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WELDABILITY OF IRON ALUMINIDES*

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ABSTRACT

A preliminary investigation was carried out to determine the weldability of a class of advanced iron aluminides. Thin sheets of iron aluminides were gas tungsten arc (GTA) and electron beam (EB) welded at different travel speeds and power levels. The results indicate that the weldability of these alloys is very sensitive to the welding conditions and compositions, producing good welds sometimes and severely cracked welds at other times. Alloys containing TiB_2 additions for improved strength and ductility cracked severely upon welding. Alloys without boron and zirconium, in particular alloy FA-129, was found to show more promise for welding than most of the other iron aluminides.

INTRODUCTION

In recent years ordered intermetallic alloys have been receiving considerable attention.[1-2] An alloy of recent interest is the iron aluminide, Fe_3Al. Iron aluminide has attractive electrical, magnetic and corrosion-resistance properties. Other features such as the low cost of iron and aluminum, and low density and adequate strength at temperatures below 600°C, make iron aluminides an attractive candidate for structural applications.

One of the major issues in the development of this new class of material, including Fe_3Al, is welding because joining by conventional processes is an important means of fabricating engineering materials into structural components. This paper describes the behavior of Fe_3Al type alloys when subjected to weld thermal cycles.

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Table 1. Alloy composition

Heat	Al	Cr	Nb	Zr	B	C	TiB_2	Fe
FA-41	17.0						0.5	Bal.
FA-37	15.7						0.5	Bal.
FA-122	15.88	5.46		0.19	0.01			Bal.
FA-129	15.86	5.45	0.97			0.05		Bal.

Table 2. EB weldability

	Speed mm/s					
Heat	2.1	4.2	8.5	12.5	16.9	20.8
FA-41		•	o		o	
FA-37		•	o		o	
FA-122	•	•		•		•
FA-129	•	•		•		•

• = No cracks
o = Cracks

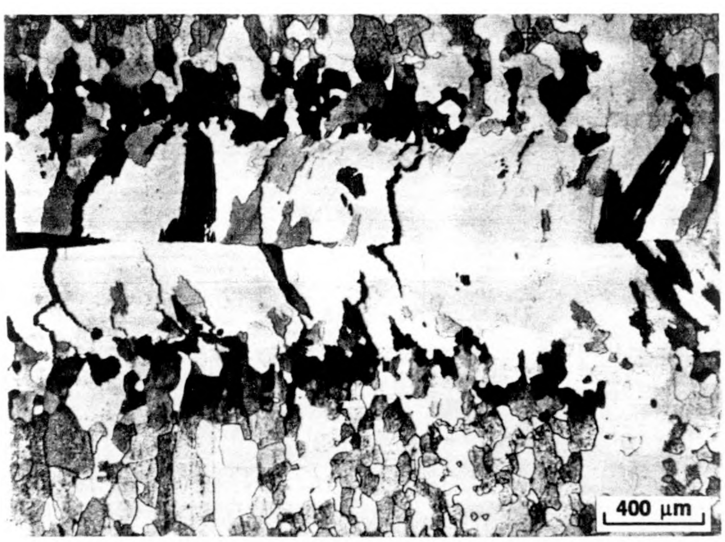

Fig. 1 Fusion zone microstructure of alloy FA-41.

EXPERIMENTAL PROCEDURE

Alloys used in this study are listed in Table 1. Both EB and GTA autogenous welds (melt runs) were made on 20 × 40 × 0.7 mm coupons. Further characterization of weldability under variable restraint conditions can be carried out using Sigmajig test.[3] Since crack-free weld was not obtained consistently during unrestrained autogenous welding, Sigmajig test was not performed on any of these alloys. The welding variables were adjusted to produce full-penetration welds at various welding speeds. Specimens for microstructural characterization were prepared by conventional metallographic techniques and etched with a solution containing 40 ml HNO_3, 60 ml CH_3CoOH, and 20 ml HCl. Microstructural characterization of the weldments was conducted by using light microscopy.

RESULTS AND DISCUSSION

Electron Beam Welding

Previous investigations on the weldability of ordered intermetallic alloys have shown that the high energy beam process, in general, can produce successful welds owing to the highly concentrated heat source and possible refinement in the fusion zone structure. Therefore, initial interest was focused on EB welding. The alloys were EB welded at speeds ranging from 2.1 to 20.8 mm/s. After welding, the specimens were carefully examined for cracks using a low-magnification microscope. The presence of cracks was further confirmed using metallographic techniques. Table 2 summarizes the results of EB welding. In general the results indicate that the alloys containing TiB_2 added for grain refinement showed a severe tendency to crack.[4] These cracks have been found to be hot cracks. Figure 1 shows the typical transverse hot cracks observed in the alloy FA-41 fusion zone. However, the higher order alloys FA-122 and FA-129 modified with chromium and niobium did not exhibit any tendency to crack. Figure 2 shows the typical crack-free microstructure of alloy FA-129. Because of the nearly circular puddle shape, the grain structure development in the fusion zone is much finer.

