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THE MICROSTRUCTURAL CHARACTERISTICS IN A SUPERALLOY HYBRID COMPONENT FABRICATED BY FRICTION PROCESS

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ABSTRACT

The dissimilar superalloy joint between Inconel 718 and Mar-M247 was fabricated by friction welding process. The microstructure in and around the welding was investigated by the Scanning Electron Microscope (SEM) and Energy-dispersive X-ray spectroscopy (EDS). The welding was found to be free of defect and the welded zone was quite narrow. The diffused zone between the two base metals was tine. The microstructure in the welded zone was recrystallized significantly and revealed a very complicated morphology and characteristics in Inconel 718 side. Inconel 718 and Mar-M247 could be joined successfully by the friction welding process.

Keywords: dissimilar friction welding, superalloys, microstructure characteristics.

1. INTRODUCTION

Inconel 718 and Mar-M247 are the superalloys suitable for high temperature applications [1]. The joining of these two superalloys is expected to produce the hybrid components possessing excellent strength. The aim to join these dissimilar alloys is addressed to fabricate the "*blisk*" in gas turbines.

Friction welding is an attractive method for dissimilar joining metals with high γ' volume fraction such as Nickel based superalloys that considered to be unweldable by other welding methods [2 - 5]. One of the most advantages of friction welding is that the joints can be archived at a temperature below the melting point and thus this technique can join all metals including MMCs (metal matrix composites). In engineering, the welding of dissimilar metals is generally more challenging than that of similar metals because of differences in the physical, mechanical and metallurgical properties of the base metals to be joined [3, 6]. However, the fabrication of the dissimilar joints is necessary in order to obtain a full advantage of the properties of different metals. By this way the designer can use most suitable materials for each part of a given structure.

This work will present the microstructure characteristics of the dissimilar superalloys Inconel 718 (denoted IN718) and Mar-M247 (denoted M247) fabricated by the rotation friction technique.

2. EXPERIMENTAL PROCEDURES

The cast polycrystalline M247 and the forged IN718 alloys were joined by the friction process. The chemical compositions of the two superalloys are shown in Table 1. The initial average grain sizes of the virgin IN78 and virgin M247 are averagely about 10 μm in and 1.0 mm, respectively.

The welding was performed on a continuous drive friction welding machine in four steps illustrated in Fig .1. In the continuous drive friction welding process, a stationary member was pressed against a rotating member with an axial pressure. The relative motion generates frictional heat which caused the material to soften and plastically deform. After a preset displacement (known as burn-off) had occurred, the machine was rapidly braked, and the pressure was increased to generate a high quality solid state weld. During welding the primary parameters (friction force, forge force, rotational speed and displacement) were continuously monitored and recorded. The processing of friction welding is depicted in the Fig. 2.

After welding, for observing the microstructure in the welding, the surfaces of specimens cut perpendicular to welding line were polished and etched by HNO_3. The microstructural characterization in and around the welded zone was investigated by the Scanning electron microscope (SEM). The main elements of the alloys in and around the welding were observed by the Energy-dispersive X-ray spectroscopy (EDS).

Figure 1. The steps of the friction process and the friction welded joint MM247-IN718.

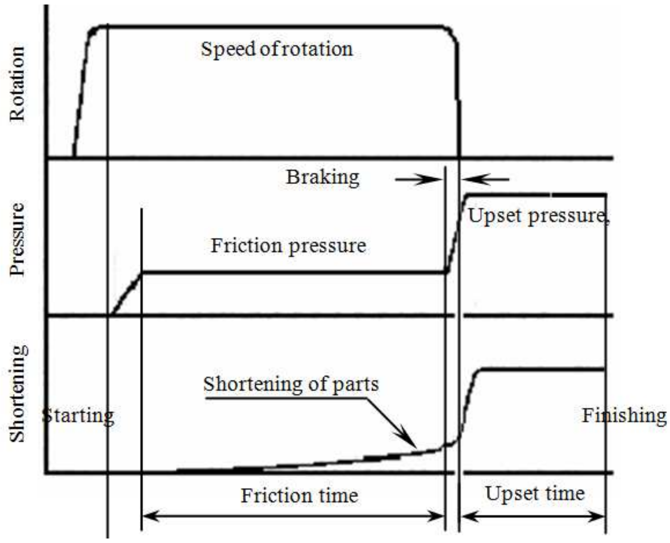

Figure 2. Illustration of the friction welding process.

