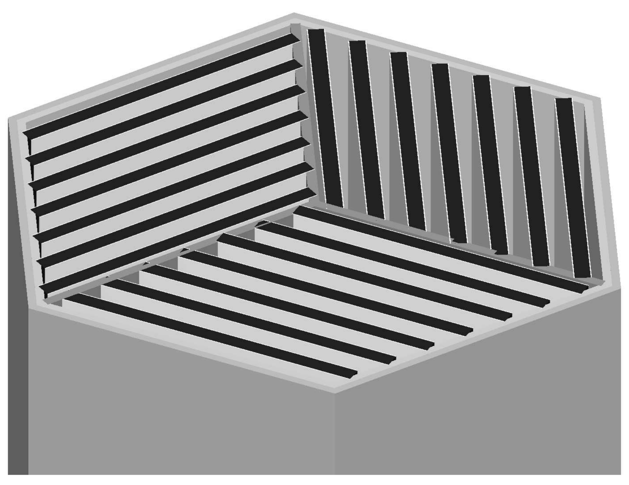
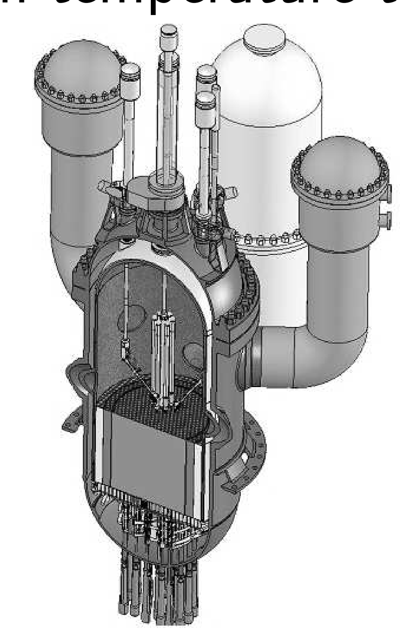
Passive shutdown device for Gas Cooled Fast Reactor: Lithium Injection Module

W.F.G. van Rooijen, J.L. Kloosterman, T.H.J.J. van der Hagen, H. van Dam
Section Physics of Nuclear Reactors, Delft University of Technology, Delft, The Netherlands

The Gas Cooled Fast Reactor (GCFR)

The Gas Cooled Fast Reactor is a helium cooled fast reactor. It features a relatively high power density of around 100 MW/m^3, high temperature operation (outlet temperature 850°C) and ceramic plate fuel. The core has a large volume fraction of coolant to reduce the pressure drop over the core. The combination of high power density and low thermal inertia result in the potential of rapid, high temperature transients.



