

RE-ENCAPSULATION OF PRE-IRRADIATED FUEL PINS AND OF STRUCTURAL MATERIAL AT THE EUROS-CELL

M. Bieth, J. Konrad, J. Oudaert, D. Pithan
Institute for Advanced Materials, Joint Research Centre,
Commission of the European Communities
Petten, The Netherlands

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SUMMARY

The cycle irradiation - unloading - intermediate measurement - reloading with Na filling - irradiation is allowed at the Petten High Flux Reactor, a 45 MW light water cooled and moderated research reactor, by the use of the EUROS-Cell.

After refurbishment, this dedicated cell has been utilized in 1993 to successfully replace three pre-irradiated FBR fuel pins and one structural material experiment into their sample holders, to remote weld the containments and fill the capsules with liquid sodium.

INTRODUCTION

The High Flux Reactor (HFR) at Petten (The Netherlands), owned by the Commission of the European Communities, is a 45 MW light water cooled and moderated research reactor [1]. It is used mainly for material testing in particular for the nuclear fission and fusion programmes. In successful operation for more than 30 years, the installation has been kept up-to-date by replacing ageing components, in particular the reactor vessel in 1984. To allow the cycle irradiation - unloading - intermediate measurements - reloading - irradiation, the EUROS Cell has been designed and constructed (Fig. 1). It permits remote welding and Na filling to reconstitute the sample holders for pre-irradiated fuel pins and structural material samples.

EUROS-Cell description

The EUROS-Cell has been installed in the lead-cells hall of the ECN hot laboratories LSO at Petten [2].

The necessary shielding is provided by standard lead blocks 254 mm thick (10"). The dimensions of the alpha box are 3.3 m x 2.3 m x 1.3 m (Fig. 2). The cell is operated through 4 manipulators and 2 windows (Fig. 3). The mobile frame carries the 5 kW ovens and the sample-holder.

The ovens are used to preheat the capsule at 180°C and to heat it at about 100°C during the sodium filling (Fig. 4). They are equipped with four thermocouples to control the temperature range.

The circular welds to close the first and second containments are realized by means of an orbital TIG computerized welding system (Fig. 5). The Na-filling mini-tubes are plugged before to be welded by a dedicated equipment.

The Na-filling facility includes two communicating vessels, the first-one filled with a calibrated volume of sodium, the second-one for the excess quantity coming from the sample-holder after filling, and a heating blower system (Fig. 6).

The vacuum facility allows to clean the capsule and the mini-tubes before the Na filling. Argon supply is necessary to push the liquid sodium from the vessel to the capsule by applying an overpressure to the Na-tank. During the Na-filling operation, the cell is filled with nitrogen in order to prevent any Na-fire.

A dedicated EUROS container allows to transport the active sample-holders from the EUROS-cell to the High Flux Reactor for subsequent irradiation.

Re-encapsulation of pre-irradiated fuel pins

In 1993, three pre-irradiated FBR fuel pins have been successfully re-encapsulated at the EUROS-cell. All fuel pins consisted of mixed oxide fuel, composed of 6,5 mm diameter pellets in a 7.6 mm diameter stainless steel can. The fuel stack length is 0.45 m while the capsule length is 1.6 m. In the capsule, the fuel cladding has to be surrounded by sodium.

The 16 mm diameter first and 17 mm diameter second stainless steel containments are separated by a gas gap, allowing with a dedicated gas mixture to obtain FBR cladding temperature when the capsule is irradiated at the Pool Side Facility of the HFR.

Re-encapsulation of pre-irradiated structural material

Pressurized creep and growth samples of structural material have been irradiated in the HFR core for about one year. After dismantling of the experiment in dedicated hot cells, the specimens have been dimensionally remote-checked.

After the measurement campaign, the samples have been remotely loaded in the EUROS-Cell. The sample-holder has been then remotely welded and filled with liquid sodium.