Table 1. Chemical composition of IN718 and MAR-M247 (wt., %).

Composition	Ni	Cr	Co	Mo	W	Ta	Nb	Al	Ti	Fe	Mn	Si	C	B	Zr	Hf
IN 718	52.5	19	-	3	-	-	5.1	0.5	0.9	18.5	0.2	0.2	0.04	-	-	-
Mar-M247	60	8.3	10	0.7	10	3	-	5.5	1	-	-	-	0.14	0.015	0.05	1.5

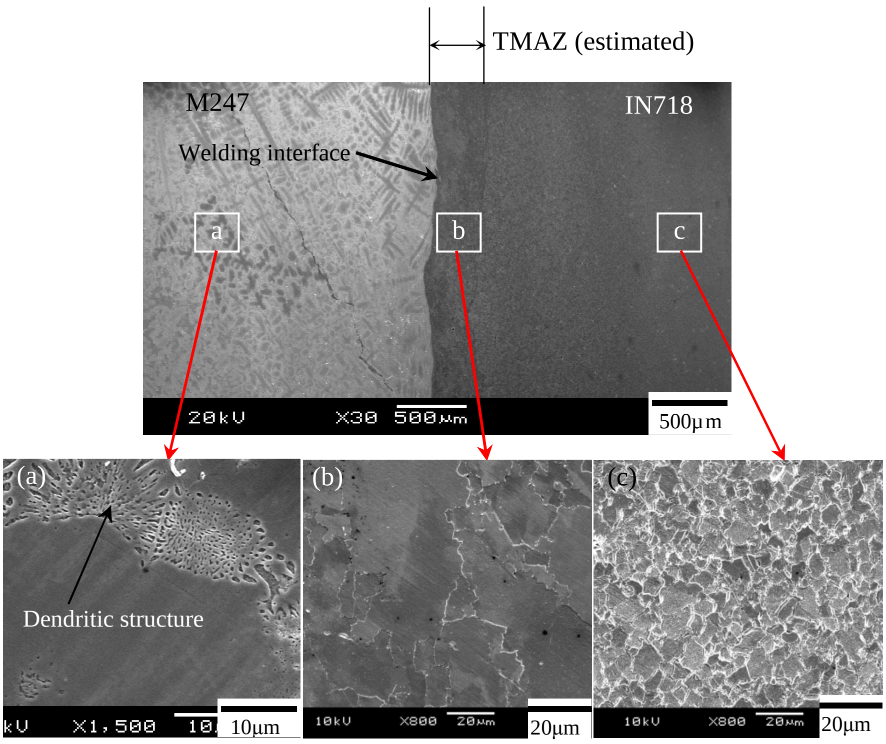

Figure 3. Microstructure in the (a) M247 side, (b) TMAZ in IN718 side, and (c) IN718 side.