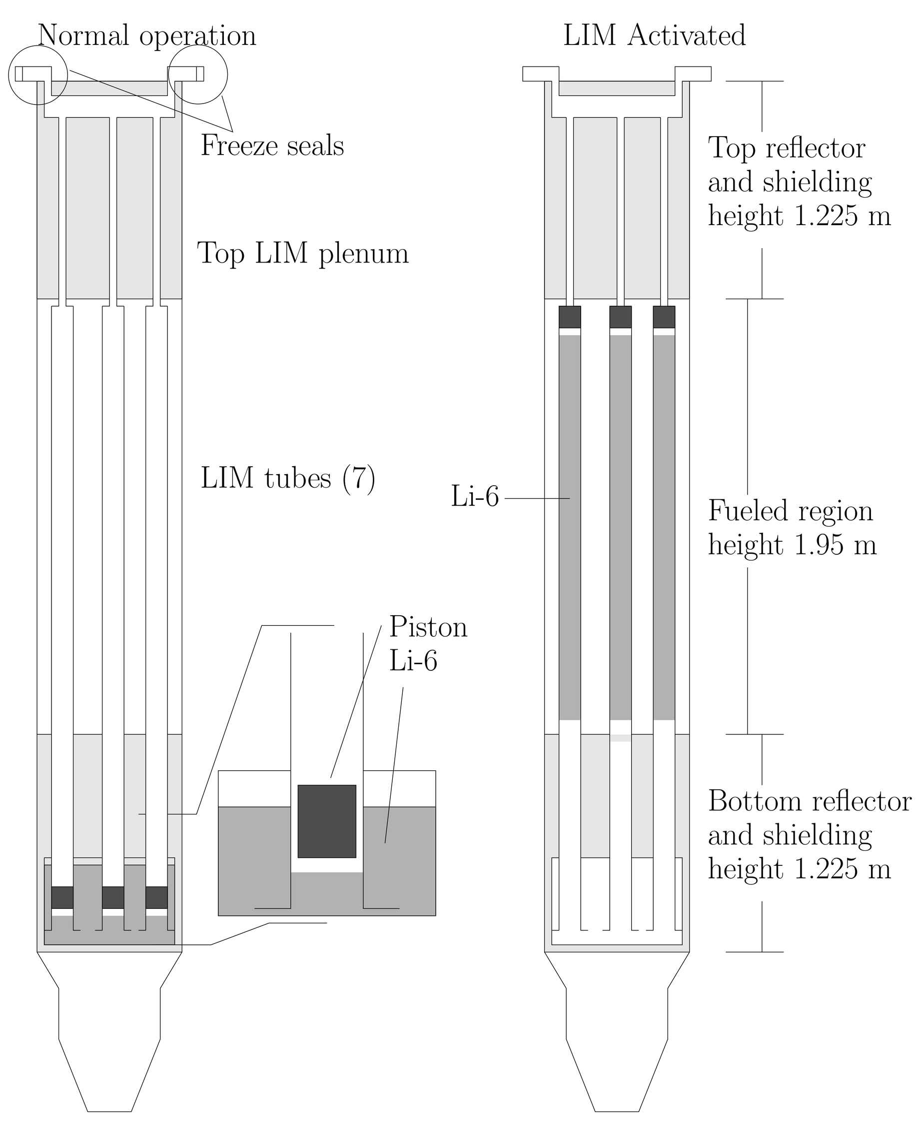


To protect the ceramic fuel plates and core structures against excessive temperatures, devices are investigated to passively introduce negative reactivity during unprotected transients. All investigations concern GFR600, a 600 MWth GCFR, studied in the European Commission GCFR STREP. GFR600 is a Generation IV design.

Lithium Injection Module

Requirements for passive reactivity device:

- Small enough to allow integration into regular control assemblies
- Only triggered when all other control devices (have) fail(ed)
- Temperature controlled, one device should be enough to control power production