Sequence of operation in the EUROS-Cell

The sequence of operations for fuel pin is the following :

- The EUROS-Cell preparation includes the manual handling of the non-active sample-holder with its instrumentation into the cell and the final functional checks of all the equipment before closing the doors of the cell.
- The fuel pin placed in a canister to avoid any contamination is then introduced from its transport container into the cell (Fig. 7). The fuel pin is moved automatically from the canister to the sample-holder without any contact with the cell equipment.
- The first containment is closed by a screwed plug, and seal welded by means of the orbital TIG machine and Helium leak tightness tested.
- The sample-holder is placed vertically, vacuum heated to 180°C and rinsed by Helium, vacuum-set and heated to about 100°C and finally filled with liquid sodium.
- After cooling, the sample-holder is placed horizontally and the mini-tubes for Na filling are cut, cleaned, plugged and sealed by welding.
- The second containment is then plugged and seal welded by means of the orbital TIG machine.
- The capsule is then turned by 180° in order to load it into the EUROS container. This positioning allows to place the sample-holder directly into the irradiation facility at the High Flux Reactor.

The sequence of operations for structural material sample is basically the same as for fuel pin, except that there is no second containment in this case.

The sample-holder design also is different, leading to a complete new layout of the welding equipment, the sample loading and two new ovens of 5 kW and 2,5 kW.

In particular, the material samples are introduced to the tip of the sample-holder from a transport canister (Fig. 8). The first containment weld is then carried out at the capsule tip while the Na filling takes place from the top. In the case of the fuel pin capsule, both operations are realized at the top, meaning more difficulties due to multiple handling at the same location.

CONCLUSIONS

In 1993, the re-encapsulation of three pre-irradiated FBR fuel pins and of pre-irradiated structural material has been successfully carried out in the EUROS-Cell at Petten.

To execute the work, a new computer driven orbital TIG welding equipment has been installed, allowing to obtain remotely welds of an excellent reproducible quality.

The cell layout and equipment has been refurbished for the structural material experiment, due to an improved capsule design.

The experience gained with those re-encapsulations shows the EUROS-Cell is a unique and efficient tool allowing the reconstruction of sodium-filled sample-holders loaded with radioactive materials.

REFERENCES

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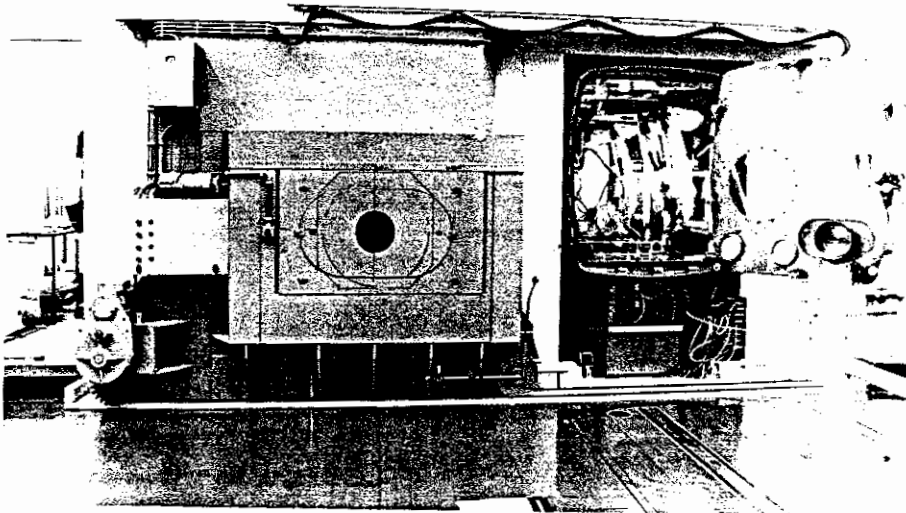


