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Microstructures and Mechanical Properties of 7075 Aluminum Alloy by Repetition Friction Stir Processing

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7075 aluminum alloy plate with 5mm in thickness was friction stir processed under both single path and repetition path processing for grain refinement. Shape of stir zone (SZ) on macrostructure of single path friction stir processing (FSP) specimen and repetition path specimens that were same direction were asymmetrical structure between advancing side (AS) and retreating side (RS) of the specimen. However repetition path specimen that was reverse direction specimen became symmetrical structure. Microstructures of SZ of both repetition path specimens were shown finer grain structure than that of single path specimen. Grain size of single path specimen had 2.6μm, and repetition path specimen was 2.3μm, these were showed finer than that of base metal such as 28μm. It is tendency that the grain size of SZ on repetition path specimens, same direction path specimen was finer than that of reverse direction path specimen. Harnesses of the SZ of both repetition path specimens were shown lower value than both base metal and single path specimen. Maximum joint efficiency of tensile strength of both repetition specimens showed 85% of base metal.

Keywords: *Friction stir processing, 7075 aluminum alloy, microstructure, mechanical properties.*

1. Introduction

Metal materials such as an aluminum alloy are well known that it becomes high strength by grain refinement. Friction stir processing (FSP) is known as a technology of grain refinement with the simple process. And research papers show a tendency to increase[1), 2)]. Authors examined it about grain refinement by FSP using 7075-T6 aluminum alloy, and reported that FSP was useful for grain refinement[2)].

When it is planned to make grain refinement by FSP, it can think about the method that a repetition FSP. However most of the research papers of FSP are related to the condition of FSP and the influence of the tool shape, and there are a few reports about repetition FSP.

In this paper, effect of the repetitions of FSP using a 7075 aluminum alloy on macro- and microstructures and mechanical properties.

2. Materials and experimental procedure

7075-T6 aluminum alloy plate of 5mm thickness was machined to 50mm width and 200mm length. Mechanical properties of base metal are shown in Table 1. FSP was done using a numerical controlled full automatic friction stir welding machine. FSP conditions are shown in Table 2. And, it was performed single path. Repetition path which was moved same direction or reverse direction for the first path. The FSP specimen is shown in the marks of Table 3 by the combination of the FSP conditions.

Table 1 Mechanical properties of base metal.

Tensile strength (MPa)	Elongation (%)	Hardness (HV 0.1)
594	12.2	188

Table 2 Friction stir processing conditions.

Rotational speed	N	(rpm)	1000
Welding speed	V	(mm/s)	1.0, 3.0
Tilt angle	θ	(deg)	3.0
Preheating time	t	(s)	30

Table 3 Marks of combination of FSP conditions.

Welding speed (mm/s)		Direction of 2nd pass for 1st pass	Marks
1st pass	2nd pass		
1.0	-	-	V1
	1.0	Same	V1V1S
		Reverse	V1V1R
	3.0	Same	V1V3S
		Reverse	V1V3R
3.0	-	-	V3
	1.0	Same	V3V1S
		Reverse	V3V1R
	3.0	Same	V3V3S
		Reverse	V3V3R

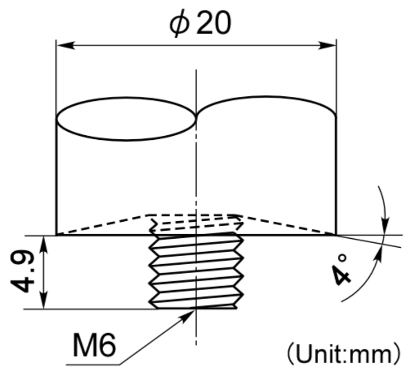

Fig.1 Shape and dimensions of tool.

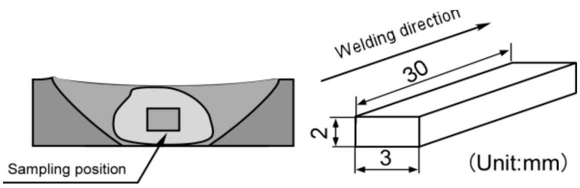

Fig.2 Sampling position of tensile test specimen.

After the first path had been FSP specimen was cooled down to room temperature, and then the second path was conducted.

Shape and dimensions of tool shows Fig.1. The tool made by SKD61 alloy tool steels. Tool rotating direction took a counterclockwise direction.

Observation of the appearance, macro- and microstructures, hardness tests and tensile tests which were measured about the center of stir zone (SZ), were conducted at room temperature. The sampling position and size of tensile test specimen is shown in Fig.2.

