EVALUATION OF HIGH TEMPERATURE CREEP STRENGTH OF AUSTENITE STAINLESS STEEL DURING MMAW

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Abstract: Creep strength of austenite stainless steel weld metal was studied at 600^0C and 700^0C. The size and distribution of intermetallic phase resulted due to the transformation of ferrite influences the creep strength of weld beads.

Keywords: Creep strength, weld beads, intermetallic phase

1. Introduction

Austenite stainless steels (ASS) are being used for the breeder reactor components. These steels have high temperature mechanical properties. But the austenite stainless steels have poor resistance to stress corrosion cracking in chloride and caustic environments. Most of the austenite stainless steels have been reported to fail owing to stress corrosion cracking in the heat effected zones (HAZ). The ASME code case N-47 specifies the allowable stress for a welded component as $0.8Rx\sigma_{min}$ where r is the ratio of rupture strength of the weld metal to that of the base metal and σ_{min} is the expected minimum stress to rupture for the base metal [1]. The austenite stainless steels consisting of austenite and ferrite phases are susceptible to hot cracking due to the transformation of ferrite to carbide [2].

This paper focuses on the evaluation of creep strength of weld beads prepared from austenite stainless steel at welding temperatures during manual metal arc welding (MMAW) process.

2. Experimental procedure

The MMAW welding was carried out on 5 mm austenite stainless steel plates. The chemical composition of austenite stainless steel plates is given in Table-1. Systematic pre-welding surface preparation was carried out to avoid weld pore formation during MMAW welding process. Constant load creep rupture test were carried at 600^0C and 700^0C in stress levels varying between 100 to 325 MPa. The weld metals were tested in the as-cast weld condition.

Table-1: the chemical composition austenite stainless steel

C	Ni	Cr	Mo	Mn	Si	S	P	Cu	B
0.06	12.00	18.7	2.05	1.40	0.57	0.01	0.01	0.05	0.005

3. Results and Discussion

Each experiment was repeated twice and each characteristic value is an average of two readings.

The variation of rupture life with applied stress for the weld metals at 600^0C and 700^0C are shown in Fig-1 and –2. It can be noticed that the rupture strengths of weld bead is higher than the expected values specified by ASME code. It can also be observed that the higher rupture strengths are registered for the creep rupture test carried at 600^0C than at 700^0C.

The relation between rupture strength and rupture life for austenite stainless steel tested at 600^0C and 700^0C are given respectively by

Rupture strength in MPa = -19.025 x ln (Rupture life in hrs) + 376.99

Rupture strength in MPa = -17.500 x ln (Rupture life in hrs) + 287.87

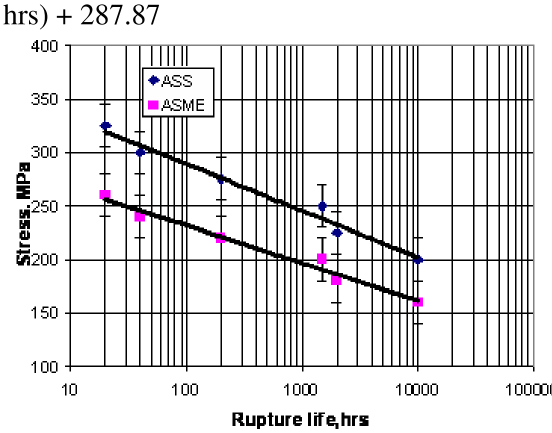

Fig-1 Variation of rupture life with applied stress at 600^0C

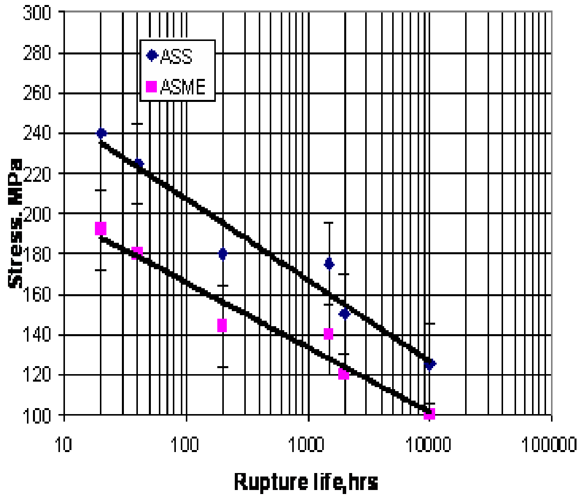

Fig-2 Variation of rupture life with applied stress at 700^{0}C

Fig-3 shows the transformation of microstructure in weld metal after exposure to creep at 600^{0}C and 700^{0}C. The δ-ferrite transforms to ferrite in the following sequence:

- Initially the δ-ferrite network breaks down forming carbides in about 60 hrs.
- Continued exposure results in the formation of an intermetallic phase σ
- On further exposure the intermetallic phase particles coarsen to form islands.

The same kind of trend was observed in both the tests. The only difference in the microstructure is the size of intermetallic phase. The weld metal at 700^{0}C results large islands. The failure of weld beads is due to nucleation, growth and linkage of cavities at the coarse and brittle σ islands.

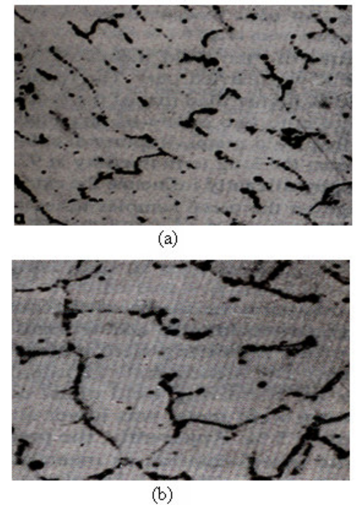

Fig-3 Microstrucutres reveling the transformation of ferrite into carbides (a) 600^{0}C and (b) 700^{0}C

4. Conclusion

The higher rupture strengths are registered for the creep rupture test carried at 600^{0}C than at 700^{0}C in the weld metal produced by the MMAW welding of 5 mm austenite stainless steel plates. The failure of weld beads is due to the transformation of ferrite to carbides and also owing to the nucleation, growth and linkage of cavities at the coarse and brittle σ islands.

References:

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