Fig. 1 : EUROS-Cell - Side view

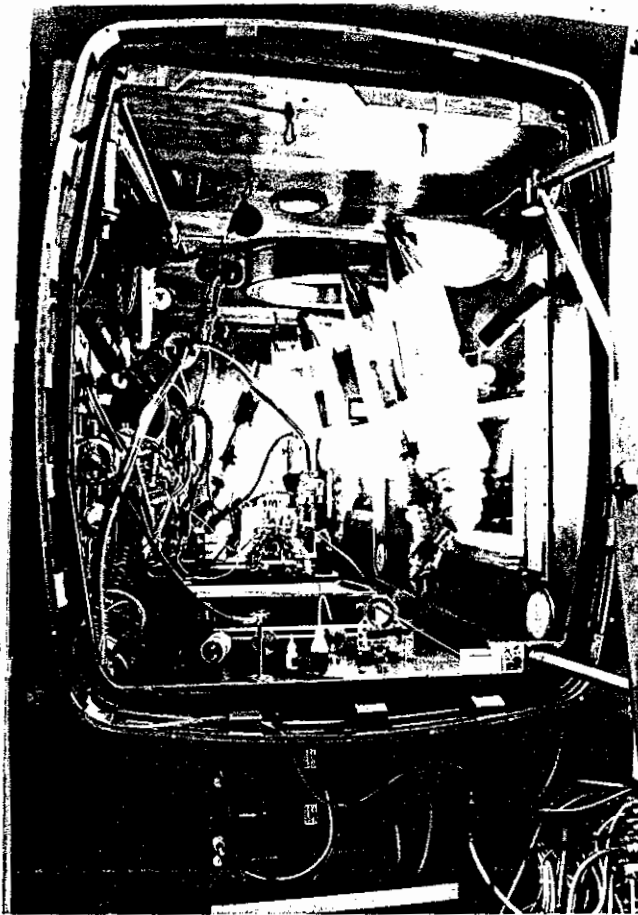


Fig. 2 : EUROS-Cell - Alpha box

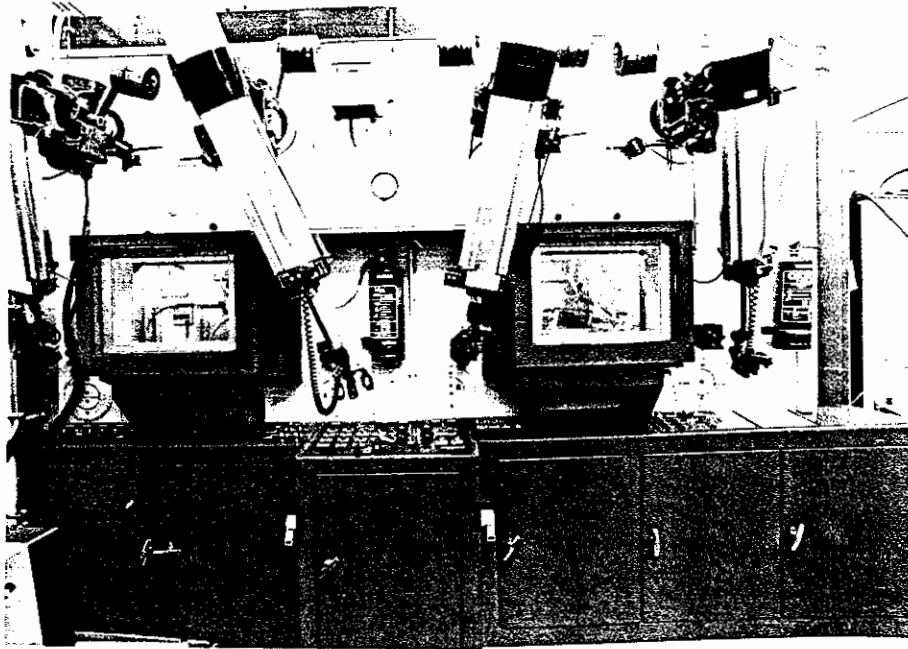


Fig. 3 : EUROS-Cell - Front view

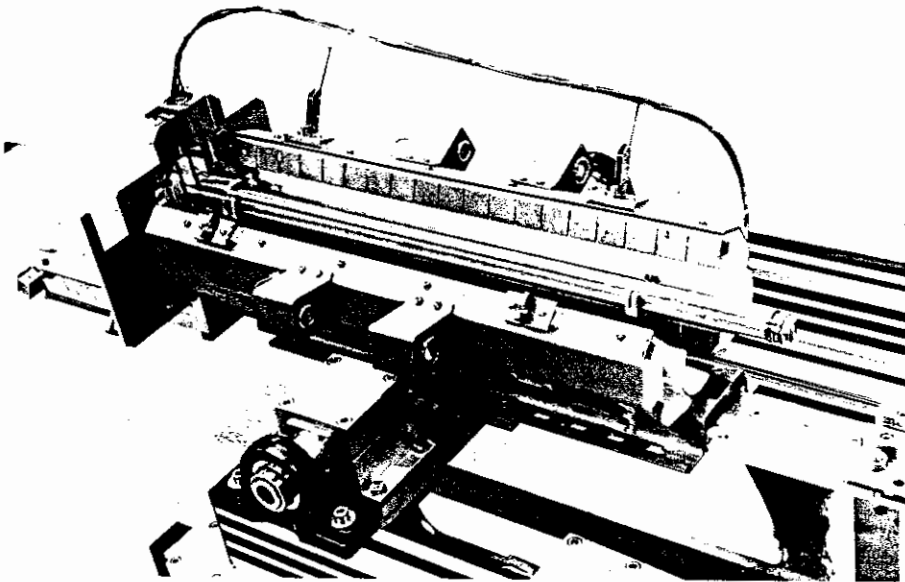


