DIFFUSION BONDING OF VANADIUM ALLOYS

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OBJECTIVE

The objective of this task is to investigate the potential of diffusion bonding for joining of vanadium-base alloys.

SUMMARY

Preliminary investigations are in progress to evaluate the potential of diffusion bonding processes for joining vanadium-base alloys. Diffusion bonds were prepared on 3.8 mm thick V-4Cr-4Ti alloy plate on a 50 KVA welder with a range of process parameters. Preliminary microstructural analyses conducted on the test samples indicated that bonding was achieved for a range of process parameters.

BACKGROUND

Continuous diffusion bond-type joining (roll bonds) potentially offers several advantages for fabrication of vanadium alloy for firstwall/blanket systems. Current blanket designs for vanadium/lithium systems provide for joining of ~4 mm thick sheet with long weld joints. This type of joining produces minimal effects on the alloy microstructure since melting is not required. Also, the extent of the heat-affected zone is more limited than in most types of welds. This approach may also reduce the stringent environmental control required to avoid excessive oxidation effects frequently observed in more conventional weld processes.

EXPERIMENTAL PROGRAM

Weld specimens were prepared from 3.8 mm thick V-4Cr-4Ti alloy (heat #832665) in the annealed condition. Specimens were surface polished and cleaned with acetone before joining. Lap-type diffusion bonds on these sheet specimens were produced on a 50 KVA welder at ANL. Process parameters that were set or varied included: transformer tap, tip geometry and size, tip force, preweld squeeze time, weld time, power setting, and post-weld hold time. Based on previous experience for other materials, several of these parameters were held constant for the first series of experiments. Primary variables included weld time and power setting.

Diffusion bonds of the specimens were metallurgically prepared and etched to reveal the microstructural features of the joints. A Nikon MSZ-B stereomicroscope, a Nikon optical microscope and a COHU high performance CCD camera were used for the microstructural evaluation.

RESULTS AND DISCUSSION

Table 1 presents a summary of the parameters and results of the diffusion bonds produced in the first series of experiments. The apparent bond strength of five of the bonds appeared to be quite good. The parameters used for test #1 produced a large heat affected zone and significant porosity in the joint (see Figure 1) indicating excessive power in this test. Tests 2, 3, 7, 10, 11, and 12 resulted in either no bonding or limited bonding, indicating insufficient power. Tests 4, 5, 6, and 8 appear to provide good bond strength with only modest restructuring. Test #6 appears to provide the best joint with apparent good bond strength with minimal restructuring. Results

obtained thus far are quite encouraging since the bond strength appears to be good and only modest changes in microstructure of the bond region are observed for several machine parameters.

TABLE I. Diffusion bonding parameters and bond characteristics of V-Cr-Ti alloy

Test No.	Squeeze (Cycles)	Weld time (Cycles)	Heat (%)	Hold time (Cycles)	Bond characteristic	Porosity
1	50	50	95	30	Good bond, grain growth	Y
2	30	25	95	30	Minimal bond	N
3	30	20	95	30	No bonding	
4	30	99	75	30	Good bond, significant structure change	N
5	30	75	75	30	Good bond, some structure change	N
6	30	50	75	30	Good bond, minimal structure change	N
7	30	25	75	30	No bonding	
8	30	99	70	30	Good bond, some structure change	N
9	30	99	65	30	Minimal bond	N
10	30	75	65	30	Broke on cooling	
11	30	99	50	30	No bonding	
12	30	25	50	30	No bonding	

FUTURE WORK

More detailed analyses will be conducted on these test specimens to further characterize the bond microstructure, strength, and any contamination; and to develop a better understanding of the effects of the machine parameters on the bond characteristics. Additional test samples will be prepared with more optimal process parameters and mechanical test specimens will be prepared from samples with good bonds.

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Figure 1 Cross section view of diffusion bond of V-Cr-Ti alloy (Test No. 1 in TABLE I) showing porosity and grain growth due to overheating.

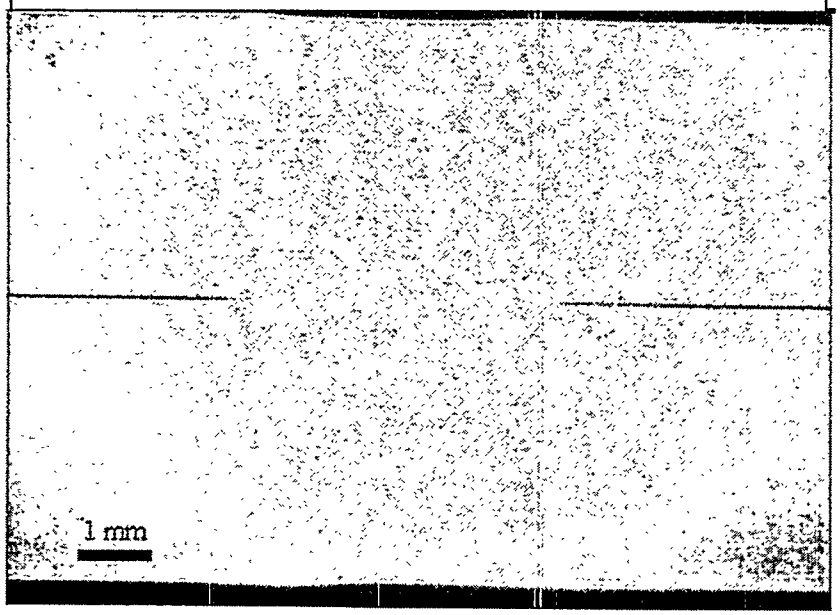

Figure 2 Cross section view of diffusion bond of V-Cr-Ti alloy (Test No. 6 in TABLE I) indicating good bond and minimal structure change of the bond.