EFFECT OF NEW PEENING TREATMENT ON FATIGUE PROPERTY OF CAST ALUMINUN ALLOY

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ABSTRACT

A new technology of peening, AS-treatment developed by ASAHITEC Corp., was developed to smoothen the surface and inner roughness of cast metal regardless of its form. To investigate the effect of AS-treatment, fatigue tests were carried out by rotating bending fatigue testing machine. It was confirmed that fatigue strength peened by AS-treatment is the almost same as that peened by conventional peening treatment.

KEY WORDS

Surface treatment, Roughness, Hardness, Residual stress, Fatigue strength

INTRODUCTION

Today, we are variously improving vehicle parts, especially the engine part, which has a big influence on the global environment.
Then, we developed the special surface treatment technique (Asahitec Surface Treatment, thereafter it is called “AS-Treatment”) to contribute to the global environment. This technique enabled engine performance improvement by smoothening the inner surface of hollow products of aluminum, and reduction of vehicle weight by fatigue strength improvement of material.
When we manufacture the hollow cast products of aluminum usually by using metal mold, sand core is always used. In general, there are horning, shot blast, and buff polish, etc. as a method of smoothening rough surface where shape of sand was reflected.
In addition, shot peening is one of the methods of generally improving fatigue strength or abrasion resistance. It shoots hard media on the surface of products at high speed and gives the compressive residual stress to the material. However, it is difficult to treat inner surface of hollow products by these methods because of cost and technology.
The AS-treatment differs from these methods, and can treat difficult parts so far. (For example: inner surface of hollow) It is a technology that does peening processing by shaking cavity where fixed products and included media. This paper describes the influence of AS-treatment, which may have equal effect to shot peening in surface properties, mechanical properties and the fatigue strength.

METHODS

Process of AS-treatment

The specimens were fixed in cavity where media were turned on. (Media are the steel balls of 5-12mm in the diameter.) After that, Media were shot to the surface of the specimens by shaking them. The energy of AS-treatment may change depending on the shaking time, size of media and etc., so two conditions of treatment (A and B) were taken. The condition A is comparatively high energy, and B is low one. The distribution of surface roughness, hardness and the residual stress were confirmed to evaluate the effect of AS-treatment. (A：media size is 10mm or more and treatment time is 5 minutes or more, B：media size is 5mm or less and treatment time is 3 minutes or less.) The condition A was selected for fatigue tests.

The surface residual stress of specimens after AS-treatment was measured by X-ray diffractmeter with 2θ- $\sin^2\Psi$method. Stress distribution was obtained by repeating the X-ray measurement and electrochemical polishing successively.

Material and specimen

The materials used for this study are Al-7Si-0.35Mg and Al-8.5Si-3Cu of aluminum alloy. The chemical composition of materials is shown in Table 1.

Table 1 Chemical composition of materials (mass %)

(a) Al-7Si0.35Mg alloy (b) Al-8.5Si-3Cu alloy

	Cu	Si	Mg	Fe	Ti	Mn	Ni	Zn	Sr	Cr	Ca
(a)	0.00	7.1	0.34	0.12	0.11	0.01	0.018	0.02	0.043	0.001	0.005
(b)	2.1	8.6	0.29	0.49	0.06	0.27	0.078	0.5	0.029	0.022	0.001

The fatigue tests were carried out by a rotating bending testing machine of about 60Hz in frequency in laboratory atmosphere. The geometry of specimen is shown in Figure 1.

