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BRASKI

Alloy Development for Irradiation Performance

Semiannual Progress Report
For Period Ending September 30, 1985

U.S. Department of Energy
Office of Fusion **Energy**

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1.1 Materials Handbook for Fusion Energy Systems (McDonnell Douglas Astronautics Company - St. Louis Division) 2

The July release of the 10th publication package of the Materials Handbook for Fusion Energy Systems to the approximately YO handbook users represented the achievement of a number of milestones. First and foremost, the release of these 30 data pages represents the first step towards reducing the backlog of over 100 data sheets awaiting pubtication. Second it represents the initiation of the handbook into the world of computer generation and subsequent support services that can be provided via the MFE computer network.

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Results are reported for a test of the 6J Japanese experiment in the Oak Ridge Research Reactor. Maximum fast fluxes above 0.1 MeV were 2.0 × 10^{14} n/cm^2-s producing about 4.5 dpa phr year in 316 stainless steel.

Analysis has been completed for the hafnium shield tests in the removable beryllium positions of the High Flux Isotope Reactor (ORNL). The shield reduces the thermal flux by YO%, the epithermal flux by 50%, and the fast flux by only 5%. Yearly helium production in 316 stainless steel, is thus reduced by a factor of 26 with little effect a displacement damage production. These new spectral analyses have been used to reanalyze previously reported results from the RBI and RE2 materials irradiations in HFIR; the damage rates have been increased by 20--30%.

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A project is presently under way to improve and increase the irradiation facility capabilities in the HFIR. These improvements will permit the installation of two instrumented experiments in the target region of the HFIR by the fourth quarter of FY 1986. Additionally, the number of large RB positions Will be increased from four to eight, and their diameter will be increased from 35 to 48 mm. This phase of the project is scheduled to be completed by May 1987.

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MFE-6J and -7J started irradiation in the ORR With cycle 172F on June 28, 1985. The total accumulated power through September 30, 1985 is 72.81 d at 30 MW.

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Three binary Fe-Mn and six Fe-Mn-Cr ternary alloys have **been** *irradiated in FFTF at temperatures of 420, 500 and 600°C to exposures ranging from 9-14 dpa. In contrast to the behavior of Fe-Cr-Ni alloys irradiated under comparable conditions there is essentially no dependence of void swelling on chromium or rmnganese content, and there-also appears to be no dependence on irradiation temperature. Like Fe-Cr-Ni alloys, however, Fe-Cr-Mn and Fe-Mn alloys do swell at ~1%/dpa after the transient regime.*

While density change data indicate an apparent weak dependence of swelling on manganese level, microscopy shows that mdiation-induced second phases that form may be responsible for a densification of the matrix. This densification approaches 2.2% at **35%** *manganese.*

3.2 Phase Stability During Annealing and Aging in Low-Activation Fe-Cr-Mn Austenitic Stainless Steels (Oak Ridge National Laboratory) 54

The first group of laboratory heats of low-activation, manganese-stabilized austenitic steels were aged for 168 h at 800°C, following solution annealing and cold working, to explore their relative precipitation responses. Delta (δ) ferrite, which was present in many alloys after solution annealing, **was** *absent in the cold-worked materials after aging. These aged alloys recovered and/or recrystallized, and the matrix became completely austenitic, with varying amounts of σ phase and $M_{23}C_6$ (τ) precipitates. Only the 15Cr-19Mn-0.4C alloy had finely distributed τ carbide particles without any evidence of σ phase. Both the σ and τ phases contained substantial amounts of rmnganese, whereas in nickel-stabilized steels, these phases would reject nickel.*

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Transmission electron microscopic examination of quenched and tempered 9Cr-2.5W-0.3V-0.15C low activation ferritic steel revealed tempered lath-type martensite with precipitation of rod and plate-like $M_{23}C_6$ and MC carbides at lath and grain boundaries. Extraction replicas of precipitates were found to be predominantly $M_{23}C_6$ carbides analyzed by diffraction. The areal density and mean particle size of carbide precipitates were appreciably increased after thermal aging at 600°C for 100 hrs. More rod-like $M_{23}C_6$ were found along prior austenite grain boundaries and martensite lath boundaries in the thermally aged specimens.

The elevated-temperature tensile strengths of this material were measured and are about 10% higher than the average tensile data of commercial heats of 9Cr-1Mo and modified 9Cr-1Mo steels up to a temperature of 650°C, with equivalent uniform elongation and -50% decrease in total elongation. The fracture toughness (K_{IC}) of this alloy is predicted to be about 10-20% lower than commercial heats of modified 9Cr-1Mo steel, but is comparable to some experimental heats of 9Cr-1MoVNb steel. The impact test results show a DBTT at —25°C and upper shelf energy of 1/3 size CVN precracked specimen at 2.2 Joules 137.2 J/cm² normalized fracture energy). Fractographic examination of tensile tested specimens shows a mixed mode of equiaxed dimple and elongated dimple at test temperatures above 500°C. The modification of the GA3X alloy composition for optimization of rmterials properties is discussed. However, the proposed low activation ferritic steel show the promise of improved mechanical properties over 9Cr-1Mo steels.

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