CHARACTERIZATION OF STEEL FOR FISSION AND FUSION APPLICATIONS

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Eurofer97 Steel

- NRG performed PIE on 300 °C and 60 °C irradiated Eurofer97 steel including tensile (Figure 1), fracture toughness and impact tests (Figure 2).

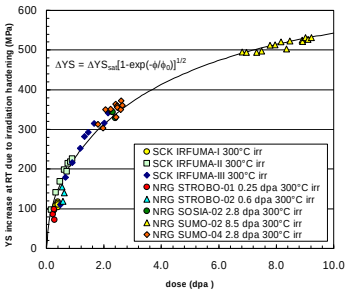

Figure 1 yield stress hardening for Eurofer97

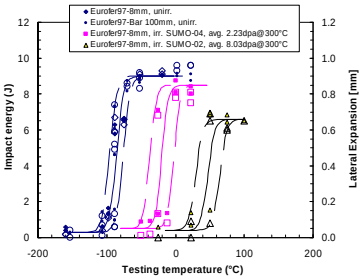

Figure 2 impact transition curves for Eurofer97

Irradiation induced stress relaxation of Eurofer97 steel

- The irradiation induced stress relaxation behaviour of Eurofer97 at 300 ºC up to 3.4 dpa and under pre-stress loads typical for the ITER applications is investigated.
- The stressed bolts (Figure 3) and the bent strips were assembled and irradiated to several dose levels.
- The irradiation-induced stress relaxation is independent on the pre-stress level. 10 to 12 % of the stress relaxation may be reached after a dose of 0.1 dpa (Figure 4), and after an irradiation dose of 2.7 dpa 42-47 % of the original pre-stress is retained in Eurofer97.

Figure 3 pre-stressed bolt specimen

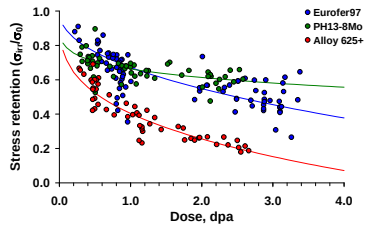

Figure 4 stress relaxation results

Re-welding of stainless steel

- A repair of the ITER VV would require the re-welding of the thick section of irradiated stainless steel by multi-pass TIG welding (Figure 5 and Figure 6) or alternative welding techniques.
- The welding process model has been applied to simulate the welding of irradiated specimens. The numerical results are in good agreement with the experimentally obtained values.

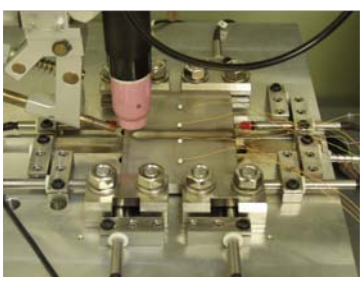

Figure 5 TIG welding set-up

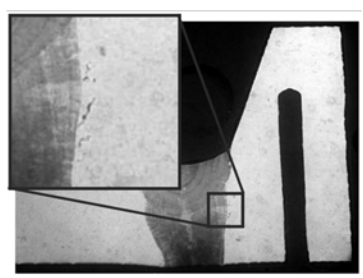

Figure 6 helium damage in irradiated steel

ODS Eurofer97 Steel

- The most advanced approach for the breeding blankets envisages the use of oxide-dispersion strengthened (ODS) steels to achieve service temperatures as high as 650 °C.
- The "EU batch" of ODS Eurofer97 (0.3 wt.% Y_2O_3) is being characterized by NRG. Mechanical characterization includes tensile (Figure 7 and Figure 8), fracture mechanics and impact tests.

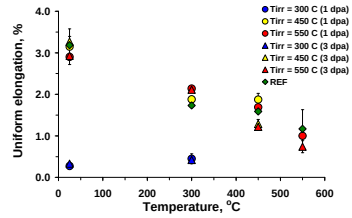

Figure 7 yield stress for ODS-Eurofer97 steel

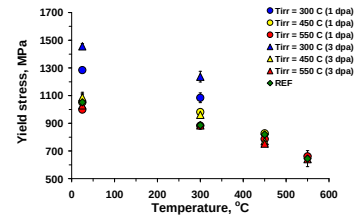

Figure 8 uniform elongation for ODS-Eurofer97 steel

- ODS steel is included in ExtreMat irradiation campaign (Figure 9): ExtreMat-I: low dose, 300°C and 550°C, ExtreMat-II: high dose, 600°C and 900°C.
- In ExtreMat NRG will perform a large part of pre- and post-irradiation characterization including tensile and bending tests (Figure 10), physical properties and microstructure characterization.

Figure 9 ExtreMat specimen selection

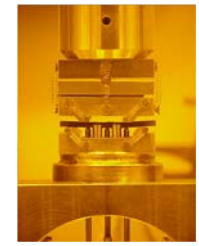

Figure 10 bending set-up (in Hot Cell)

- Within GetMat project NRG will perform SEM/TEM microstructural investigations of irradiated Eurofer97 ODS steel and the assessment of the feasibility of explosive and friction stir welding of ODS steels.

T91 and 316 Steels and Weldments

- Characterization of the synergistic effects of LBE and neutron irradiation up to 2 dpa on the mechanical properties and microstructure of T91 and 316L and welds will be done in GetMat project.

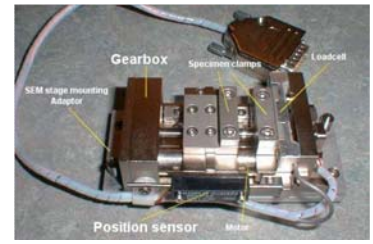

Figure 11 micro test system used in GetMat project

- To improve the reactor pressure vessels of future V/HTRs creep experiments have been performed to determine the negligible creep temperature of irradiated T91 thick section weldment.