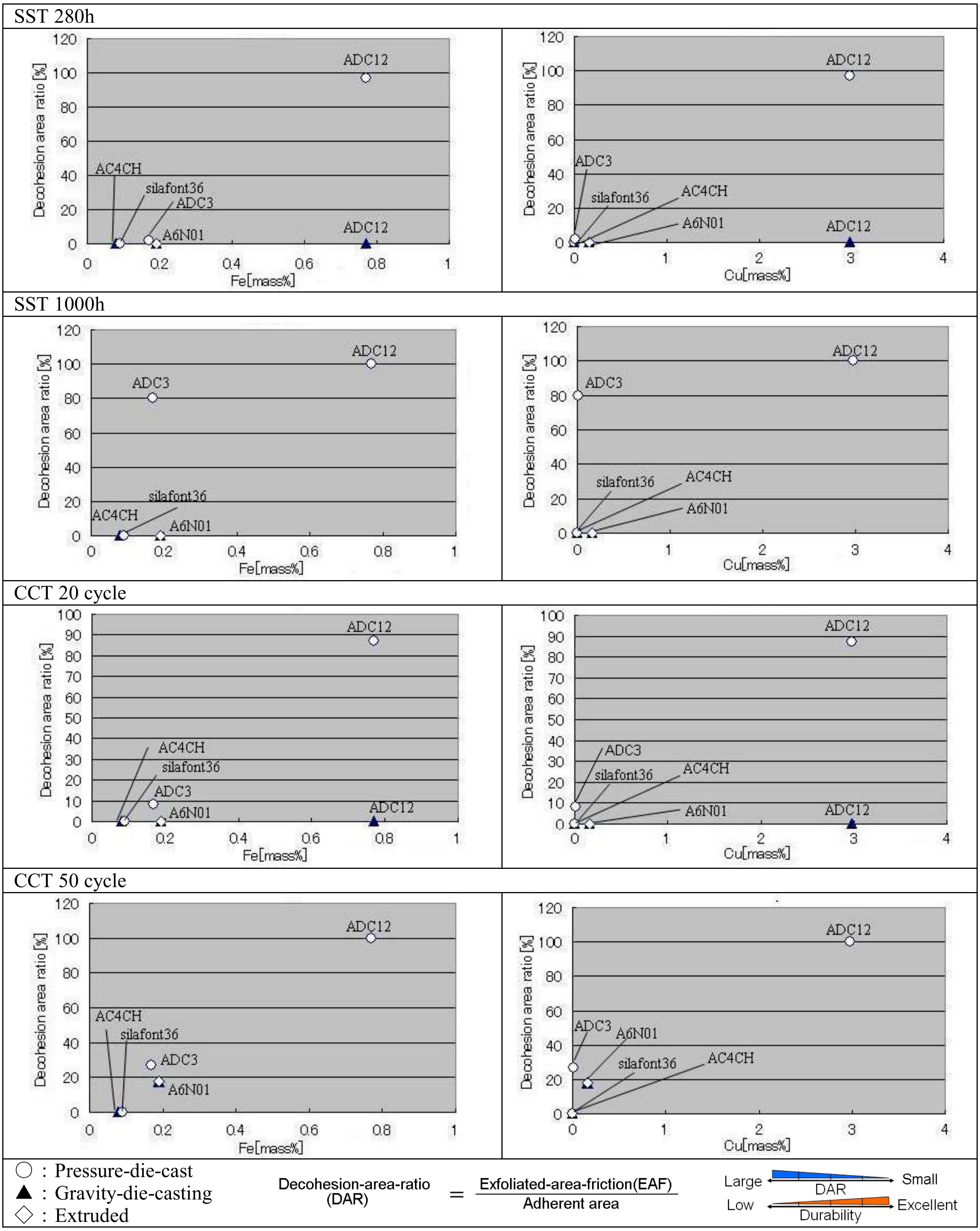

Fig.3 Result of corrosion tests.

