Effect of Welding Processes on Tensile Properties of HT9 Alloy Joints

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1. Introduction

The present investigation is aimed at to study the effect of welding processes such as GTAW, LBW and EBW on mechanical properties of HT9 alloy [1]. The preferred welding processes of these alloys are frequently GTAW and RW due to their comparatively easier applicability and better economy [2]. In this experiment, to make sure proper welding process, GTAW, LBW and EBW apparatus using welding head and vacuum chamber was used [3], and preliminary experiments for optimizing weld parameters of the specimens using HT9 alloy were also performed. Furthermore, weldability test using HT9 alloy was carried out by tensile tester to comply with inspection procedure. The weld characteristics of end plug joint for the SFR fuel rod fabrication was also studied by mechanical testing and metallographic examinations.

2. Methods and Results

2.1 Test Materials

The material used in this experiment was HT9 alloy. The chemical composition of test specimen is given in Table 1 and its schematic configuration, as shown in Fig. 1. These test specimens were prepared by using bottom end cap and cladding tube. These test specimens were also ultrasonically cleaned in ethyl alcohol, and then dried.

Table 1. Chemical compositions and mechanical properties of HT9 alloy.

(a) Chemical compositions wt. %

Alloy	C	Cr	Mo	Mn	V	W	Ni	Si	Fe
HT9	0.2	12	1.0	0.6	0.25	0.5	0.5	0.4	bal.

(b) Mechanical properties of HT9 alloy

Alloy	0.2% Proof stress (Mpa)	Tensile strength (MPa)	Elon. (%)
HT9	580	805	6 - 15

2.2 Examination Procedure

Tensile tests were performed at room temperature and three to four specimens were tested for every weld as shown in Fig. 1.[3] The strain rate was 1 mm/min. The macro-structure of welded specimens was investigated by the optical microscopic examination. Macro-sections of welded specimens were investigated through metallographic examination in order to determine undercut depth and penetration depth of the bottom end cap to the cladding tube. The laser welding conditions applied are summarized in Table 2. All welded specimen using bottom end cap to cladding tube were polished and etched electrically with the following etchant: 90% H_2O, and 10% oxalic acid (vol. %).

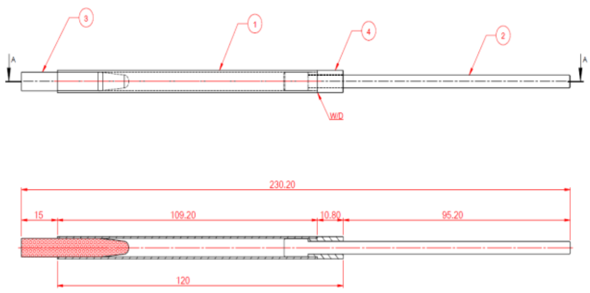

Fig. 2. Dimension of tensile specimen and scheme of test specimen.

2.3 Effect of welding processes tensile strengths

The mechanical properties such as tensile strength, and percentage of elongation of HT9 alloy welded specimens were investigated. In each welding process, three specimens were tested, and the three results of tensile strengths were presented in Fig. 2, Fig. 3 and Fig. 4. It was found that the tensile strengths of the welds were higher than those of the base materials, but their strains were lower. The EB welds were slightly stronger than the GTA and LB welds as shown in Fig. 5. No significant difference could be found between the tensile properties of specimens using GTAW, LBW and EBW processes, respectively. The fracture of the transverse welded specimens occurred in the base metal of the cladding tube far from the weld metal.

Table 2. Tensile properties of HT9 GTA, LB and EB welds.

Type of specimens	Max. Tensile strength (MPa)	Elongation (%)
GTAW	1154	5.2
	1195	7.8
	1171	7.0
LBW	1222	7.2
	1195	8.1
	1210	8.9
EBW	1261	8.6
	1223	8.7
	1218	8.6

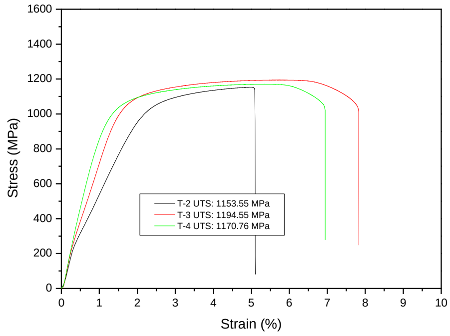

Fig. 2. Stress-strain curves for HT9 GTA welded specimens.

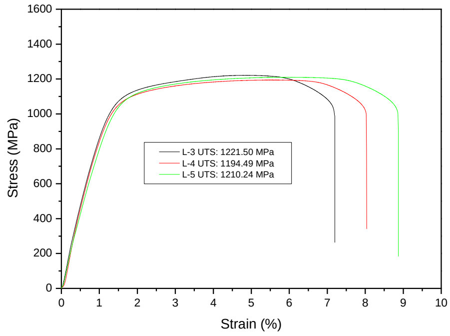

Fig. 3. Stress-strain curves for HT9 LB welded specimens.

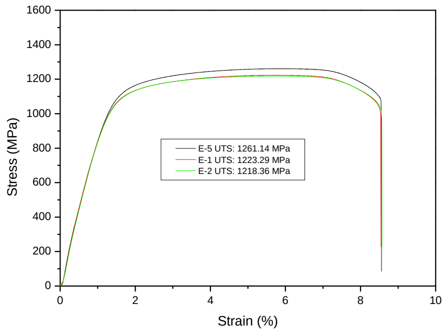

Fig. 4. Stress-strain curves for HT9 EB welded specimens.

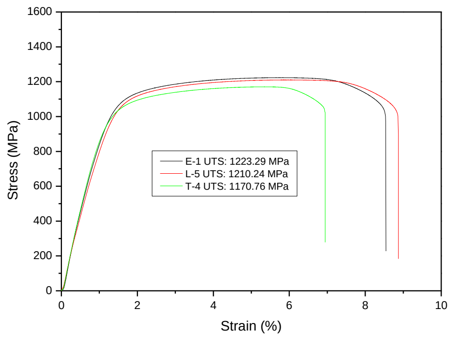

Fig. 5. Stress-strain curves for HT9 welds compared with GTA, LB and EB welded specimens.

3. Conclusions

In this study, the mechanical properties of GTAW, LBW and EBW joints of HT9 alloy were investigated. In the present experiment, satisfactory welds of the mechanical test specimens were also found. In comparison with the GTA, LB and EB welds of test specimens, the tensile strengths were no difference between the end plug and cladding tube welds using HT9 alloy. Based on this fundamental experiment, fabrication of the SFR metallic fuel rods and assemblies will be provided for the sodium-cooled fast reactor project.

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