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The investigation of materials related to nuclear technologies by means of neutron imaging methods

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In the context of nuclear installations like nuclear power plants as well as accelerators and target facilities, there are many research topics relating to safe operation, improved utilization of nuclear fuel, waste disposal and final disassembling. In particular, non-invasive and non-destructive methods are needed to gain insight into non- or difficult reachable locations in materials or components, to reduce the risk of contamination and the applied doses for the involved scientists.
Neutron imaging can provide very interesting options for the study of nuclear fuel and its cladding. The high penetration power for heavy elements (in particular uranium) and the high contrast for light elements (hydrogen, boron) provide often better condition than the more common X-ray techniques. It makes it possible to apply special sample environments like shielding or furnaces with well defined atmospheres and use them for in-situ experiments.
On the one hand, it becomes possible to investigate the integrity of spent fuel even if the high burn up is accompanied with the emission of large amounts of gamma radiation. In respect to the cladding, the uptake of hydrogen by the Zr alloy is linked to the risk for embrittlement and failure. Studies with irradiated cladding were successfully done. Current investigations are focused onto the understanding of the hydrogen ingress to cladding under operational and accidental conditions where inactive samples are investigated ex-situ and under in-situ conditions. Additionally, basic research for instance of the hydrogen diffusion in zirconium or of the sequence of formation of chemical compounds during air oxidation of zirconium alloys is in progress.
For the efficient use of nuclear fuel and the safe operation of power plants the thermal hydraulic conditions of the coolant flow are essential. Due to the high attenuation properties of neutrons for water, annular two-phase flows can be very efficiently studied on-line and in 3D in dummy fuel rod bundles.
We also used the technology of neutron imaging of highly activated samples for the study of target components of the SINQ target after 2 years of full exposure. The lead rods are sufficiently transparent for thermal neutrons and the request was to find out which "visible"modifications happen during proton beam exposure.
The NEUTRA beam line is well equipped for such kinds of studies and can be used for similar experiments on request.

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