STATUS OF VANADIUM ALLOY IRRADIATION EXPERIMENT X530 IN EBR-II*

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OBJECTIVE

The objective of the X530 experiment in EBR-II was to obtain early irradiation performance data, particularly the fracture properties, on the new 500-kg production heat of V-4Cr-4Ti material. Irradiation was completed in EBR-II and postirradiation disassembly is underway.

SUMMARY

To obtain early irradiation performance data on the new 500-kg production heat of the V-4Cr-4Ti material before the scheduled EBR-II shutdown, an experiment, X530, was expeditiously designed and assembled. Charpy, compact tension, tensile and TEM specimens with different thermal mechanical treatments (TMT) were enclosed in twelve subcapsules and irradiated in the last run of EBR-II, Run 170A. The accrued exposure was 35 effective full power days, yielding a peak damage of ≈4 dpa in the specimens. In this reporting period, the irradiation vehicle was disassembled at the Hot Fuel Examination Facility (HFEF) at ANL-West and the subcapsules shipped to ANL-East for disassembly. Subcapsule disassembly is scheduled to be completed at ANL-East in the next reporting period.

PROGRESS AND STATUS

Introduction

The X530 experiment was conducted to provide an early confirmation on the irradiation performance of the new 500-kg production heat of V-4 wt.%Cr-4 wt.%Ti alloy. For comparison, several previous laboratory heats of ternary and binary vanadium alloys with known properties and a Russian heat of V-4Cr-4Ti were included in the experiment. TMT of the material before irradiation was a key test parameter for this experiment. A ^{10}B-doped V-4Cr-4Ti material was included to study the effect of helium generation on materials properties.

The specimens were enclosed in 12 lithium-bonded subcapsules, which were contained in two flow-through (weeper) capsule tubes for the irradiation. The list of specimens included in the X530 experiment is shown in Table 1 and specimen loadings in the 12 subcapsules are summarized in Table 2.

The irradiation was conducted in Run 170A from August 9 through September 27, 1994. The core position was 2F1 with a fast flux of 2.4 x 10^{15}n/cm^2/s, E>0.1 MeV. The accrued exposure was 35 effective full power days, yielding a peak damage of ≈4 dpa in the specimens. To accommodate the needs of this experiment, the reactor inlet temperature for Run 170A was lowered from the nominal 371 to 366°C. The reduced inlet temperature and the flow-through capsule design yielded in the test specimens the desired low temperature of ≈375-400°C.

Status of Vehicle Disassembly

In this reporting period, the X530 irradiation vehicle was discharged from EBR-II and transferred to the adjacent HFEF for disassembly. Neutron radiographs of the subcapsules in the two flow-through capsule tubes were taken at HFEF. The data, shown in Fig. 1, indicate the condition of the subcapsules to be normal and that the locations of specimens in the subcapsules to be as expected.

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Table 1. Types and Numbers of Specimens Irradiated in the X530 Experiment

Composition, wt.%	ANL ID Number	DCT-A, 0.140 in.	DCT-B, 0.230 in.	1/3-size Charpy	SS-3 Tensile	TEM
V-3Ti-1Si	BL-45	-	-	5	2	-
V-5Ti	BL-46	3	-	5	2	5
V-4Cr-4Ti	BL-74	-	4	6	-	-
V-7Cr-5Ti	BL-49	3	-	5	2	5
V-5Cr-3Ti	BL-54	-	-	5	-	-
V-3Ti	BL-62	3	-	5	2	4
V-5Cr-5Ti	BL-63	-	2	5	2	-
V-5Cr-5Ti	BL-63-CR950	1	-	5	2	3
V-5Cr-5Ti	BL-63-CR1050	1	-	5	2	3
V-5Cr-5Ti	BL-63-WR950	1	-	5	2	3
V-5Cr-5Ti	BL-63-WR1050	1	-	5	2	3
V-4Cr-4Ti-RF	BL-69	-	-	-	5	5
V-4Cr-4Ti-B	BL-70	4	4	6	5	5
V-4Cr-4Ti	BL-71-WR950	4	-	6	5	5
V-4Cr-4Ti	BL-71-WR1050	4	-	6	5	5
V-4Cr-4Ti	BL-71-WR1125	3	-	6	5	5
SUBTOTAL		28	10	80	43	51

B = Boron doped (250 appm ^{10}B)

RF = Russian Federation

CR950 = Cold roll and final anneal at 950°C

CR1050 = Cold roll and final anneal at 1050°C

WR950 = Warm roll and final anneal at 950°C

WR1050 = Warm roll and final anneal at 1050°C

WR1125 = Warm roll and final anneal at 1125°C

The routine water rinses of the flow-through capsules during the transfer from EBR-II to HFEF did not sufficiently remove the residual sodium in the capsules. To remedy this situation for subsequent handling at ANL-E, the capsules were cut open at HFEF and the subcapsules removed and cleaned individually with alcohol. The 12 sodium-free subcapsules were then placed in a shipping tube and shipped to ANL-East for disassembly and specimen retrieval.

