Study on actinide conversion capabilities of Molten Salt Reactors (MSR)

To date, French nuclear power plants mainly use uranium extracted from the mines and enriched. The used fuel is reprocessed to extract useful materials, such as plutonium, which is recycled once in dedicated PWRs of the park. Once used, the quality of the plutonium decreases and it becomes more difficult to recycle this plutonium in thermal spectrum reactors.

A molten salt reactor (MSR) is a liquid fuel reactor, which flexibility allows different fuel types to be used. This concept is inherently safe thanks to its negative feedback coefficients due to the liquid fuel travelling in the entire fuel circuit, from the core to the heat exchangers. Its versatility is such that this reactor can operate in burning or breeding modes. If operated with a fast neutron spectrum, the fission over capture ratio will be improved for all heavy nuclei, allowing to fission significantly most of the actinides. This reactor concept is therefore theoretically adapted to convert actinides such as plutonium.

New studies have started in a CNRS/Orano collaboration to evaluate the efficiency and options of MSR to convert actinides. Indeed, the concept of MSR, called MSFR, the most studied up to now in France and European projects is a fast thorium-cycle breeder reactor, hence a lack of knowledge on the converter concept.

In this presentation, we will show some preliminary results of these conducted studies. Neutronic studies use a Monte-Carlo approach to calculate the burn-up and feedback coefficients. The molten solvent considered in the calculations – NaCl-$MgCl_2$ – to incorporate plutonium has shown a neutronic impact according to the proportions of the two constituents. A large amount of magnesium tends to epithermalise the spectrum, which is deleterious when considering non-fissile actinides. Nonetheless, the calculated feedback coefficients are very good ($\approx$-15 pcm/K), which assure a good inherent safety. Different materials have been studied to evaluate their neutronic impact on the reactor, some of which will be used in further simulations. The ongoing studies thus demonstrate the promising potential of fast neutron chloride MSR for such applications.