Influence of humidity on a shot peened aluminium alloy piece

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Keywords: Shot peening, Aluminium alloy, Residual stress, Humidity, Fatigue

Introduction

Aluminium alloy 7075 is an aluminium alloy, with zinc as the primary alloying element. It is strong, with a strength comparable to many steels, and has good fatigue strength and average machinability, but has less resistance to corrosion than many other Aluminium alloys. Its relatively high cost limits its use to applications where cheaper alloys are not suitable.
The first 7075 was developed in secret by a Japanese company, Sumitomo Metal, in 1943. 7075 was eventually used for airframe production in the Imperial Japanese Navy. 7000 series alloys such as 7075 are often used in transport applications, including marine, automotive and aviation, due to their high strength-to-density ratio. Their strength and light weight are also desirable in other fields. Rock climbing equipment, bicycle components, inline skating-frames and hang glider airframes are commonly made from 7075 aluminium alloy.
Generally many airplane components are made of Aluminium alloy. As this alloy has good fatigue strength but low resistance to corrosion, it is necessary to maintain low-humidity air inside the airplane. Because of this, the airplane’s conditioned air works in low temperatures, in order to provide dry air.
In this study, the specimens were applied to a rotating bending fatigue strength test under two conditions: dry air (humidity = 25%) and moist air (humidity = 85%). The specimens manufactured in aluminium alloy 7075 material were shot peened.

Objectives

This experiment aims to verify if the resistance to corrosion of the specimens manufactured in aluminium alloy 7075 material is improved after shot peening, what the peening effect is for small and large size shot media, and what the influence of humidity is on fatigue strength.

Methodology

The test piece material

The test piece material of the fatigue testing is aluminium alloy Al7075-T6. The chemical ingredients of the test piece material and the strength are indicated in Table 1 and 2.

The shape and size of the test piece

The shape and size for the test piece are indicated in Fig. 1. After mechanical processing of the test pieces, they were peened by ceramic media of two different diameters using airblast shot peening. The shot peening conditions are shown in Table 3.

Rotary bending fatigue test

The testing machine used by this test was the Ono system rotary bending fatigue test machine. (Torque: 14.7 N.m and the number of rotations: 3000rpm (SHIMADZU)) The humidity is controlled using a dehumidifier and humidifier. The precision of the humidity is RH ± 5 %. Further the temperature of the test environment was normal room temperature for all conditions, and the temperature wasn't controlled. The end number of times for the test was set to 107 times.

Table 1. Chemical ingredient of the test piece (mass%)

Al	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Ti+Zr
89.56	0.09	0.2	1.5	0.04	2.61	0.2	5.72	0.03	0.05

Table 2. The strength of the test piece

0.2% Offset yield strength (MPa)	True stress(MPa)
510	573

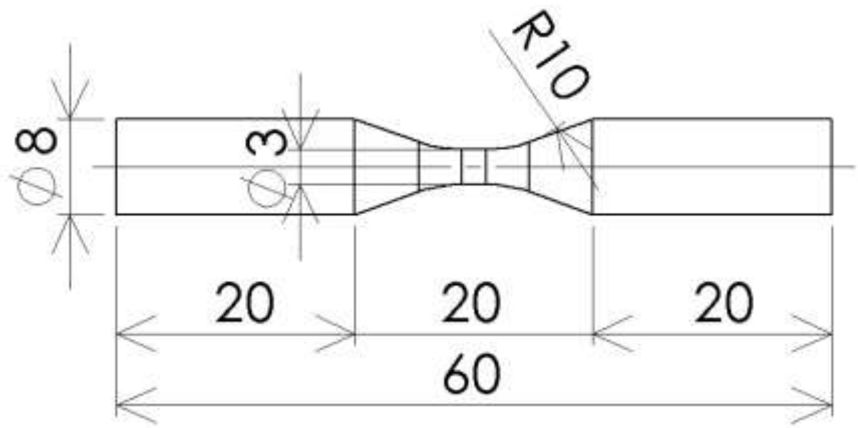

Fig.1 the shape and sizeof test piece

Table 3. media-size and humidity

		Media-size (mm)	
		φ0.6	φ0.05
Relative humidity	25%	LISP-L	FPSP-L
	85%	LISP-H	FPSP-H

Results and analysis

Rotary bending fatigue test

Figure 2. is the S-N curve of media-size φ 0.6mm. The vertical axis indicates stress amplitude and the horizontal axis indicates the number of repeats. Black squares are the high humidity state, and white squares are dryness. Arrows are the final points of the end number of 107 times. It was found that the fatigue life of high humidity state is lower than dry state.