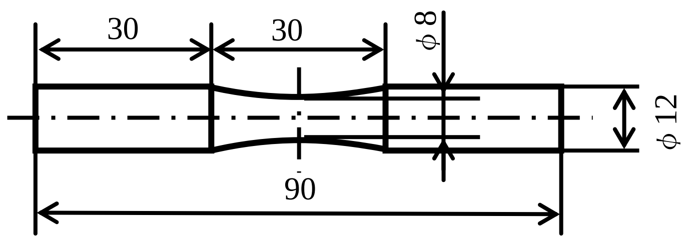
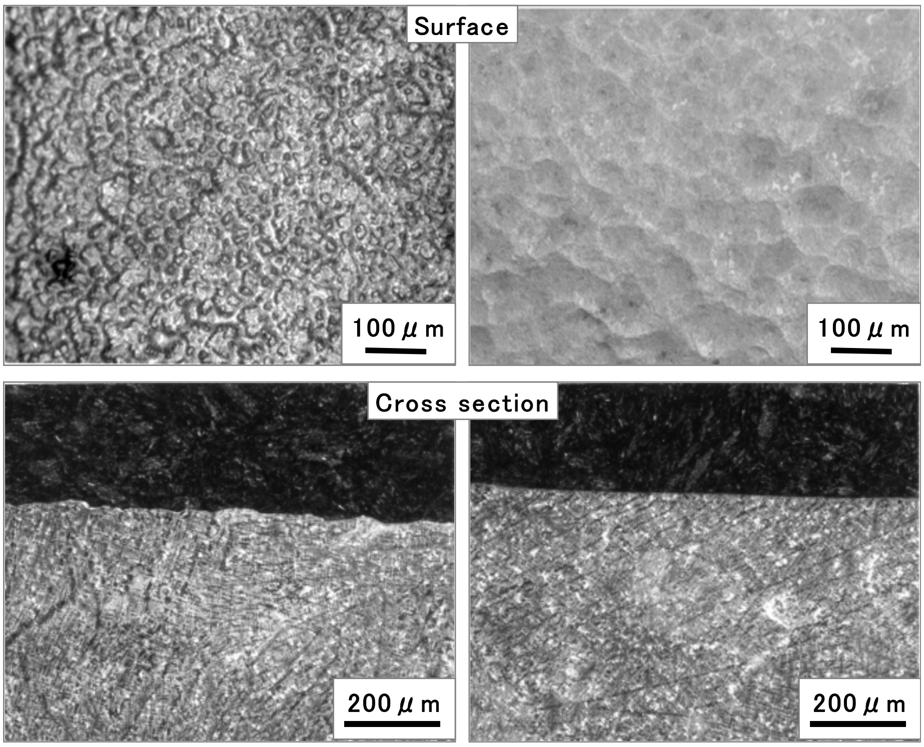


Figure 1 Geometry of specimen

RESULTS AND DISUCUSSION

1. Surface roughness

We applied AS-treatment to inner surface of intake manifold manufactured by general gravity die casting. Figure 2 shows the surface and cross section of specimens.



(a) Before AS (b) AS

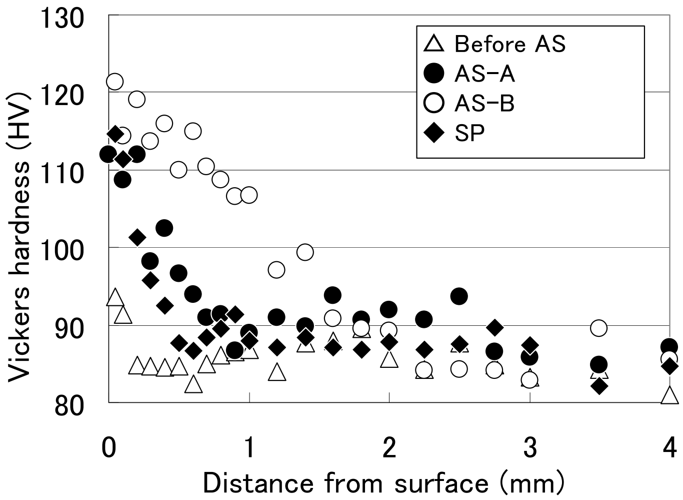
Figure 2 The comparison of surface morphology before AS and AS-treatment.

Left pictures in the figure show inner surface of the intake manifold before AS-treatment. It can be confirmed that there is a big roughness in the surface. This surface roughness is Ra=12.3 μ m. Right pictures show it after AS-treatment. The smoothened surface is confirmed at once. Actually, the surface roughness is improved up to 3.2 μ m. Moreover, continuous dimples are seen on the surface after AS-treatment. Because the surface roughness after AS-treatment is much smaller, it hardly influences fatigue strength(2).

2. Hardness and residual stress

The Vickers hardness and residual stress of specimens in Al-7Si-0.35Mg alloy with AS-treatment was measured. The specimens of conventional shot peening were used as a reference.