3. Experimental results and discussions

The appearances of specimen are shown in Fig.3. The circularly patterns made by shoulder of the tool were observed on the surface. As welding speed increased the pich of the circularly pattern was increased. Burr was observed on advancing side (AS) a little, and deposit was observed in the retreating side (RS). The deposit is observed at the surface of specimen by V1V1R and V1V3R conditions, the deposits decreased with increase the welding speed of the second path.

Macrostructures of cross section of FSP specimen are shown in Fig.4. Onion ring on single path specimen was observed clearly, and width of onion ring area of second path specimen was become slightly big. It is thought that the flow of the metal of SZ became easy for the fine structures by first path.

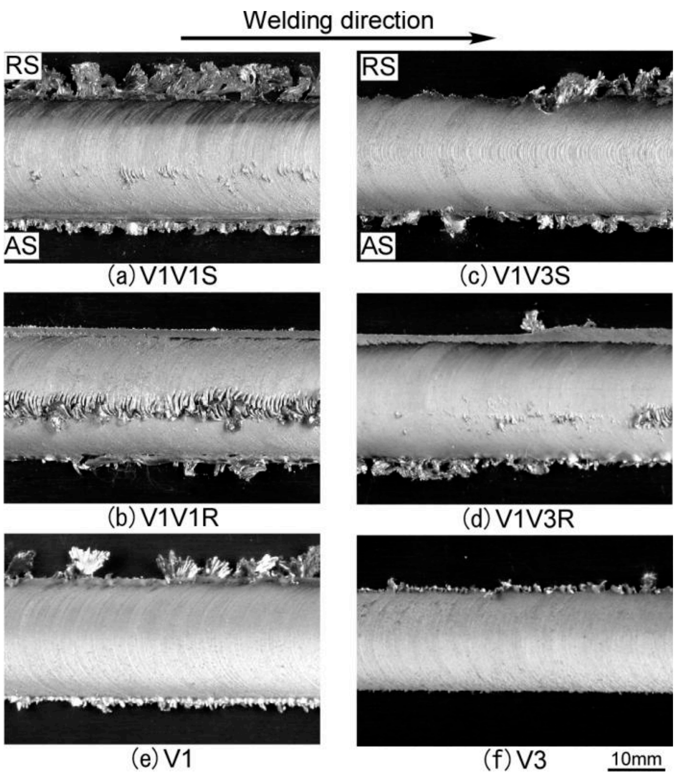

Fig.3 Appearances of joint.

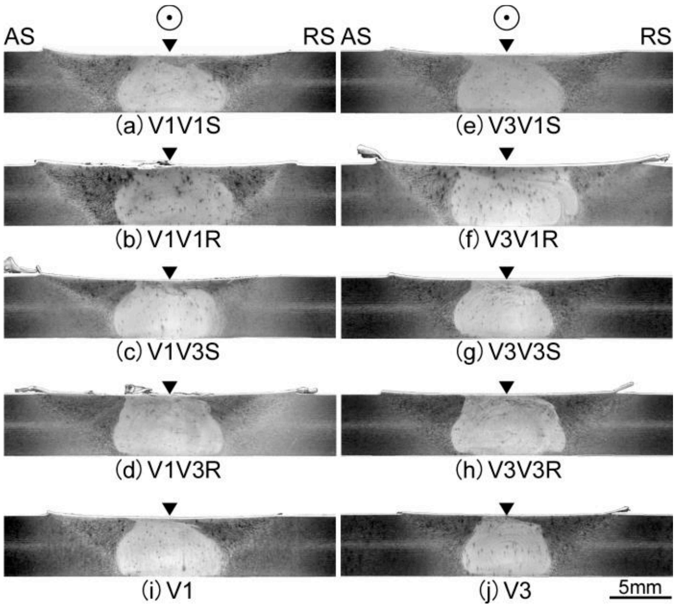

Fig.4 Macrostructures of joint. (▼: weld center)

Shape of SZ of single path specimen and repetition path specimens those were same direction were asymmetrical structures between AS and RS of specimen. But reverse direction of repetition specimens were shown symmetrical structure. And width of onion ring area of reverse direction specimen was bigger than that of same direction path specimen. The thermo-mechanically affected zone (TMAZ) and a heat affected zone (HAZ) were shown similar tendency of SZ.

Figure 5 shows microstructures of center of SZ. Repetition path specimens were shown finer grain structures than that of single path FSP specimens. Grain size of repetition path specimen became more small by increased the welding speed of the second path, the effect of the repetition path was admitted.