Figure 3. is the S-N curve of media-size φ 0.05mm. As with the result of media-size φ 0.6mm, it was found that the fatigue life of high humidity state is lower than dry state. When, figure 2. and figure 3. are compared, the difference in the fatigue strength is clearly found between dry state and high humidity.

Figure 4. is the S-N curve of non-peening test pieces. As with the result of shot peening test pieces, it was found that the fatigue life of high humidity state is lower than dry state. When, figures are compared for shot peening and non-peening, it is found that the fatigue strength increased by shot peening in both the dry state and the high humidity state.

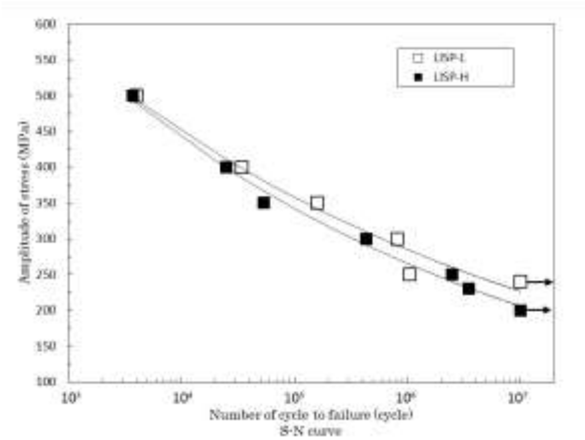

Fig.2 S-N curve (ϕ 0.6 SP)

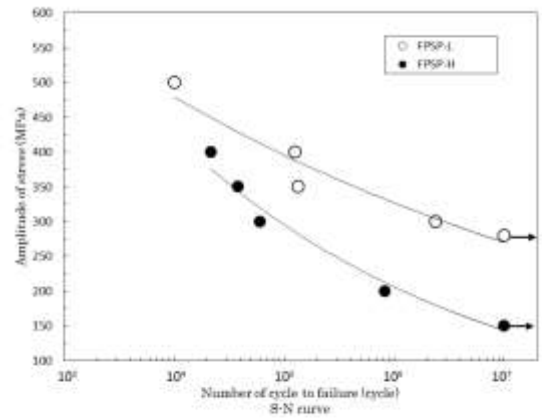

Fig.3 S-N curve (ϕ 0.05 SP)

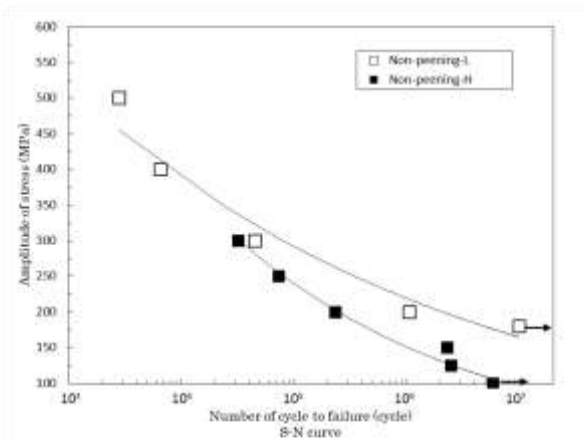

Fig.4 S-N curve (Non-peening)

Table 4. Surface roughness measurement

	Media-size (mm)	Max roughness Rz (μm)
FPSP	0.05	4.50
LISP	0.6	10.5

Surface roughness measurement

Table 4. shows the result of surface roughness measurement. Max roughness Rz was 4.5 μm by media-size φ0.05mm, and it was 10.5μm by media-size φ0.6mm. By the result of the measurement, it was found that as the grain-size of the media increases, the max roughness Rz value also tends to increases.

