Development of Temper Bead Welding Process for Weld Overlay of Dissimilar Welds

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1. Introduction

In recent years, the dissimilar weld metal used to connect stainless steel piping and low alloy steel or carbon steel components have experienced cracking in nuclear reactor piping systems. The cracking has been observed in several Pressurized Water Reactors in overseas. In Several cases, the cracking was repaired using structural weld overlays, a repair technique that has been in use in the U.S. in Boiling Water Reactors for over twenty years. Although weld overlays have been used primarily as a repair for flawed piping, they can also be applied at locations that have not yet exhibited any cracking, but are considered susceptible to cracking.[1]
The purpose of this research is to develop the temper bead weld process for the weld overlay of the dissimilar weld pipe. We developed equipment for the overlay system, applied Procedure Qualification(PQ) for the temper bead welding process.

2. Experiment & Results

2.1 Experiment method

The base was SA508 Grade3 Class1, the filler materials were alloy 52 and 52M. The chemical compositions of the base and the filler materials are shown in table 1 and 2. The conditions of welding parameters are shown in table 3.

The welding process was used as the temper bead welding method and the welding position was vertical up process.[2][3]

Table. 1 The chemical compositions of base material.

Element	C	Mn	P	S	Si
Wt %	~0.25	1.2 ~1.5	~0.025	~0.025	0.15 ~0.4
Element	Ni	Cr	Mo	Va	Fe
Wt %	0.4 ~1.0	~0.25	0.45 ~0.6	~0.05	Rem.

Table. 2 The chemical compositions of filler material.

Element	C	Mn	Fe	S	Si	Mo	Cu
Wt %	~ 0.04	~ 1.0	7.0 ~11.0	~ 0.015	~ 0.5	~ 0.5	~0.3
Element	Cr	Ti	Al	P	Nb	Ni +Co	
Wt %	28 ~31.5	~1.0	~1.1	~0.02	~ 0.1	Bal.	

Table. 3 The welding conditions.

Process	GTAW	Shield gas	Ar, 22*l*/min
Polarity	DCSP	Gas cup	30mm
Electrode	4.0mm, EWTh-2	Position	Vertical up
Frequency	2.8 Hz	Duty	0.4
Interpass temp.	Max. 65^{O}C	overlap	50%
Current	200~260 A	Welding speed	80~120 mm/min

※ DCSP : Direct Current Straight Polarity
※ EWTh-2 : 2% Thorium Tungsten Electrode (AWS A5.12)

2.2 Results

Figure 2, 3 and 4 show the bead shape, the macrostructure and the microstructure after temper bead welding. Figure 5 shows the hardness test after temper bead welding. Table 4 shows the mechanical test results.

From these experiments, we accomplished the good results. The optimum welding conditions were average current 170A, welding speed 80mm/min and wire feeding rate 690mm/min.

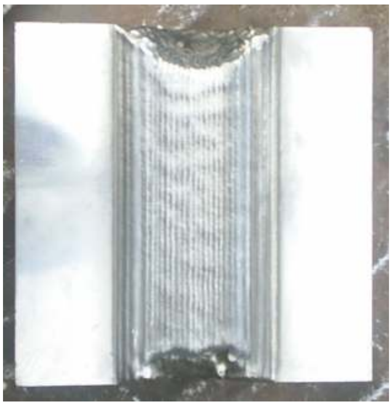


Figure 2. Bead shape

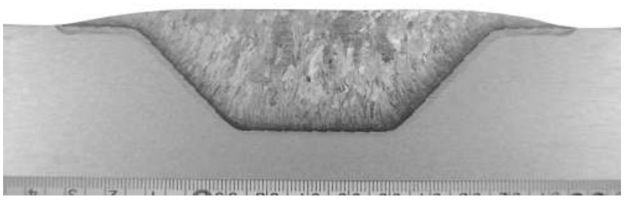
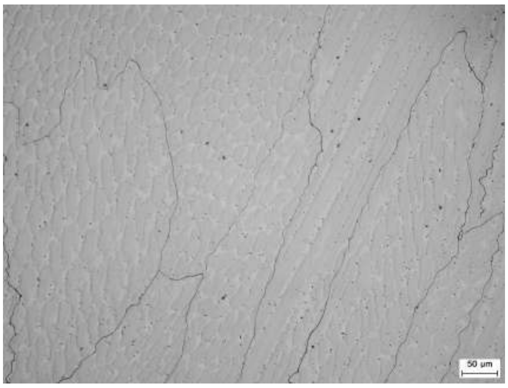
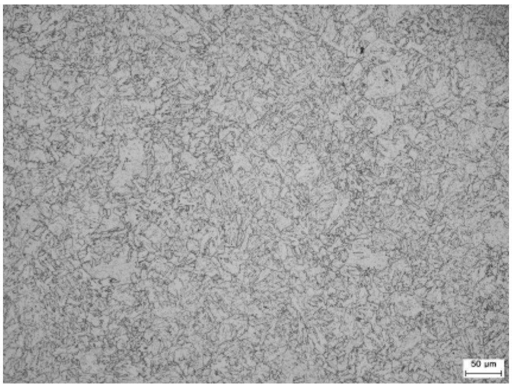


Figure 3. Macrostructure



(a) Weld metal

(b) Heat affected zone



(c) Base metal

Figure 4. Microstructure

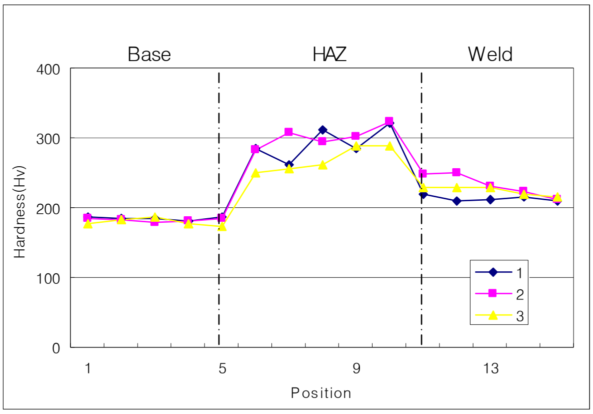


Figure 5. Hardness(applied load : 10kg)

Table. 4 Mechanical test results

No.	Tensile Test (MPa)	Charpy V-Notch Test			Guided Bend Test (mm)
		Absorbed Energy (J)	Lateral Expansion (mils)	Percent Shear (%)	
	550 ~ 725	HAZ>Base			Crack < 3.0
1	622/616	HAZ : 328 Base : 220	HAZ : 95 Base : 94	HAZ : 94 Base : 84	Max.4.0
2	633/623	HAZ : 295 Base : 197	HAZ : 95 Base : 89	HAZ : 93 Base : 68	No Open Crack
3	633/623	HAZ : 233 Base : 118	HAZ : 81 Base : 63	HAZ : 44 Base : 37	No Open Crack

3. Conclusions

We are underway to develop a weld overlay system and the temper bead weld process. The results of temper bead weld experiment is as follows.

REFERENCES

[1] C. King and G. Frederick, “Materials Reliability Program : Technical Basis for Preemptive Weld Overlays for Alloy 82/182 Butt Welds in PWRs(MRP-169), EPRI Technical Report.

[2] ASME Code Case, N-740, Dissimilar Metal Weld Overlay for Repair of Class 1, 2, and 3 Items Section XI, Division 1.

[3] D.W. Gandy, S.J. Findlan and W.J. Childs, Fatigue, Fracture, and Risk, ASME PVP Vol. 215, 117-122 (1991).