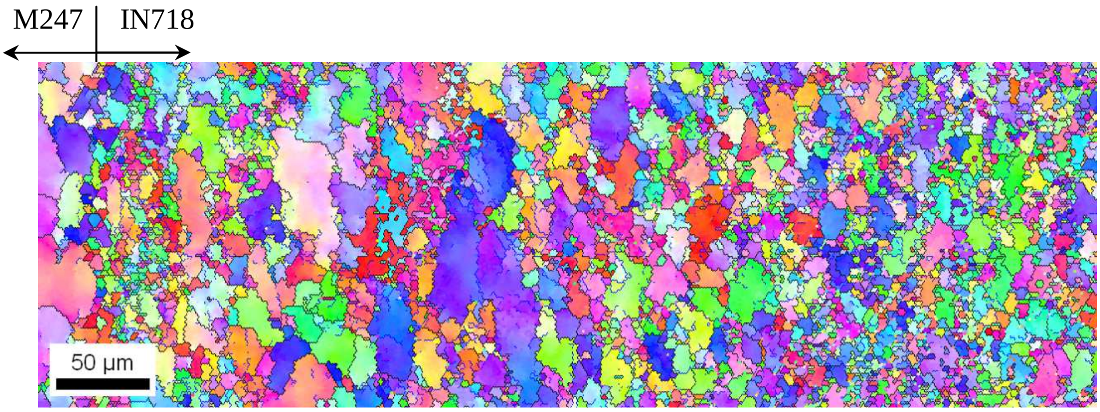

Figure 4. The significantly recrystallized microstructure in IN718 side in the welding zone.

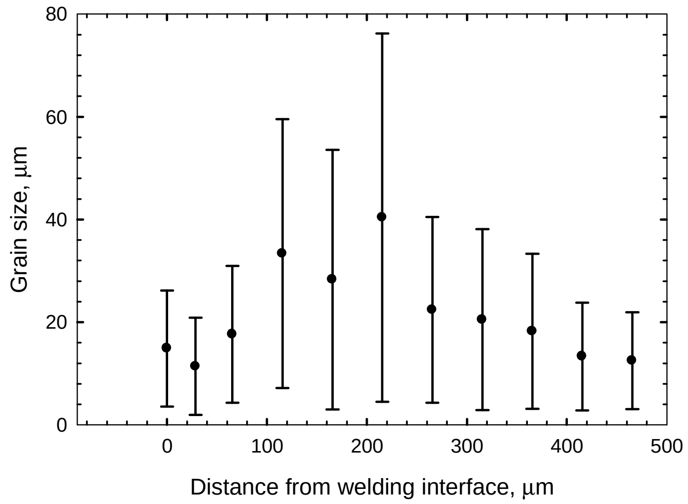

Figure 5. Grain sizes measured in the welded zone.

3. RESULTS AND DISCUSSION

In the welding fabrication of IN718 and M247, several primary tests were carried out to determine an optimum joint. The microstructure in and around the welding of the dissimilar welding of IN718 and M247 is presented in Fig. 3. On a microscopic scale, there were no visible defects in the welded zone. The thermo mechanical affected zone (named TMAZ) taken in IN718 side can be seen clearly in this figure with the width about 200 µm. The microstructures of the base metal M247 and IN718 exhibit the conventional microstructures. The M247 possesses dendritic structure (Fig. 3(a)) which consists of very large polycrystalline grains of millimeter order in diameter. The microstructure in the welded zone is recrystallized significantly and reveals a very complicated morphology and characteristics as shown in Figs 3 and 4. The grain size distribution in the TMAZ is significantly coarsened with a diversified scatter. Outside the TMAZ, the grain microstructure seems to be decreased gradually in the heat affected zone (HAZ) as seen in Fig. 5.

