LFR safety activities: CIRCE-THETIS pre-test and transients analysis

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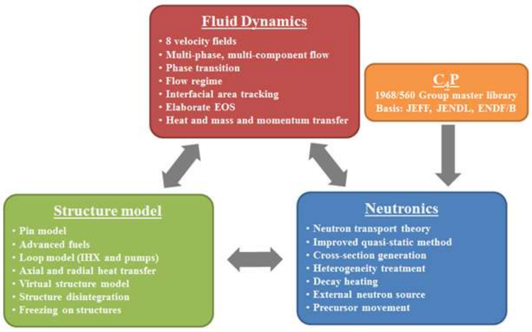
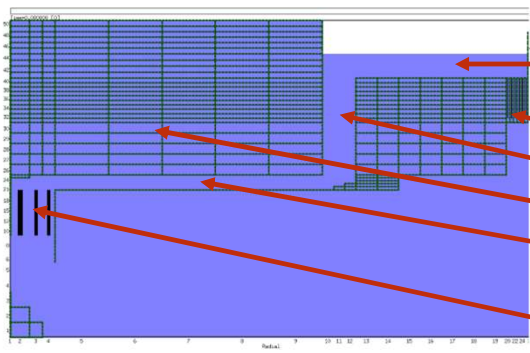
This poster presents the results of a SIMMER code validation campaign, based on experimental activities conducted using the CIRCE-THETIS facility. The primary objective is to assess the predictive capabilities of the SIMMER code in simulating integral experimental facilities.

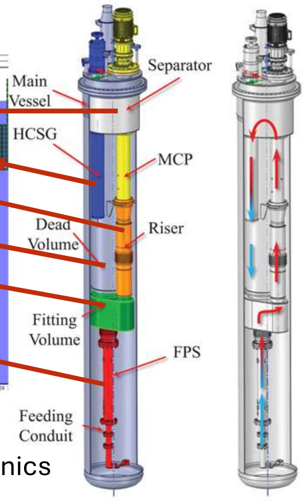
Introduction

The CIRCE experimental facility [1] has been designed to operate with **liquid LBE** to study thermal-hydraulic phenomena in **liquid-metal-cooled reactors**.

The new test section **THETIS**, installed in the CIRCE main vessel, introduces **new components**, including a *vertical mechanical pump* and a prototypical *helical-coil steam generator* (HCSG), currently being tested.



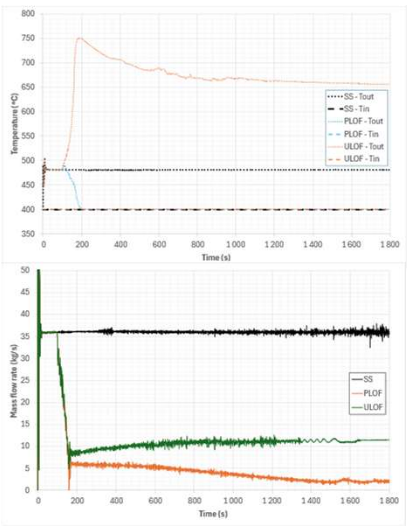




The SIMMER code

SIMMER [2] is a multi-phase, multi-component, multi-velocity-fields, coupled TH-neutronics code considered a reference for transient analysis of liquid metal cooled systems.

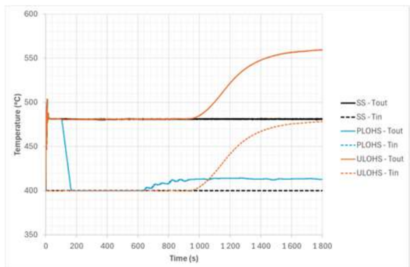
PLOF/ULOF

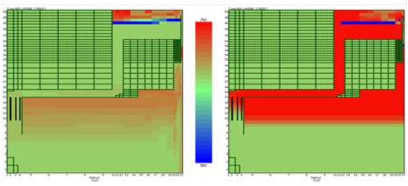


Protected case: System rapidly at safe state; coast-down flow + natural circulation are sufficient to cool down the FPS.

Unprotected case: The natural circulation reaches asymptotically 1/3 of the reference flow rate. This is sufficient to lower the FPS outlet temperature, approaching 650°C.

PLOHS/ULOHS



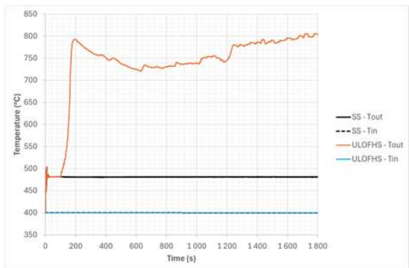


No significant differences in mass flow rates.

Protected case: T_{out} quickly drops at T_{in}; eventually, the hot pool lead, cooled down by mixing into the cold pool, reenters the FPS. The average time required for a whole loop is about 500 seconds.

Unprotected case: Hot pool lead has to reenter the core before seeing any difference. The time required for the hot lead to reenter the core is longer than for the protected case due to stratification phenomena.

ULOF+ULOHS



Combined Unprotected Loss of both Flow and Heat Sink.

The initial behavior is similar to the ULOF, with a peak of the outlet temperature, that is later reduced as the natural circulation accelerates.

However, due to the loss of heat sink, the temperature difference between cold and hot pools reduces over time, resulting in the **natural circulation to drop too**: it never exceeds 9 kg/s.

After the **grace time provided by the cold pool** thermal inertia ends (about 10 minutes), the FPS outlet temperature starts rising again, eventually exceeding 800 °C.

REFERENCES

[1] Stefanini, P., Pucciarelli, A. et al., "Numerical analyses of the CIRCE-THETIS facility by mean of STH and CFD codes", *Nuclear Engineering and Design*, Volume 409 (2023)

[2] Maschek, W., Rineiski, A. et al., "The SIMMER safety code system and its validation efforts for fast reactor application", *Proc. Int. Conf. PHYSOR 2008*, Switzerland. September 14-19 (2008).

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