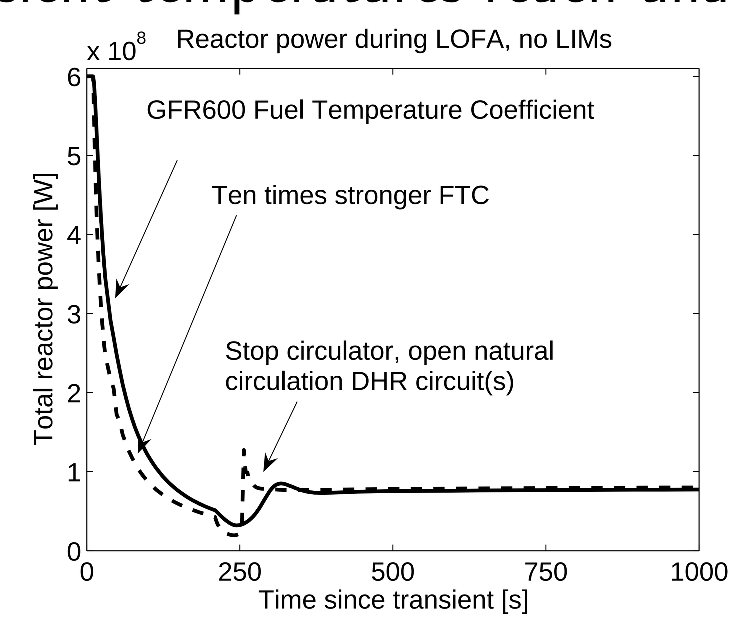


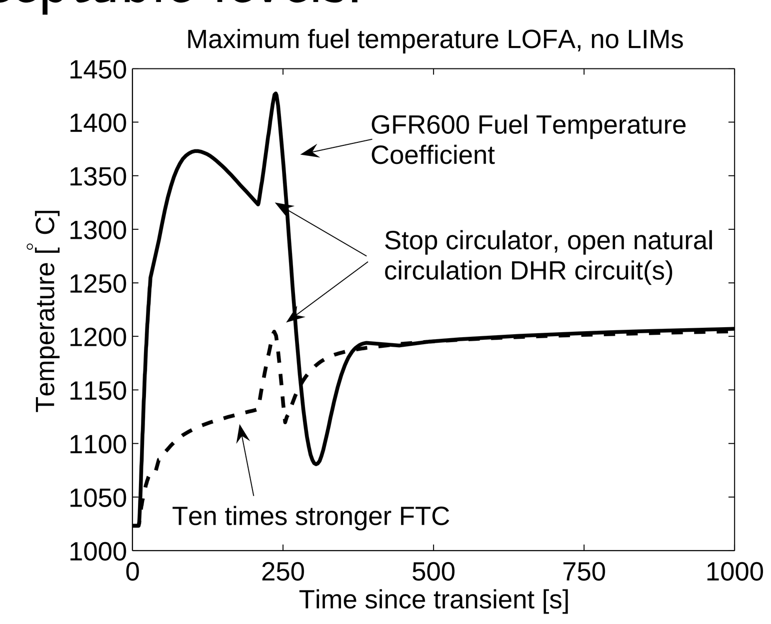
Enter the Lithium Injection Module: Liquid Li-6 (a strong neutron absorber) is maintained in a tank in the bottom of a control assembly. Freeze seals are maintained in the outlet gas stream. When a freeze seal melts, the liquid Li-6 is pushed up inside the LIM-tubes into the core region due to the pressure in the storage tank. Small pistons above the Li-6 seal the tube to avoid spilling the Li-6 into the core.

Transient analysis

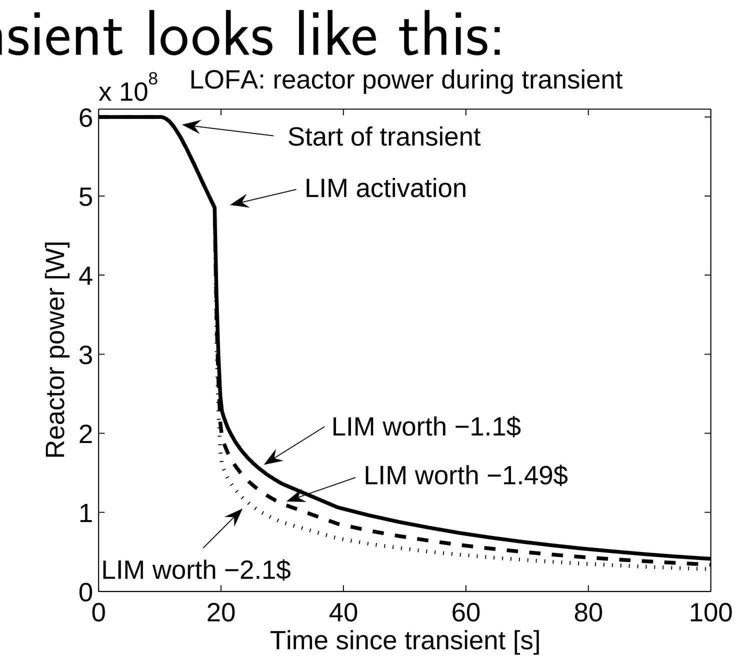
Transient analyses were performed with the general thermohydraulic code CATHARE2. Two possible accidents are reported here.

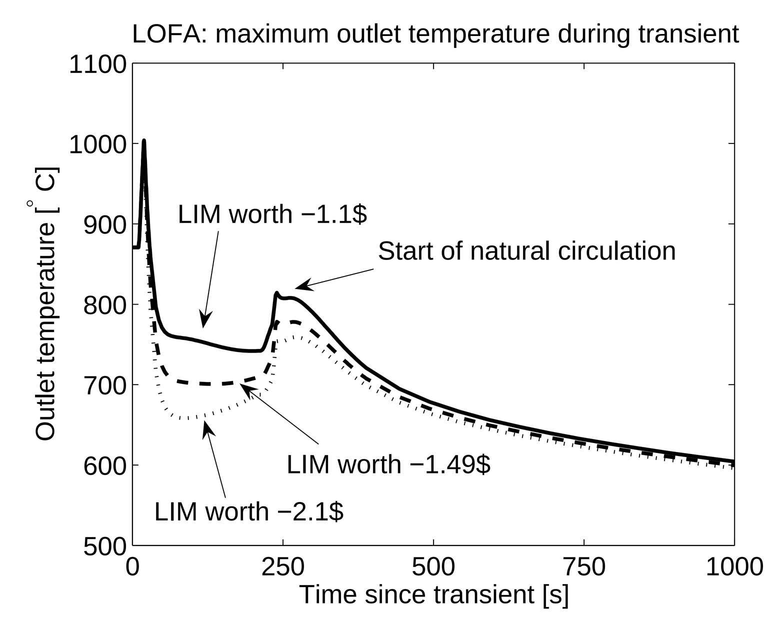
Loss Of Flow (LOF): The circulators run down to 5% of their nominal speed. Then the valves on the DHR circuits are opened and natural convection is allowed to develop to cool the core. Without LIMs, the transient temperatures reach unacceptable levels.



