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THE EFFECT OF DOSE AND TEMPERATURE OF NEUTRON IRRADIATION ON MECHANICAL PROPERTIES AND STRAIN LOCALIZATION OF AUSTENITIC STAINLESS STEELS

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The sensitivity of mechanical properties of austenitic stainless steels (AuSS) to irradiation temperature after high dose neutron irradiation (up to 57 dpa), already highlighted in one of our previous publications (https://doi.org/10.1016/j.actamat.2022.117858), shows significant variation from severe embrittlement to increased ductility. Thus, further study of how irradiation temperature affects mechanical properties and strain localization in AuSS is necessary to predict the behavior of such materials during and after irradiation.
For this purpose, specimens of AuSS were cut from fuel wrappers of the sodium-cooled BN-350 fast reactor located in Aktau, Kazakhstan at various heights in the core, corresponding to a range of doses (0.1–57 dpa) and irradiation temperatures (280–405℃). These were subjected to room-temperature uniaxial tensile testing combined with digital image correlation and microstructural analysis. It was found that in different temperature-dose ranges, different parameters determine the ductility of AuSS at room temperature. Dose plays a significant role in the form of changes to strength and plasticity of specimens irradiated to low doses of irradiation at lower temperatures. On the other hand, irradiation temperature plays a defining role in shaping mechanical response in the case of high dose irradiation at high temperatures. We hypothesize that this behavior was caused by a unique set of conditions: An increase in strain hardening due to strain-induced martensite, and to the formation of large defects like voids and precipitates specifically at higher temperatures.
Within the framework of this research, the universality of the conclusions for all metastable AuSS is confirmed based on the results of presented studies, and as published in the open literature by other authors. Therefore, it can indeed be generalized to this highly-used class of structural materials, and is therefore highly applicable to many future uses of these materials in Gen IV reactor designs.

Section

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