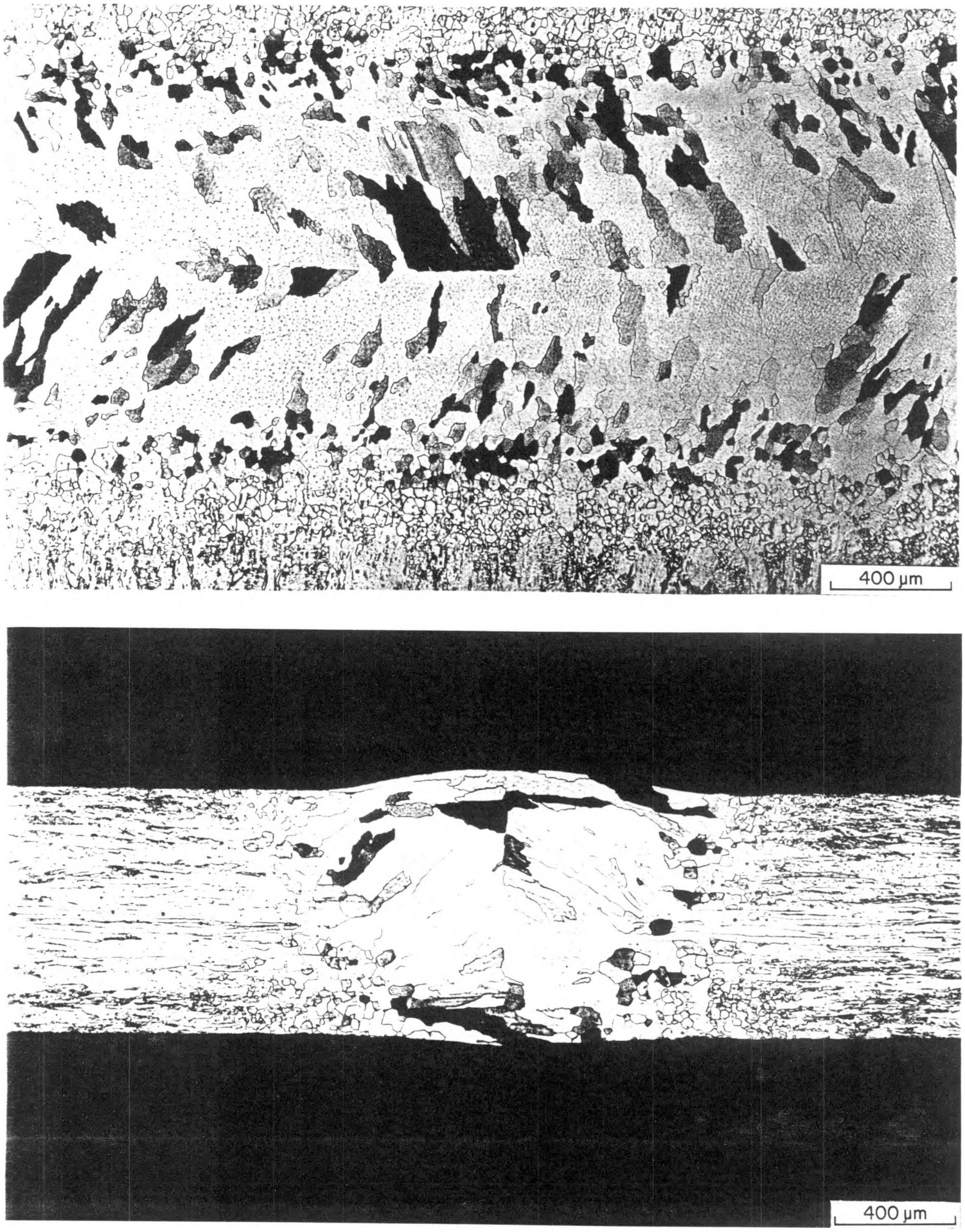

Fig. 2 Optical micrograph showing the longitudinal and the transverse section of the EB weld fusion zone of FA-129B alloy.

Gas Tungsten Arc Welding

Table 3 summarizes the results of the GTA welding of the various alloys investigated. Full penetration GTA welds were made at welding speeds ranging from 4.2 to 21.6 mm/s. The results indicate that some of the alloys can be successfully welded using GTA welding process at low welding speeds. The alloys containing TiB_2 (FA-41 and FA-37) and zirconium and boron (FA-122) cracked severely. Indeed, zirconium in combination with boron may be a bad activator for weldability. Of all the alloys investigated, the alloy FA-129 modified with niobium, chromium, and carbon has been found to exhibit some promise for weldability. Figure 3 shows a typical FTA weld made in alloy FA-129. In contrast to the fine fusion zone grain structure observed in the EB welds, the fusion zone structure is much coarser in the GTA welds.

