IFMIF - DESIGN STUDY FOR IN SITU CREEP FATIGUE TESTS (P4-I-73)

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While the high flux volume (20-50 dpa/fpy) of the International Fusion Materials Irradiation Facility (IFMIF) is dedicated to the irradiation of ~1100 qualified specimens that will be post irradiation examined after disassembling in dedicated Hot Cells, various in situ experiments are foreseen in the medium flux volume (1-20 dpa/fpy). Of specific importance for structural lifetime assessments of fusion power reactors are instrumented in situ creep-fatigue experiments, as they can simulate realistically a superposition of thermal fatigue or creep fatigue and irradiation with fusion relevant neutrons.

Based on former experience with in situ fatigue tests under high energy light ion irradiation, a design study has been performed to evaluate the feasibility of in situ creep fatigue tests in the IFMIF medium flux position. The vertically arranged test module for such experiments consists basically of a frame similar to a universal testing machine, but equipped with three pulling rods, driven by independent step motors, instrumentation systems and specimen cooling systems. Therefore, three creep fatigue specimens may be tested at one time in this apparatus. Each specimen is a hollow tube with coolant flow in the specimen interior to maintain individual specimen temperatures.

The recently established IFMIF global 3D geometry model was used together the latest McDeLicious code for the neutral and charged particle transport calculations. These comprehensive neutronics calculations have been performed with a fine special resolution of 0.25 cm3, showing among others that the specimens will be irradiated with a homogeneous damage rate of up to 13(9%) dpa/fpy and a fusion relevant damage to helium ratio of 10-12 appm He/dpa. In addition, damage and gas production rates as well as the heat deposition in structural parts of the test module have been calculated.

Despite of the vertical gradients in the nuclear heating, CFD code calculations with STAR-CD revealed very homogeneous temperatures of the gauge volume over a wide temperature window. This has been achieved by introducing an innovative cooling concept that controls the local coolant efficiency of the helium gas inside the hollow creep fatigue specimen. Hence, the related absolute temperature difference amounts to only 10 K at 250 °C and 30 K at 650°C. Finally, the design integration of the in situ creep fatigue is shown based on CATIA drawings together with the latest view of the Test Cell design.