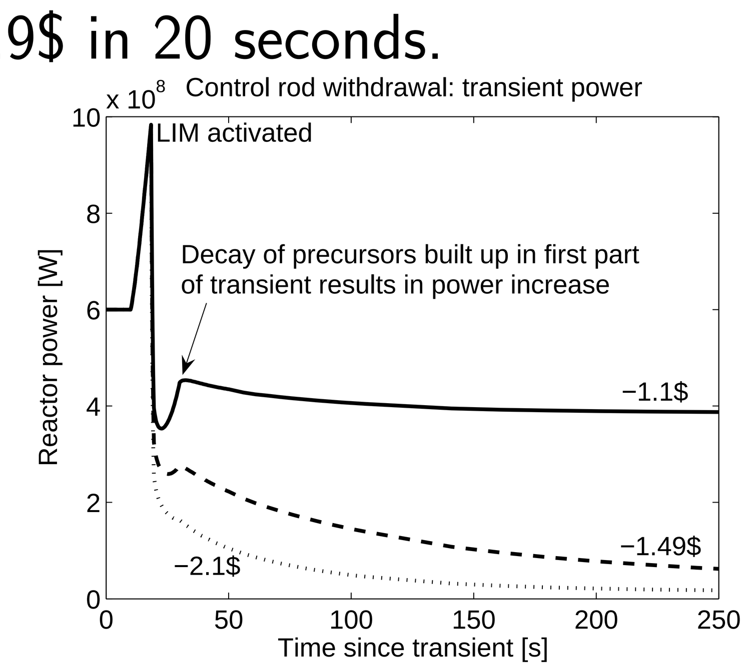


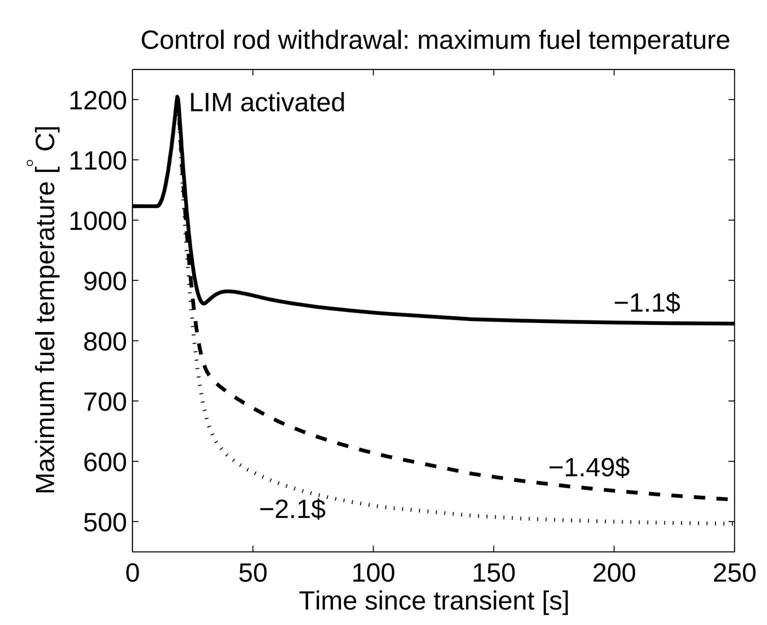
The LIM is activated when the outlet gas reaches 1000°C. The resulting transient looks like this:





Control rod movement: A (faulty) withdrawal of a control rod can cause an increase in power. In this scenario the control rod introduces +0.9$ in 20 seconds.





Conclusion: The LIMs are capable of controlling the reactor power under accidental situations. The reactivity worth of 1 LIM does not need to be very large (about 1.5$). LIMs are a promising option for passive shutdown under accidental conditions.

Acknowledgement

The authors acknowledge the support of the European Commission. The GCFR STREP is carried out under Contract Number 012773 (FI6O) within the EURATOM 6th Framework Programme (`http://www.cordis.lu/fp6/`) and is effective from March 1st 2005 to February 28th 2009. More information about the GCFR STREP is available from the project website: `http://www.gcfr.org`. CATHARE2 v2.5 mod3.1 is developed by CEA, EdF, Framatome-ANP and IRSN.

GCFR GAS COOLED FAST REACTOR

TU Delft