Hardness measurement

Figure 5. shows the result of the hardness measurement. The vertical axis indicates Vickers hardness (HV) and the horizontal axis indicates depth from surface. As shown in figure 5. , max surface hardness by media-size φ0.6mm is HV182, The depth range of more than HV160 is up to 300 μm. The difference in the max surface hardness by the grain-size of media is hardly seen, and it was found that the depth range of more than HV160 by media-size φ0.6 is deeper than media-size φ0.05.

Residual stress measurement

Figure 6. shows the result of the residual stress measurement. The vertical axis indicates residual stress (MPa) and the horizontal axis indicates depth from surface. As shown in figure 6. , max residual stress by media-size φ0.6mm is -370MPa, and the depth from surface is 120 μm. Max residual stress by media-size φ0.05mm is -340MPa, and the depth from surface is 10 μm. The depth at which the residual stress exists is 500 μm by media-size φ 0.6 mm. And the depth at which the

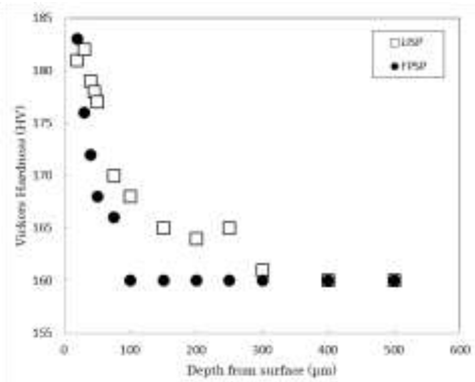

Fig.5 Hardness measurement

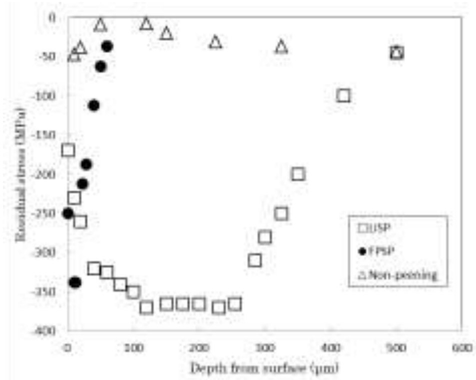

Fig.6 Residual stress measurement

residual stress exists is 60 μm by media-size φ 0.05 mm. The difference in maximum residual stress due to media- size is relatively small. However, it can be seen that there is a large difference in the depth at which the maximum residual stress occurs.

Analysis of comparison of two materials

Media-size φ0.6mm and φ0.05 mm were compared, and fatigue strength was the same degree in low humidity. But in high humidity fatigue strength of media-size φ0.05mm fell compared to media-size φ0.6mm. This is explained by the effect of the residual stress and the influence of hydrogen exerted on its spread at an early stage after crack initiation. In the case of media-size φ 0.6mm, the maximum residual stress was at a depth of about 0.02-0.03mm, where it was shallow from the surface like in the case of media-size φ 0.05mm. However, residual stress of the same degree was distributed to the deep areas. In the case of media-size φ0.05mm, the depth at the maximum residual stress was shallow at about 0.01mm, and the depth distributed was also shallower. Generally, the effect of obstructing crack propagation by residual compressive stress is larger in the case where the maximum value exists at the short crack. This is the reason why a large difference in fatigue strength did not occur between media-size φ 0.05 mm and φ 0.6 mm in low humidity even though the residual stress distribution area was largely different. However, in high humidity, the effective area of compressive residual stress decreases due to corrosion melting damage. In addition, since cracks are shear-shaped cracks for a short period even after cracks occur, the obstruction effect by compressive residual stress in the crack propagation process decreases. In addition, acceleration by hydrogen against initial propagation after cracking occurs in the same way as with the non-peened material. As a result, the fatigue life is considered to be shorter in the case of φ 0.05 mm. As clarified above, shot peening not only improves the fatigue strength but also it is expected to further improve the fatigue strength in high humidity.

Conclusions

From the S - N curve obtained by the rotational bending fatigue test, the influence of humidity on the fatigue strength is large, and the fatigue strength clearly decreases due to high humidity. Also, the difference between the fatigue strength in the high humidity state and the dry state is larger in media-size ϕ 0.05 mm.