The measurements of the grain size of center of SZ are shown in the Fig.6. Grain size of single path specimen had 2.6μm, and repetition path specimen was 2.3μm, these were shown finer than that of base metal such as 28μm. It is tendency that the grain size of SZ of same direction path specimen was finer than that of reverse direction path specimen on repetition path specimens.

Figure 7 shows measurements of the grain size distribution of center at thickness of cross section on specimens. Grain size of the onion ring was remarkably small in all conditions. It became clear that shape of onion ring of V1, V1V1S specimens were asymmetrical from Fig.7. The grain size of TMAZ was bigger than SZ and increased with to approach

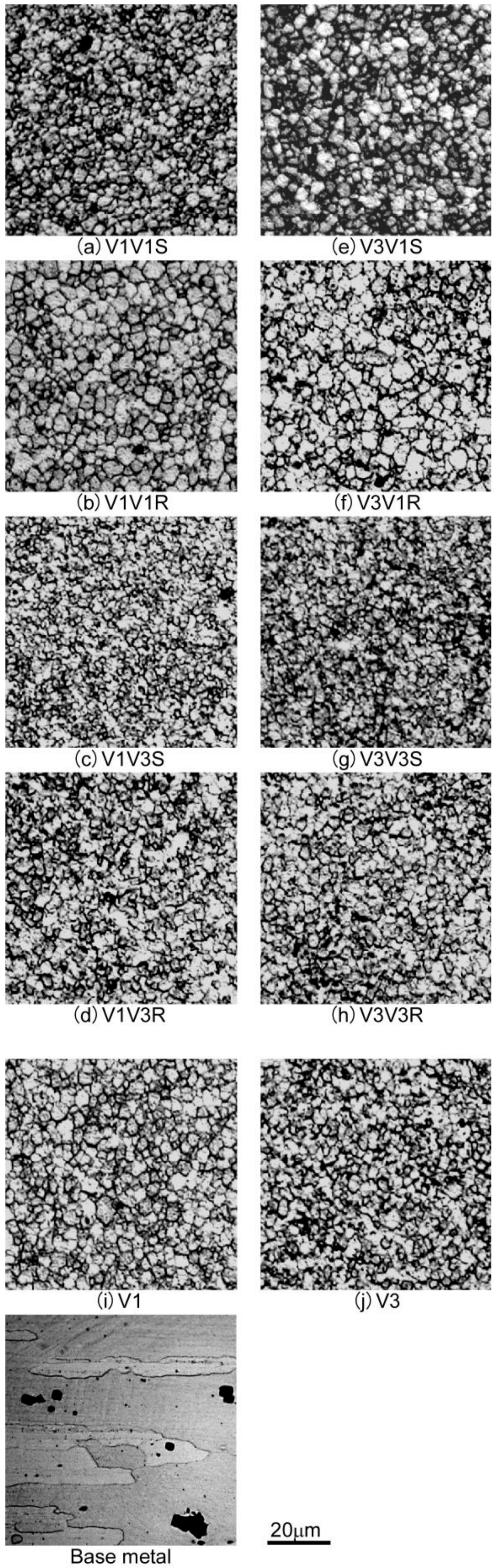

Fig.5 Microstructures of center of stir zone.

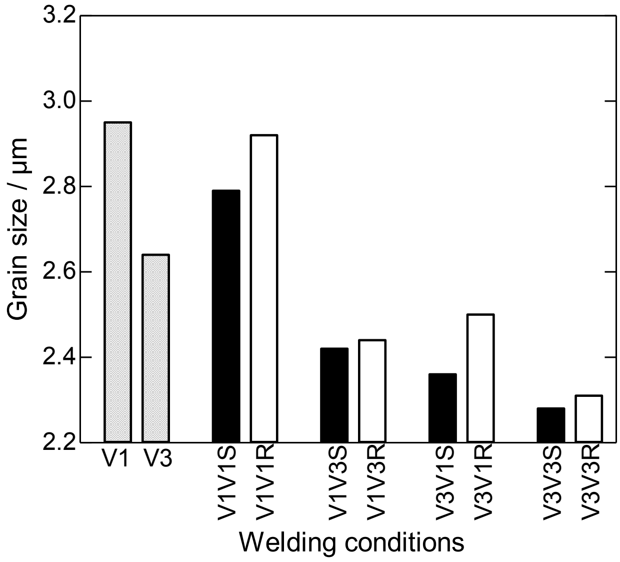

Fig.6 Measuring results of grain size of center of stir zone.

