Compatibility of Structural Materials for Fusion Reactors with Candidate Blankets and Coolants

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Corrosion and deposition rates and mechanisms have been determined of austenitic (AISI 316, AISI 304, AISI 316L, Nitronic 33, Nitronic 40, Carpenter 18/18 plus), ferritic (WN 1.4922, EM12, DTO2) steels, the light alloy Ti 6Al4V and refractory alloys (Nb, V20%Ti, TZM) exposed in the hot and cold section of a pumped loop system. The loop system was operated for total exposure times up to 7400 h with pure lithium (50 to 200 ppm N_2) at temperatures of 400°C (hot section) and 355°C (cold section). The forced convection loop is equipped with a cold and a hot trap and a magnetic trap for removing metallic impurities present in the lithium.

The tests have been carried out at various velocities (1,785.s^{-1} to 0.046 m.s^{-1}) with pre-exposed and new specimens, Nitronic 33, Nitronic 40, Carpenter 18/18 plus are Mn modified type AISI 304 or AISI 316 alloys and DTO2 is an oxide dispersion strengthened ferritic with nominal composition Fe 13Cr 1.5Mo 3.5Ti 2TiO_2.

The measured corrosion rates at 400°C of ferritic steels (in the range between 4.10^{-6}m.a^{-1} and 12.10^{-6}m.a^{-1}), austenitic steels (in the range between 1.10^{-5} m.a^{-1} and 3.10^{-5} m.a^{-1}) and of refractory and light alloys (in the range between 1.10^{-7} m.a^{-1} and 1.10^{-6} m.a^{-1}) are interpreted taken into account the structural and chemical changes at the alloy - lithium interface, the chemical composition of the lithium (metals and non-metals) and the chemical composition of corrosion and deposition products found in the heating and cooling zone of the loop system.

The observed influence of the lithium velocity on the corrosion rates of all tested alloys is explained by the hydraulic condition in the hot test sections at different lithium velocity.
The influence of on-line purifying of the lithium by magnetic trapping on the corrosion rates of structural materials is discussed as a function of the resulting subsaturation of the lithium and the nature (chemical composition, morphology, etc.) of the deposited species found in the magnetic trap system.
The measured corrosion rates are discussed and compared with measured and reported corrosion rates with other potential coolants and blankets (e.g. $Li_{17}Pb_{83}$ and solid Li_2O).
The mechanisms determing the increase of the corrosion rate of pre-exposed and cleaned specimens is discussed in relation to caustic attack and sensilibisation of grain boundaries.

PUBLISHED LITERATURE

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