ANNEX XXVII

Neutron irradiation up to 0.8 dpa at 200-250^{0}C of EUROFER plates

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In collaboration with the SCK-CEN Association and under secondment of a scientist of our team in MOL, work was carried out for the development of a high temperature irradiation and in the areas of a) Mechanical strength calculations, b) Hydraulic calculations, c) Thermal assessment, d) Safety aspects, e) Nuclear calculations, f) Drawings, g) Specifications and e) Instrumentation and data acquisition. Also is under way work on in-pile instrumentation which will be associated with the high temperature irradiation rig and in particular with the integration of sensors in rig assembly, calibration and testing and the data acquisition system. In conjunction experimental and modelling work was carried out for different neutronic and safety aspects associated with the high temperature irradiation rig.

Figure 1 shows a typical cross-section configuration of the preliminary design for an irradiation experiment. The samples to be irradiated are first placed inside an aluminium matrix holder. A gas gap filled with high purity (99.999%) He is surrounding the samples forming an insulating annulus. An outer Aluminium containment tube then follows which is in contact with the reactor's pool water. For such an in-pile experiment, heat is dissipated inside all the metallic parts of the rig due to gamma radiation. Heat flows along the radial direction through the gas gap where due to the very low thermal conductivity the highest temperature gradients are observed. The actual temperature difference across the gas gap is therefore the dominant and the most crucial one for such a system. For that reason one usually refers for such or similar configurations as "gas cooled experimental rigs". The width of the gap (thickness d in figure 1) and the pressure of the contained Helium uniquely define the Knudsen dimensionless number which relates to the thermal conductivity of the gas gap. For pressures lower than atmospheric and depending on the thickness d, rarefied gas conditions apply and since departure from continuum happens, the thermal conductivity of the gas gap drops leading to thermal isolation of the matrix and the samples. As higher vacuum is approached samples can be further insulated thermally.

It is therefore obvious that for fixed geometries, pressure control of the gas gap plays a very important role in the thermal behaviour of the system and that it can be effectively used as a temperature control mechanism of the system.

The assembly in Figure 1 refers to the proposed configuration for the THECORE experiment. The main difference with an actual irradiation experiment is the inclusion of an electric heater which simulates the effect of heat generation due to gamma radiation. The only difference with the actual future configuration in terms of thermal behaviour is the fact that for THECORE heat is only generated at the sample (i.e. heater) location, while for irradiation experiments heat generation occurs at every metallic part of the facility exposed to gamma radiation.

The main objectives of the present experimental facility THECORE can be summarised as follows:

1) Verify the design thermal calculations concerning
    a) Radial one dimensional heat conduction across the gas gap.
    b) Rarefied gas conditions inside the gas gap (pressure vs. thermal conductivity).
    c) Thermal control through pressure control in the He circuit (response times, actual pressure/vacuum levels required for rarefied conditions etc.).
2) Test the construction and assembly details on
    a) Introduction of heating elements, thermal isolation across the length of the containment (so that one dimensional approach is valid).
    b) Combining custom made components with "of the self" commercial vacuum components.
    c) Introduction of thermocouples in the matrix and data acquisition.
3) Test and verify the control procedure used in order to achieve a temperature controlled environment.

Thus the main output of the present experiment should be a correlation function between the pressure of He in a gas gap with respect to the temperature of the matrix for various heat inputs in the electric heater and various thicknesses of the gas gaps. It is expected that the wider the gas gap d, the lower the pressure should be in order to achieve similar thermal conductivity since more He molecules should be extracted for rarefied gas condition to occur.

EXPERIMENTAL APPARATUS-DESCRIPTION

The experimental facility THECORE mainly consists of:

1) The in-pile section (tubes of Figure 1) containing
    a) Heated part and the outer flanged tube
2) Transition to the out of pile equipment
    a) PVC coiled tubes for the He line
    b) Extension wires transmitting the signals from the heated part.
3) The out-of-pile section
    a) Monitoring system and data acquisition
    b) Heater supply
    c) He circuit (He bottle pumps, valves, connecting lines)

TESTING BEFORE COMMISSIONING

After the assembly and before the actual commission of the experiment a series of tests should be conducted in order to verify that the design and construction phases have been completed successfully and meet the design specifications. These tests should include:

- Basic assembly inspection:
    a) Is the gas gap well reserved around the heater?
    b) Is the heater in contact with its supports at its both ends?
- Leak tightness tests for the following:
    a) Outer brass tube.
    b) Vacuum side.
    c) High pressure side.
- Electrical tests for cable integrity and continuity (by resistance measurements) for the:
    a) Heater and power feedthrough connections.
    b) Thermocouple and feedthrough connection

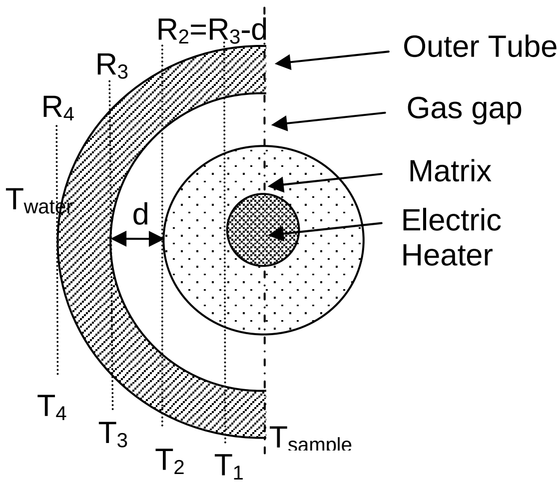

Figure 1. Configuration of the present experiment THECORE.