Fig. 4 : EUROS-Cell - 5 kW Oven

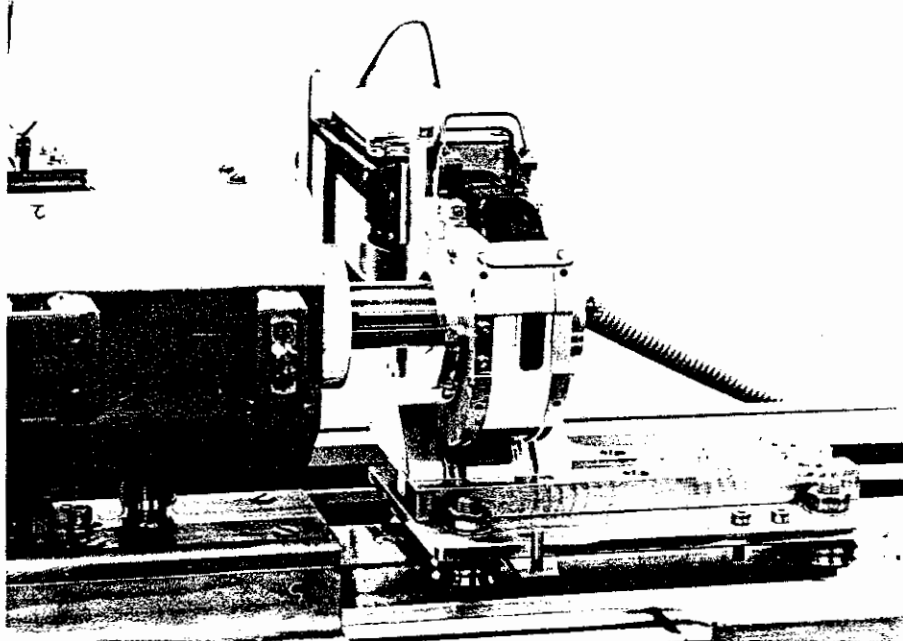


Fig. 5 : EUROS-Cell - Orbital TIG welding system

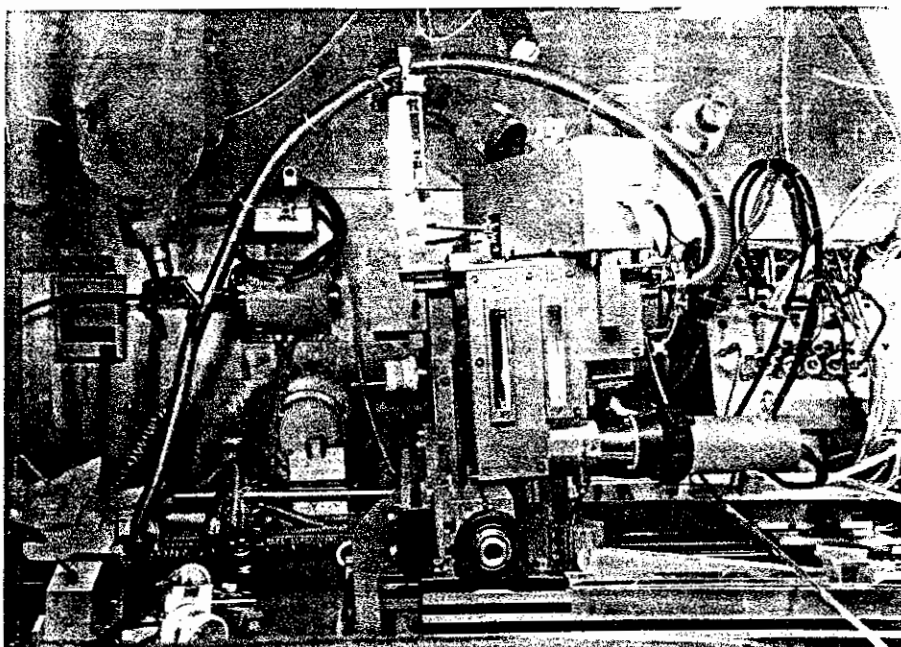


Fig. 6 : EUROS-Cell - Na-filling system

