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Influence of Thermal Ageing on Microstructural Features and Mechanical Properties of Reduced Activation Ferritic/Martensitic Grades

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Abstract : Reduced Activation Ferritic/Martensitic (FM) steels like EUROFER are of interest for first wall application in the future demonstration (DEMO) fusion reactor. Depending on the final design codes for the DEMO reactor, the first wall material will have to function in low-temperature mode or high-temperature mode, i.e. around 250-300°C of above 550°C respectively. However, the use of RAFM steels is limited up to a temperature of about 550°C. For the low-temperature application, the material suffers from irradiation embrittlement, due to a shift of ductile-to-brittle transition temperature (DBTT) towards higher temperatures upon irradiation. The high-temperature response of the material is equally insufficient for long-term use in fusion reactors, due to the instability of the matrix phase and coarsening of the precipitates at prolonged high-temperature exposure. The objective of this study is to investigate the influence of thermal ageing for 1000 hrs and 4000 hrs on microstructural features and mechanical properties of lab-cast EUROFER. Additionally, the ageing behavior of the lab-cast EUROFER is compared with the ageing behavior of standard EUROFER97-2 and T91. The microstructural features were investigated with light optical microscopy (LOM), electron back-scattered diffraction (EBSD) and transmission electron microscopy (TEM). Additionally, hardness measurements, tensile tests at elevated temperatures and Charpy V-notch impact testing of KLST-type MCVN specimens were performed to study the microstructural features and mechanical properties of four different F/M grades, i.e. T91, EUROFER97-2 and two lab-casted EUROFER grades. After ageing for 1000 hrs, the microstructures exhibit similar martensitic block sizes independent on the grain size before ageing. With respect to the initial coarser microstructures, the aged microstructures displayed a dislocation structure which is partially fragmented by polygonization. On the other hand, the initial finer microstructures tend to be more stable up to 1000hrs resulting in similar grain sizes for the four different steels. Increasing the ageing time to 4000 hrs, resulted in an increase of lath thickness and coarsening of M23C6 precipitates leading to a deterioration of tensile properties.

Keywords : ageing experiments, EUROFER, ferritic/martensitic steels, mechanical properties, microstructure, T91
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