Appearances of ADC12/PDC and GDC test pieces after SST by 540 cycles is shown in Fig. 4 with SEM images. In ADC12/GDC, corrosion is found to take place in primer and cover coat, while in ADC12/PDC, serious corrosion occurs, resulting in corrosion products. The area fraction of eutectic area in ADC12/PDC is larger than in ADC12/GDC according to the microstructure on the cross section. This is thought to be the cause for the result that ADC12/PDC was more prone to be corroded than ADC12/GDC. In addition, in ADC12/PDC, the durability was found to be improved when 10-1100μm of the surface layer was removed by etching in a strong acid or by mechanical milling

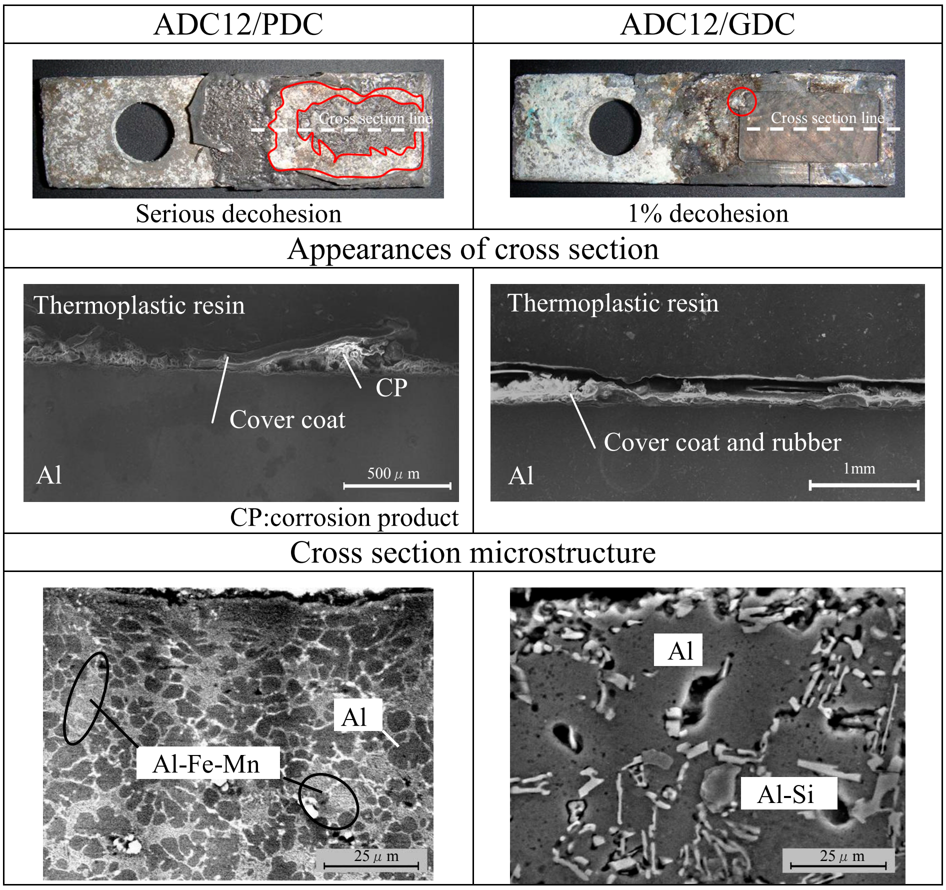

Fig. 4 Macroscopic appearance and SEM image of ADC12/PDC and ADC12/GDC test pieces after SST by 540 cycles that have been originally jointed with rubber. **CP: corrosion product.**

4. Summary

The following results have been obtained from the durability tests on aluminum alloy/rubber joints under corrosive atmospheres and microstructural observation after the tests.

(1) Low durability caused by decohesion of the joint was found in pressure-die-cast ADC12 and ADC3 alloys.

(2) Small amount of impurity Fe and alloying Cu tended to cause the low durability.

(3) In ADC12/PDC, large fraction of eutectic area adjacent to the surface was deduced to be the cause of the low durability.

References

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