IRRADIATION OF FUSION MATERIALS

Background

In collaboration with the EFDA (European Fusion Development Agreement), SCK•CEN irradiates several materials in the BR2 reactor at different temperatures and up to different doses to study their mechanical and physical properties during and after the irradiation.
These materials are candidates for the construction of different parts of the ITER (International Thermonuclear Experimental Reactor) fusion reactor and of the long-term DEMO (DEMOnstration) reactor.

Objectives

- To irradiate RAFM (Reduced Activity Ferritic Martensitic) steel joints and RAFM ODS (Oxide Dispersion Strengthening) at 300°C up to 2 dpa.
- To irradiate RAFM steel and different FeCr alloys at 300°C above1.5 dpa.
- To irradiate Beryllium and Tungsten specimen at 300°C up to 0.75 dpa.
- To irradiate copper/stainless steel joints at 150°C up to 0.1 dpa.
- To perform in-situ creep-fatigue tests with CuCrZr specimens under neutron irradiation.

Principal results

1. Survey of irradiations in 2005

IRFUMA IV experiment
In 2005 we continued the IRFUMA IV (IRradiation of FUsion MAterials) specimens irradiation. The materials involved in this IRFUMA IV experiment are RAFM steel with denomination EUROFER97.
The irradiation was conducted at 300 °C in the D180 channel (IPS 2) of the CALLISTO loop in the BR2 reactor. The test section was shared with specimens irradiated for the FRISCO and IBETUS experiments which are also Fusion tasks.

FRISCO-F experiment
The Heavy-Section Steel Irradiation (HSSI) Program, funded by the U.S. Nuclear Regulatory Commission (USNRC) at Oak Ridge National Laboratory (ORNL), has proposed to collaborate with SCK•CEN on a project to investigate the effects of relatively high fast neutron flux on reactor pressure vessel steel and on fusion materials.
The irradiation programme called FRISCO (**F**usion and **R**eactor material **I**rradiation **S**CK•**C**EN – **O**RNL) consists of 2 separate experiments: characterization of fusion materials (FRISCO-F) and characterization of reactor pressure vessel (RPV) steel (FRISCO-R).
In 2005, we irradiated 8 different fusion materials (FeCr alloys with at least 9% of Cr) at 300°C in the D180 channel (IPS 2) of the CALLISTO loop in the BR2 reactor.

IBETUTS experiment
The experiment **IbeTuTS**, which stands for **I**rradiation of **Be**ryllium and **Tu**ngsten **T**hermal **S**hock specimen, aims to investigate the thermal shock behaviour of ITER relevant first wall materials under irradiation.
The irradiation was conducted at 300 °C in the D180 channel (IPS 2) of the CALLISTO loop in the BR2 reactor.

CUSSIR experiment
CUSSIR stands for copper (Cu) / Stainless Steel joints Irradiation. The aim of that experiment is to irradiate specimens of Cu/SS joints. These specimens underwent different heat treatments. These materials are candidate materials for the future fusion reactors (ITER and DEMO). This project is jointly carried out with

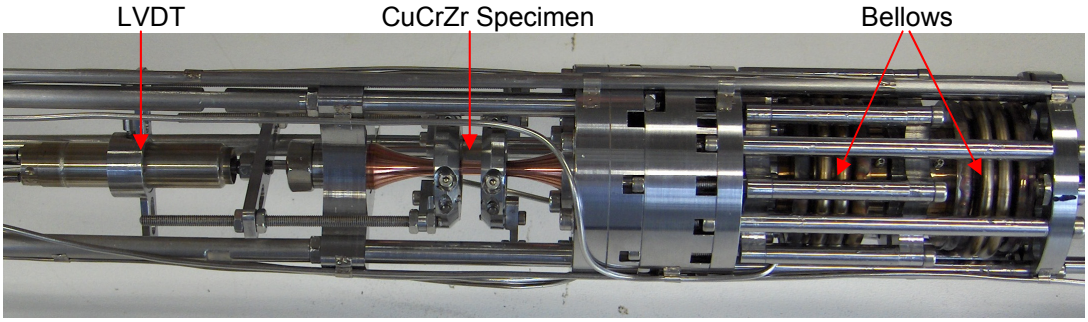
RISØ (Denmark) and VTT Industrial Systems (Finland) who supply the samples.

The irradiation was conducted at 150 °C in the ROBIN basket (**RO**tating **B**asket with **I**nstrumented **N**eedles) loaded in one BR2 thimble tube.

COFAT experiment

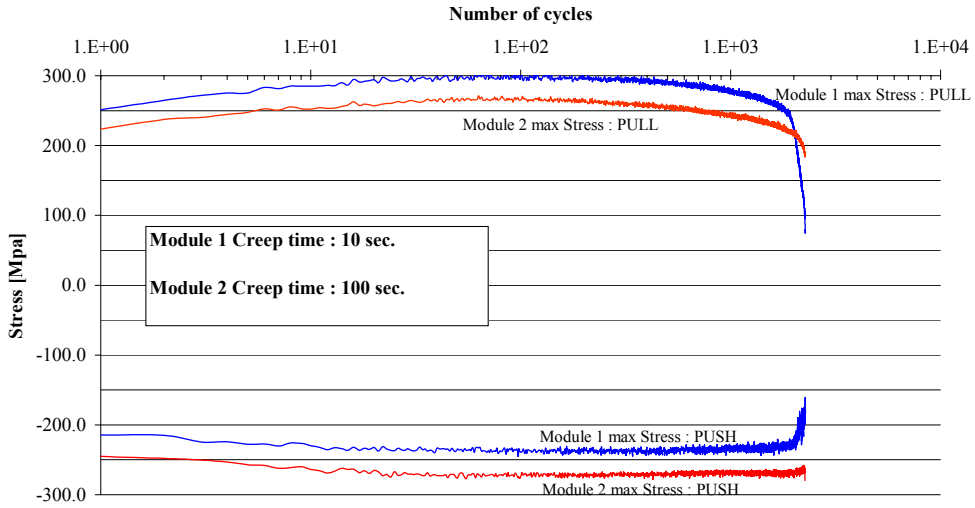
The aim of the COFAT experiment (**CO**pper **FAT**igue) is to investigate in-situ the dynamic effects of cyclically applied stresses in the copper components of ITER on the neutron damage accumulation and to assess the mechanical performance during neutron irradiation.

The COFAT rig contains 2 creep-fatigue test modules designed in teamwork with VTT. Each module is made of 2 bellows (one to push and the other to pull on the specimen) and of one LVDT (Linear Variable Differential Transformer) to measure the gage length variations.



Fatigue module with a CuCrZr specimen loaded

In 2005, we performed the first two in-situ creep fatigue experiments with a 0.5% strain (strain controlled experiments). The first experiment was carried out with 10 seconds creep time and the second with 100 seconds creep time. One can see on the following chart the preliminary results of these experiments showing the evolution of maximum stresses versus the number of fatigue cycles.



COFAT : Evolution of maximum stresses with the number of cycles

Future work

- Perform other in-situ creep-fatigue experiments with copper alloys at low temperature in water.
- Perform in-situ tensile tests of copper alloys and FeCr alloys at low temperature in water.
- Irradiations of RAFM specimens with implanted helium at 350°C up to 0.2 dpa.
- Continue irradiations of IRFUMA, FRISCO, IBETUTS and CUSSIR experiments

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Main reference

Marc Decréton, November 2005, *Fusion Annual Report 2005*, BLG-1017.