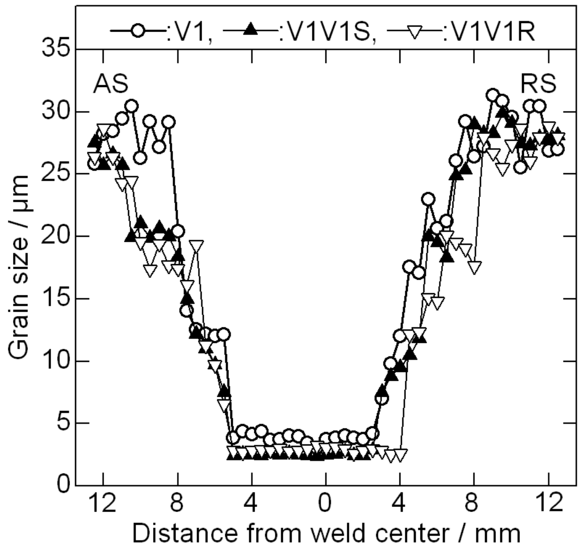

Fig.7 Grain size distributions of joint.

base metal.

Hardness distributions of FSP specimens were shown in Fig.8. There were measured of hardness after FSP for 30 days. Hardness of SZ of repetition path specimen was lower value than both base metal and single path specimen. In addition, the most soften area was observed at the position equivalent to shoulder diameter of rotational tool.

Figure 9 shows the results of tensile test of the FSP specimens. As for single path, there were no relations to the welding speed, and tensile strength decreased with about 60% of the base metal. V3 specimen declined more than V1 specimen as for the tensile strength. Tensile strength of second pass speed V3 specimens showed higher value than that of second pass speed V1 specimens. The effect of the second path on the tensile strength of V1 specimen was higher than that of V3 specimen. Maximum joint efficiency of tensile strength of repetition path specimen showed 85% of base metal in this experiment.

It is that became high intensity on the condition in the reverse direction with the benefit that the shape of the SZ and TMAS were symmetrical by making the second path reverse.

References

[1] M. Sibayanadi, M. Maeda and M. Naka: J. Jpn. Inst. Light Met. 56 (2006)7, 347.

[2] M. Asano and K. Katoh: Proc. of The 114th Cnof. Jpn. Inst. Light Met. (2008) , 31.

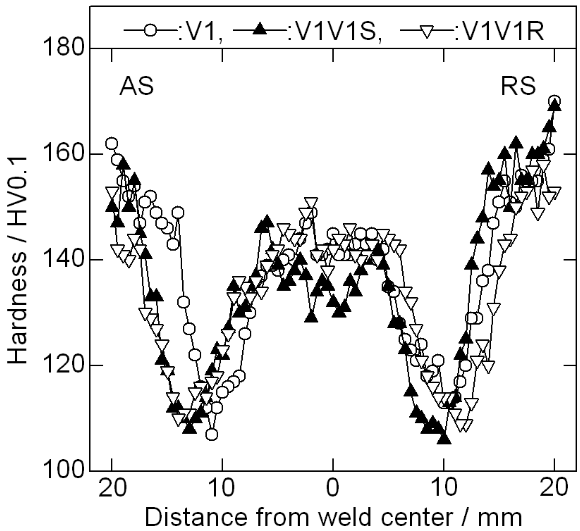

Fig.8 Hardness distributions of joint.

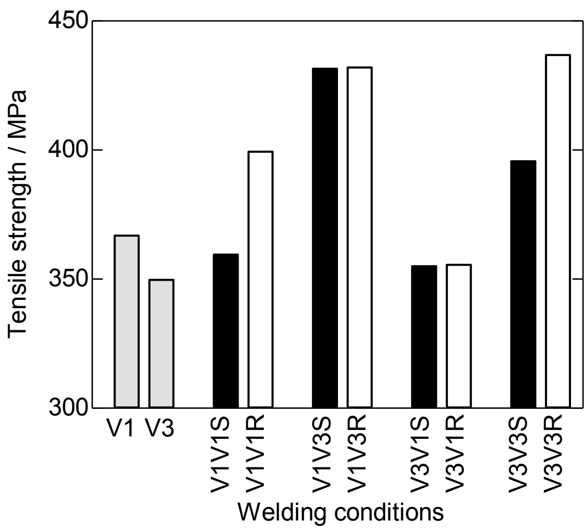

Fig.9 Results of tensile test.