Table 3. GTA weldability

	Speed mm/s				
Heat	4.2	8.5	12.5	16.9	21.6
FA-41	o	o			
FA-37	o	o			
FA-122	o	o	o		o
FA-129	•	•	•		o

• = No cracks
o = Cracks

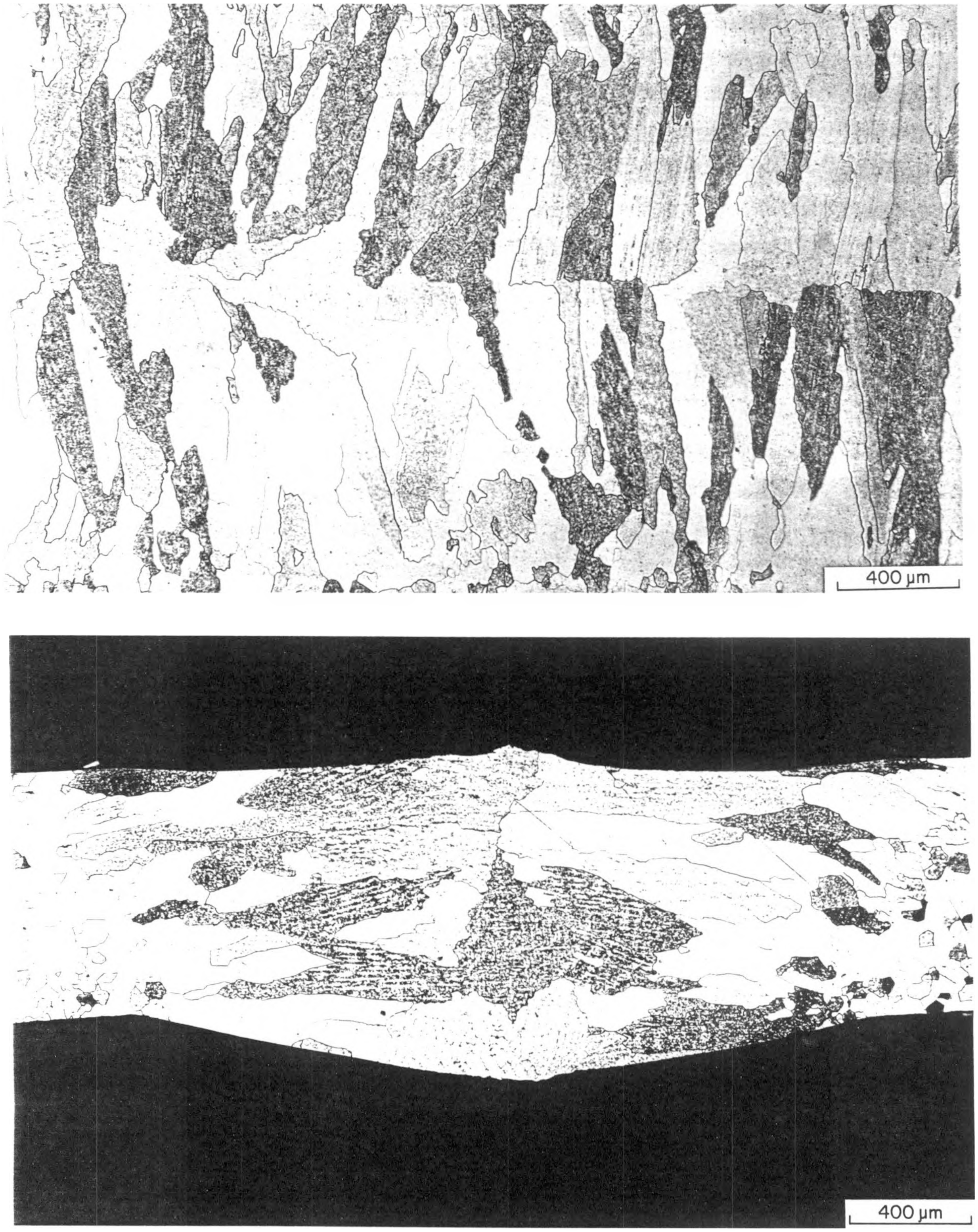

Fig. 3 Optical micrograph showing the longitudinal and the transverse section of the GTA weld fusion zone of FA-129B alloy.

SUMMARY

The preliminary weldability studies indicate promising results for one of the iron aluminides investigated i.e., alloy FA-129. Successful welds with minimum cracking were produced in this alloy. The results indicate that the weldability of iron aluminides is very sensitive to composition and welding parameters. Alloy compositions with zirconium in combination with boron and TiB_2 have been found to be bad activators for weldability of these alloys.

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