Because of the high induced radioactivity of the subcapsules (made of stainless steel), the procedure previously established at ANL-East for processing lithium-bonded TZM subcapsules had to be modified. This procedural modification has been accomplished and an appropriate hot cell area has been identified for the work. Preparations are underway in this hot cell area to conduct the work.

Table 2. Subcapsule Specimen Loading for X530

Capsule	Specimen Type	Material Composition	Quantity	Capsule	Specimen Type	Material Composition	Quantity
S1	DCT-B	V-4Cr-4Ti (BL-74)	2	S8	Tensile	V-3Ti (BL-62)	2
	Charpy	V-3Ti-1Si (BL-45)	5		Tensile	V-5Ti (BL-46)	2
	Charpy	V-5Ti (BL-46)	5		Tensile	V-7Cr-5Ti (BL-49)	2
	Charpy	V-7Cr-5Ti (BL-49)	2		Tensile	V-3Ti (BL-62)	2
					Tensile	V-5Cr-5Ti (BL-63	2
S2	DCT-B	V-4Cr-4Ti (BL-74)	2		Tensile	V-5Cr-5Ti (BL-63)	2
	Charpy	V-4Cr-4Ti (BL-74)	6		Tensile	V-5Cr-5Ti (BL-63)	2
	Charpy	V-7Cr-5Ti (BL-49)	1		Tensile	V-5Cr-5Ti (BL-63)	2
	Charpy	V-5Cr-3Ti (BL-54)	5		Tensile	V-5Cr-5Ti (BL-63)	2
					Tensile	V-4Cr-4Ti (RF)	3
S3	DCT-B	V-5Cr-5Ti (BL-63)	2		TE	V-5Ti (BL-46)	5
	Charpy	V-7Cr-5Ti (BL-49)	2		TE	V-7Cr-5Ti (BL-49)	5
	Charpy	V-3Ti (BL-62)	5		TE	V-3Ti (BL-62)	4
	Charpy	V-5Cr-5Ti (BL-63)	5		TE	V-5Cr-5Ti (BL-63)	3
					TE	V-5Cr-5Ti (BL-63)	3
S14	DCT-B	V-4Cr-4Ti-B (BL-70)	2		TE	V-5Cr-5Ti (BL-63)	3
	Charpy	V-5Cr-5Ti (BL-63)	5		TE	V-5Cr-5Ti (BL-63)	3
	Charpy	V-4Cr-4Ti-B (BL-70)	6				
				S9	Tensile	V-4Cr-4Ti (RF)	2
S5	DCT-B	V-4Cr-4Ti-B (BL-70)	2		Tensile	V-4Cr-4Ti-B (BL-70)	5
	Charpy	V-5Cr-5Ti (BL-63)	5		Tensile	V-4Cr-4Ti (BL-71)	5
	Charpy	V-4Cr-4Ti (BL-71)	6		Tensile	V-4Cr-4Ti (BL-71)	5
					Tensile	V-4Cr-4Ti (BL-71)	5
S6	DCT-A	V-5Ti (BL-46)	2		TE	V-4Cr-4Ti (RF)	5
	Charpy	V-5Cr-5Ti (BL-63)	5		TE	V-4Cr-4Ti-B (BL-70)	5
	Charpy	V-4Cr-4Ti (BL-71)	6		TE	V-4Cr-4Ti (BL-71)	5
					TE	V-4Cr-4Ti (BL-71)	5
S7	DCT-A	V-5Ti (BL-46)	1		TE	V-4Cr-4Ti (BL-71)	5
	DCT-A	V-7Cr-5Ti (BL-49)	1				
	Charpy	V-5Cr-5Ti (BL-63)	5	S10	DCT-A	V-7Cr-5Ti (BL-49)	2
	Charpy	V-4Cr-4Ti (BL-71)	6		DCT-A	V-3Ti (BL-62)	3
					DCT-A	V-4Cr-4Ti (BL-71)	3
				S11	DCT-A	V-5Cr-5Ti (BL-63)	1
					DCT-A	V-5Cr-5Ti (BL-63)	1
					DCT-A	V-5Cr-5Ti (BL-63)	1
					DCT-A	V-5Cr-5Ti (BL-63)	1
					DCT-A	V-4Cr-4Ti-B (BL-70)	4
				S12	DCT-A	V-4Cr-4Ti (BL-71)	4
					DCT-A	V-4Cr-4Ti (BL-71)	4

FUTURE ACTIVITIES

In the next reporting period, all 12 subcapsules in X530 are scheduled to be disassembled. Bond lithium will be removed by dissolution with liquid ammonia and alcohol. The cleaned specimens will be available for examination and testing.