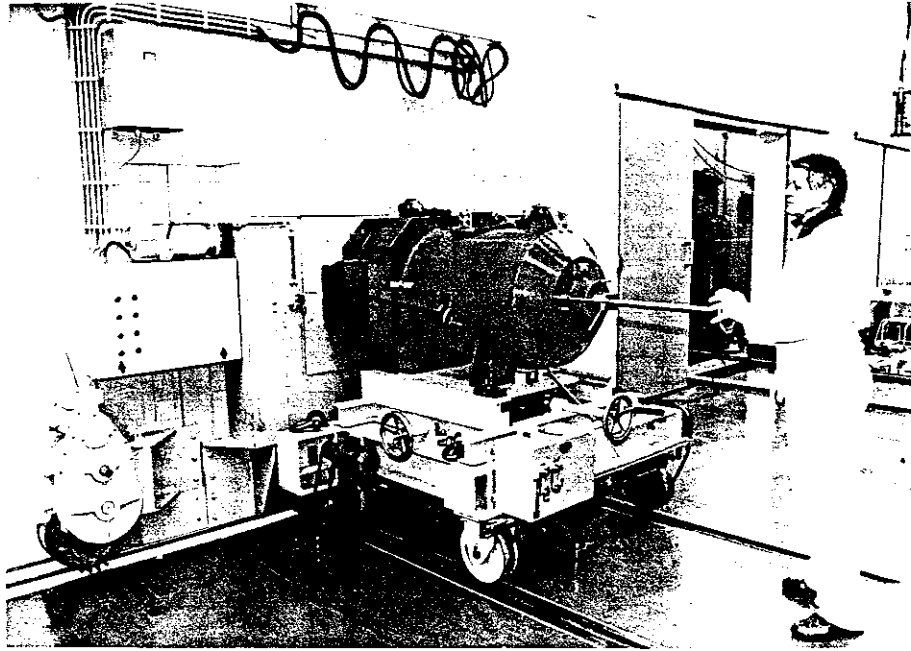


Fig. 7 : Transport container at the EUROS-Cell door

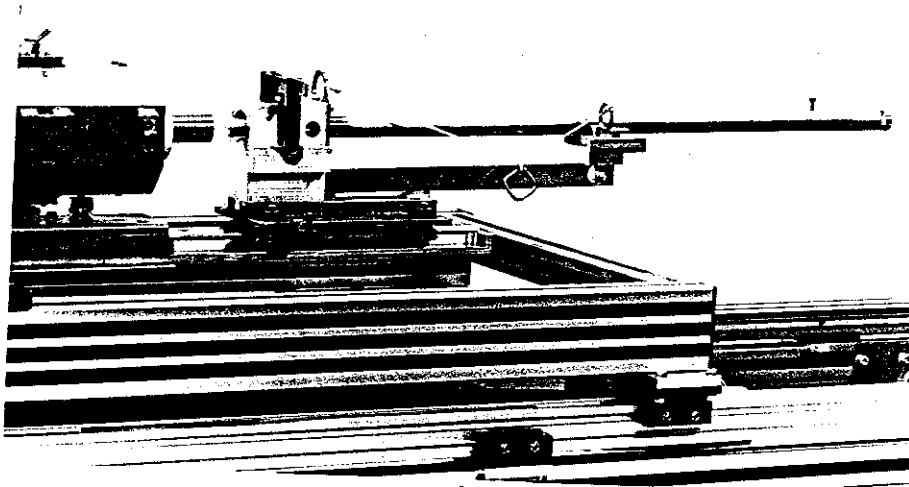


Fig. 8 : Loading of pre-irradiated structural material sample at EUROS-Cell