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Neutron imaging techniques for the study of energy related materials, structures and processes

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The demands for a transition from nuclear and fossil energy generation processes towards more environmental neutral ones have induced new research fields for innovative materials, energy conversion procedures and energy storage devices. For a perfect understanding and the determination of the performance modern research tools are utilized and common.

In this context, neutron imaging methods provided at a few places like MLZ (ANTARES, NECTAR at FRM-2) and PSI (NEUTRA, ICON at SINQ) can play an important role. Alternatively and complementarily to X-ray studies it becomes possible to investigate light and most relevant materials like hydrogen and lithium even within thick metallic structures (pressure vessels, heaters, coolers, ⋯). These investigations can be performed on versatile length scales of 40 cm down to 1 cm while obtaining a spatial resolution of 100 μm to 5 μm, accordingly. On the other hand, time series from transition processes can be monitored with a frame rate of about 25 Hz in continuous mode. If repetitive processes (e.g. running engines) have to be observed, repetition rates up to 8000 rpm are common.

Based on these advanced techniques which are available in 2D and 3D, we have selected in our contribution to the conference the following results, available as demo for further investigation by our customers and researchers:
• Time- and space-resolved water distribution in sorption enhanced methanation reactors
We measured the spatial water distribution in a model sorption enhanced methanation reactor using time resolved neutron imaging. Due to the high neutron attenuation coefficient of hydrogen, the absorbed water in the sorption catalyst gives a high contrast allowing us to follow its formation and map its distribution. At the same time, the product gas was analysed by FTIR-gas analysis. The measurements provided important insights into functioning of sorption reactors and are essential for the future design and upscaling.

Further investigations mentioned and illustrated in the talk are:

• Hydrogen storage processes visualized and quantitatively observed
• Li-ion migration in batteries during charging and discharging processes
• Fuel cell performance determination in-situ and under variable operation conditions
• Diesel fuel injection processes and the cavitation problems in injection nozzles
• The accumulation process of soot in Diesel particulate filters

Most of the topics are still under investigation with partners from industry and research labs. Unfortunately, some industry projects are still confidential and cannot be communicated freely.
Next to the "standard"neutron imaging techniques, we are already on the way to implement advanced methods like neutron grating interferometry or energy-selective studies into the daily practice for our customers.

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