Figure 3 and Figure 4 show the Vickers hardness and residual stress of specimens in Al-7Si-0.35Mg alloy with AS-treatment. Horizontal axis is distance from the surface; these figures show the hardness and residual stress distribution to the direction of depth. The surface roughness of specimens peened by all treatment was up by HV20～30. The depth of effect is about 1mm in the shot peening, on the other hand, it is about 1-2mm in AS-treatment. The effect of AS-treatment reaches deeper than it of shot peening depend



on the condition.

Figure 3 The Vickers hardness of specimens in Al-7Si-0.35Mg alloy with AS-treatment.

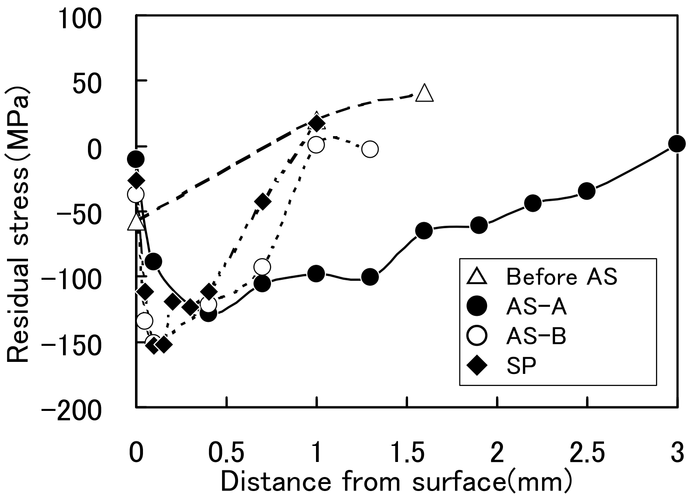


Figure 4 The residual stress of specimens in Al-7Si-0.35Mg alloy with AS-treatment.

The compressive residual stress is 150MPa or less. The depth of effect is about 1-3mm in the AS-treatment while it is about 1mm in the shot peening. The tendency of residual stress is similar to it of hardness.

The hardness and residual stress changed because of dislocation caused by the strong processing to the surface in AS-treatment.

Figure 5 shows the TEM (Transmission Electron Microscope) observation of the specimen in Al-7Si-0.35Mg alloy with AS-treatment. Actually, there is dislocation network in observation of specimens after AS-treatment.

It was reported that the effective depth of the compressive residual stress increases in proportion to the size of media, and the maximum value of it tends to move to the inside[1]. In hardness and residual stress, Al-8.5Si-3Cu alloy was a tendency similar to Al-7Si-0.35Mg alloy.

Because media of AS-treatment are much larger than those of the shot peening, the effect of hardness and residual stress was reached in a deeper direction. Moreover, the change of hardness and residual stress depends on the hardness before treatment and the material itself.

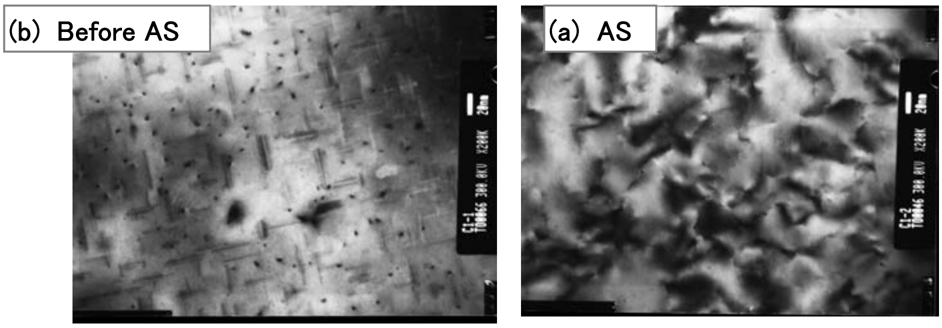
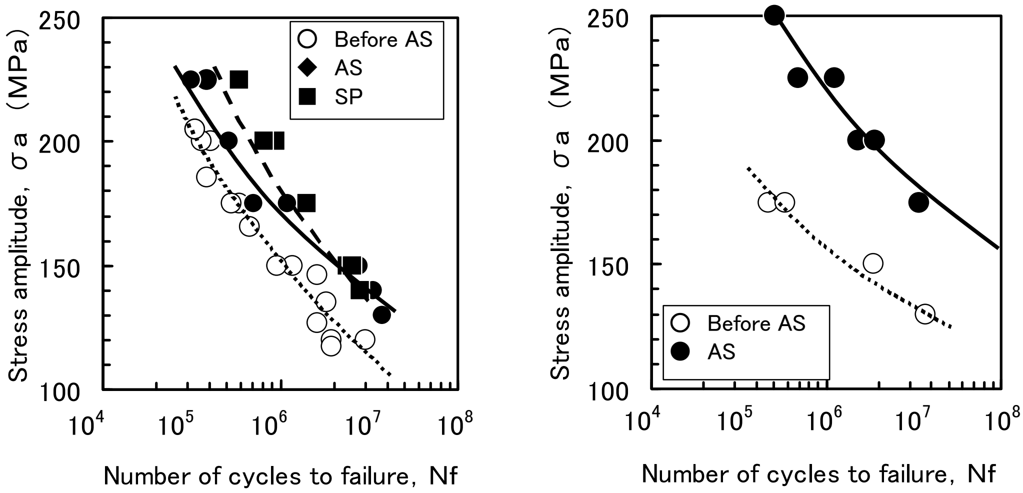


