IMPACT OF AN ACCIDENTAL CONTROL ROD WITHDRAWAL ON THE ALFRED CORE: TRIDIMENSIONAL NEUTRONIC AND THERMAL-HYDRAULIC ANALYSES

M. Sarotto[1], G. Grasso[1], F. Lodi[1], G. Bandini[1], M. Sumini[2]

[1]Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA), Italy
[2]University of Bologna (UniBO), Bologna, Italy

Corresponding Author: M. Sarotto; massimo.sarotto@enea.it

Track 3. Fast Reactor Safety

ABSTRACT

In the last years an international effort has been pursued for the development of the Advanced Lead Fast Reactor European Demonstrator (ALFRED), whose design was initially conceived in the EURATOM FP7 LEADER project and now is being carried on by the FALCON International Consortium signed by Italian, Romanian and Czech organizations. In line with the vision of the Gen-IV initiative, the LFR concept following ALFRED is expected to excel in safety and economics while allowing the closure of the nuclear fuel cycle.
The article - dealing with the ALFRED core design - analyses the local and global effects due to the accidental extraction of one Control Rod (CR) during nominal plant conditions. The impact on the core neutronics was evaluated with the ERANOS deterministic code in terms of:
• reactivity balance and power distribution among the Fuel Assemblies (FAs);
• distortion of the local power distribution inside the hottest FA.
By means of specific ERANOS procedures, a detailed 3D power map was evaluated at the level of single fuel pins. The steady state neutronic results were then used as input for accurate transient and thermal-hydraulic studies made by:
• the RELAP5 system code, to investigate the evolution of the worst conceivable scenario, associated with the un-adverted withdrawal of the CR and failure of the scram actuation by the reactor protection system, thereby resulting in an Unprotected Transient of Over-Power (UTOP);
• the ANTEO+ sub-channel code, developed and validated by ENEA, to evaluate the temperature distributions in all the pins and surrounding sub-channels at key instants of the transient.
The main objective of the study was the assessment of the new thermal conditions of the hottest FA in order to verify the compliance with the safety limits. By adopting a credible maximum withdrawal velocity of the CR, a margin of about 250 °C resulted from the melting point of the MOX fuel even in a completely unprotected scenario. Such margin should be high enough to accommodate the modelling, material and fabrication uncertainties. Similarly, by looking at the stainless steel cladding temperature behaviour and its ability to withstand creep, the grace time for operator intervention resulted far higher than the minimum target of 30 minutes to allow for operators' intervention.

Session: 3.7 Core Disruptive Accident Prevention