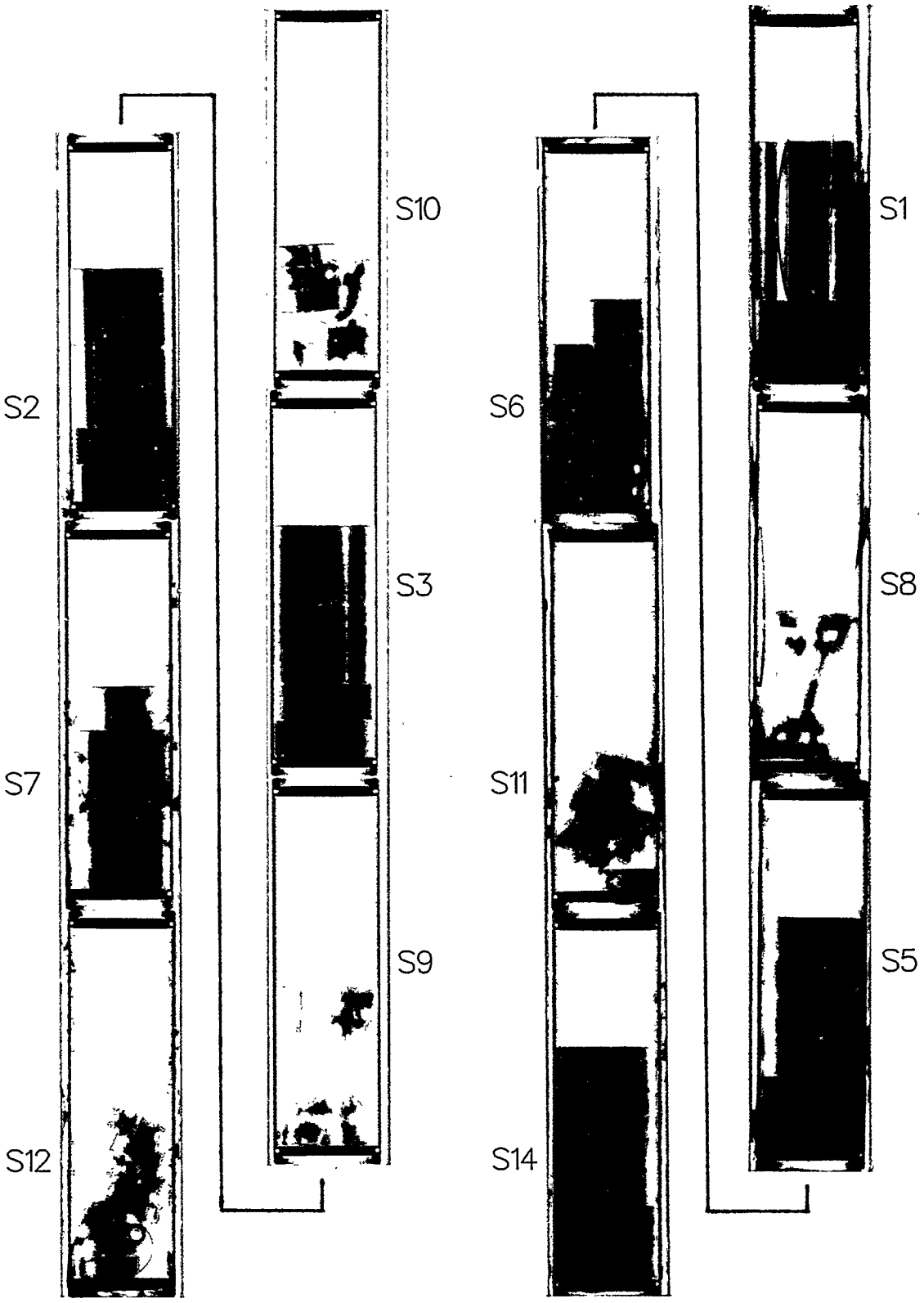

Fig. 1. Radiograph of X530 subcapsule in two flow–through capsule tubes after irradiation. All features of subcapsules and specimens appear normal.