Welding technology of the intermetallic Fe₃ Al phase

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Abstract

This paper presents the analyses of the welding terms and estimation of the welded joints quality for intermetallic Fe₃Al. Materials, on the base which, joints were made and some welding technologies has been examined. Results of investigations let one to type welding methods and materials that gives the best physicochemical effects of the joints. Regarding to the specific properties of the welded material especially its quite high hardness and fragility, it has been proposed that when joining intermetallic Fe₃Al advisable would be welding in an argon cover with using Es9CrNiB electrode optionally electrowelding with Es 9CrNiB electrode. Welds made that way are thought to have the best properties within methods and welding materials being tested.

Keywords: Intermetallic; Fe₃Al; Welding; Microstructure connectors;

Introduction

The interest of alloys in a groundmass of the ordered intermetallic phases of Fe-Al system is caused by unique combination its oxidative, carburisative or containing compounds of sulphur atmospheres immunity joined with high abrasion and an elevated temperatures resistance with relatively low density. In Fe-Al phase diagram, two intermetallic phases FeAl I Fe₃Al can be a groundmass for a potential constructive materials. Fe₃Al phase appears in alloys which contain 23-36% of aluminum while FeAl phase in alloys contained 36-48% of this chemical element. The main defect of alloys with groundmass FeAl and Fe₃Al phase, is its low plasticity in a room temperature caused by influence of environment especially by aqueous vapour and by low endurance in a increased temperature [1, 2, 3].

Alloys of Fe-Al phase diagram (Fe₃Al - FeAl) after being plasticized are concerned to be used as, for example: heating elements, gas filters, regenerator discs in a gas turbine, pipes, car elements, exhaust systems, heat exchangers, electric radiators, toasters etc.. Low material costs of FeAl alloys in comparison with stainless steel contracting expensive chrome, nickel, and molybdenum made them desirable, which in a near future will be wide applicable in a petrochemical chemical and aircraft industry, energetics, shipbuilding, etc.[4, 5, 6].

2. Investigated material

During investigations, rectangular samples 20x4x80mm made from intermetal Fe₃Al were used. The researches of a base material were conducted before welding specimens with the joined surfaces with dimensions 20x3mm. On the investigation ground it can be declared that alloy in start state has coarse-grained structure (fig. 1).

Average grain size were estimated on about 2mm fig.2. Moreover it was observed (especially in a flat sample) explicitly columnar crystallites setup. Its heights are about two or three times higher than its diameters, that confirmed proper chemical constitution stoichiometry (fig. 3).

The results of carried out linear microanalysis of examined material’s chemical constitution confirmed that it mainly contains Fe and Al and small amounts of such elements as: Mn, Cr, Ni, Si. These kind of admixtures are desirable to improve stress properties in an increased temperature [7].
3. Experimental work

Following methods were used during investigation:
1. Joint welded in an argon cover without additional electrode’s material (fig. 4);
2. Joint made in an argon cover with Es9CrNiB electrode (fig. 5);
3. Joint electrowelded with coated EB-150 electrode (fig. 6);
4. Joint electrowelded with ES9CrNiB electrode (fig. 7);

3.1. Microstructure of welded joint

Quality of welded joint has been conducted by using organoleptic methods, optical microscopy and scanning microscope. Investigations explored on the metallographic smooth surfaces were prepared with traditional methods - grinding, polishing and pickling – fig. 4, 5, 6, 7.
3.2. Welded joint hardness measurement

The probe conducted with Vickers method allowed to find out that the best welding method from all proposed in this paper, is welding in an argon cover with using Es9CrNiB electrode. From all joints examined during the investigations, that combination obtained the highest hardness (fig. 8).

3.3. Static tensile test of welded joint

Tensile test of intermetallic Fe₃Al proved that examined material is fragile. An audible yield strength were not observed. Regarding figures received during examination it was affirmed that sample welded both side without chamfering showed higher absolute elongation and held out greater weight than the sample welded one sight with chamfering (fig. 9).
Acknowledgments

Welded joint made in an argon cover without additional electrode’s material were fractured along longitudinal axis. The coarse-grained structure was observed – crystals with a sharp and irregular shapes and differential size. The fracture is similar to the parent material (fig.10).

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Fig. 10. Photo of fractured sample - welded joint made in an argon cover without additional electrode’s material.

References


4. Conclusions

Through the conducted micro- and macro - scopic researches it can be declared that the best methods of Fe₃Al alloy welding, taking under consideration gained structure of a joint are: welding with Es9CrNiB electrode and electrowelding with Es9CrNiB electrode.

Summing up the results of investigations it can be affirmed, that the best welding methods for very hard and fragile material which was examined are: electrowelding with use of Es9CrNiB electrode and welding in an argon cover with Es9CrNiB electrode. In the joints made by using such methods, was observed, the smallest amount of defects and incompatibility.