Figure 5 The TEM observation of the specimen in Al-7Si-0.35Mg alloy with AS-treatment.

3. Fatigue test

To investigate the effect of fatigue strength peened by AS-treatment in Al-7Si-0.35Mg alloy and Al-8.5Si-3Cu alloy, the rotating bending tests were carried out.

The specimens of conventional shot peening were used as a reference in Al-7Si-0.35Mg alloy. Figure 6(a) and (b) show the S-N curves for AS-treated Al-7Si-0.35Mg alloy and Al-8.5Si-3Cu alloy respectively.



(a) Al-7Si-0.35Mg alloy (b) Al-8.5Si-3Cu alloy

Figure 6 The S-N curves for AS-treated Al-7Si-0.35Mg alloy and Al-8.5Si-3Cu alloy.

The fatigue strength of specimens peened by the AS-treatment has increased in both alloys. For example, the number of failure of specimen after AS-treatment rise up to 10^7 while it before AS-treatment is 10^6 when the stress amplitude is 150MPa in

Al-7Si-0.35Mg alloy. The range of the improvement of fatigue strength by the AS-treatment was larger in the Al-8.5Si-3Cu alloy.

The fatigue strength peened by AS-treatment is equal to it by shot peening in long life.

It was confirmed that the AS-treatment improved the fatigue strength of the aluminum alloy as well as the shot peening. The factor of improving fatigue strength is giving of residual stress to specimens.

Here, figure 7 shows the comparison of residual stress before test and after 10^7 rotations (stress amplitude:130MPa) with AS-treatment and shot peening. Both of the AS and the shot peening don't have difference of the stress before and after fatigue test. It is thought that the residual stress does not disappear in the repetition of the low stress, and there is no difference of fatigue strength between the AS-treatment and the shot peening.

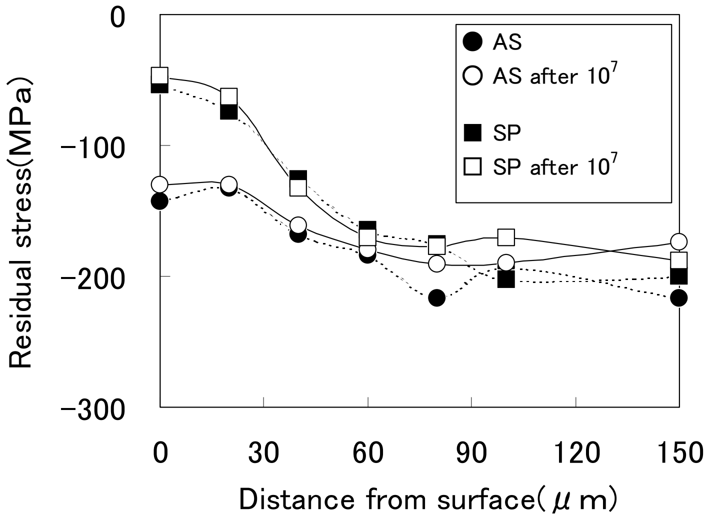


Figure 7 The comparison of residual stress before test and after 10^7 cycles.

CONCLUSION

・The AS-treatment which is one of peening processing newly developed can treat the inside of the hollow product, and improve surface roughness and fatigue strength.

・The fatigue strength peened by AS-treatment is equal to it by shot peening.

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