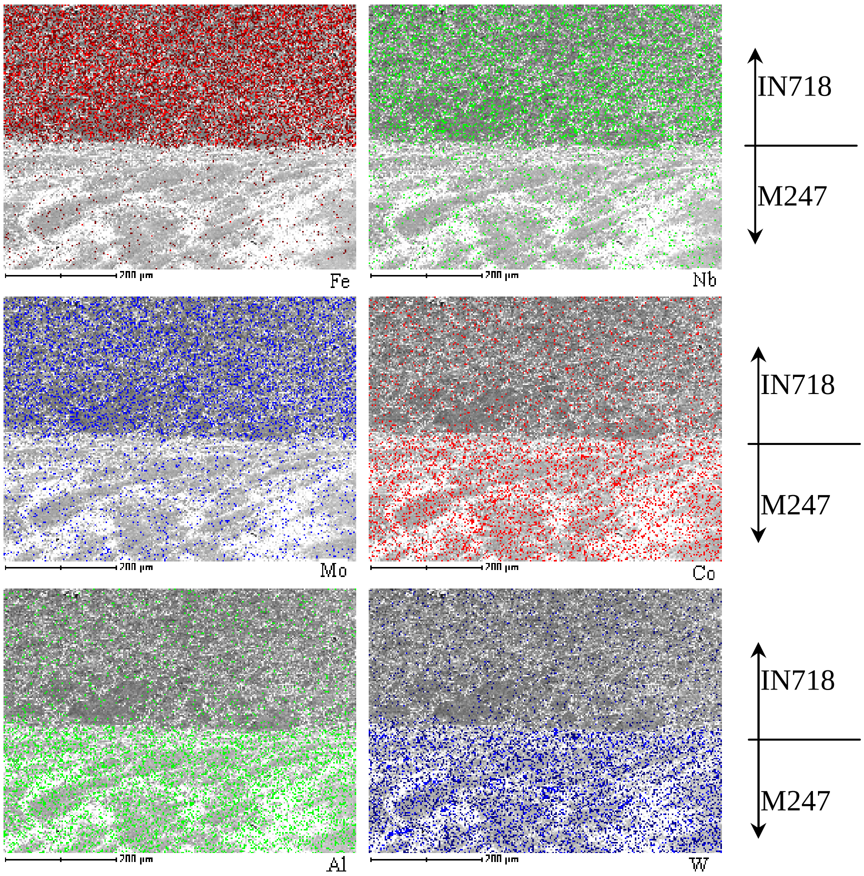

Figure 6. The distribution of the alloy elements in the welded zone.

From these observations, it can be believed that the dissimilar joint between IN718 and M247 can be obtained with a good microstructure property by the friction welding. However, the recrystallized microstructure seen in Fig. 4 indicates that the mechanical properties in the welded zone might be changed. In order to apply this dissimilar joint it is necessary to investigate the mechanical properties of this welding. This work will be done in the next step.

The distribution of the main alloy elements across the welding is shown in Fig. 6. Here the distribution of iron, niobium, molybdenum, cobalt, aluminum, and tungsten is presented. The figure shows obviously the dissimilar composition between the two base metals. The diffusion area between the two base metals at the interface zone seems to be quite tiny. From this view, it can be expected that the joint could be obtained with a very narrow welded zone.

4. CONCLUSIONS

The dissimilar superalloy Inconel 718 and Mar-M247 was joined successfully by friction welding process. The joint can be obtained with a narrow welded zone. The microstructure in the welded zone in IN718 side is significantly recrystallized with a complicated morphology. This research result provides several opportunities to fabricate hybrid components by friction welding process.

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REFERENCES

1. Roger C. R. - The Superalloys: Fundamentals and Applications, Cambridge university press (2006).
2. Ma T., Yan M., Li W., Chao Y. J. - Microstructure evolution in a single crystal nickel-based superalloy joint by linear friction welding, Materials & Design **85** (2015) 613-617.
3. John N. D., John C. L., Samuel D. K. - Welding Metallurgy And Weldability Of Nickel-Base Alloys, John Wiley & Sons, Inc (2009).
4. Homam N. M.,Mohammad-Reza A., Seyed H. S., Carlo M. - Microstructural, mechanical and weldability assessments of the dissimilar welds between γ'- and γ''-strengthened nickel-base superalloys, Materials Characterization **82** (2013) 41- 49.
5. Daus F., Li H. Y., Baxter G., Bray S., Bowen P. - Mechanical and microstructural assessments of RR1000 to IN718 inertia welds - Effects of welding parameters, Materials Science Technology **12/23** (2007) 1424-1432.
6. Huang H.Y., Li M., Preuss M., Karadge P., Bowen S., Bray G. - Baxter-Inertia friction welding dissimilar Nickel-based superalloys alloy 720Li to IN718, Metall Mater Trans A **38** (2007) 1608-1619.