Transactions of the Korean Nuclear Society Autumn Meeting
Goyang, Korea, October 24-25, 2019

Preliminary Safety Analysis of ULOF for Conceptual TRU Burner Reactor

Jae-Ho Jeong [a*], Jonggan Hong [a], Seok-Hun Kang [a]
[a] *Korea Atomic Energy Research Institute, 989-111, Daedeok-daero, Yuseong-gu, Daejeon, 34057*
[*] *Corresponding author: jhjeong@kaeri.re.kr*

1. Introduction

KAERI is developing an advanced sodium-cooled fast reactor for a TRU (Transuranic waste) burning with a power of 3800 MWt. The TRU burner reactor with the pool concept and metal fuel consists of the PHTS (Primary Heat Transport System), IHTS (Intermediate Heat Transport System), and DHRS (Decay Heat Removal System). The reactor has negative reactivity feedbacks except density reactivity during the transients. Also, it has passive safety system to prevent the loss of power by utilizing a natural circulation in DHRS.

In this study, a preliminary safety analysis of unprotected loss of flow (ULOF) for TRU burner reactor is implemented using MARS-LMR code.

2. Safety Analysis Methodology

Fig. 1 shows the safety analysis nodalization for the TRU burner reactor. The core is modeled by five parallel flow channels such as the hottest inner driver fuel assembly, the hottest outer driver fuel assembly, the rest of driver fuel assemblies, non-fuel assemblies, and leakage flow. The PHTS is placed in a large pool, which is divided into hot pool and cold pool zones. The six sodium-to-sodium DHXs (Decay Heat eXchangers) and three pumps are located in the cold pool, whereas six IHXs (Intermediate Heat eXchagers) are located in the hot pool to transfer the reactor generated heat from the PHTS to the SG (Steam Generators).

3. Safety Analysis Results

Table I describes the steady state comparison of the design value and the calculated value with a MARS-LMR code on each parameter. Based on the steady state results of Table I, a preliminary safety analysis has been carried out using MARS-LMR code for ULOF, which is anticipated as the most severe event of ATWS (Anticipated Transient Without Scram) for the TRU burner reactor.

Fig. 2 and 3 shows the preliminary safety analysis results of reactivity and peak coolant temperature for ULOF. The TRU burner reactor has two hottest fuel assemblies in an inner and outer driver fuel group, respectively. As Fig. 2 and 3, the reactivity and peak coolant temperature are remarkably dependent on the number of PHTS pump trip. At 0.0 second, PHTS pumps are tripped. The peak coolant temperature in a core rapidly increases due to the significant decrease of the core flow rates since pumps trip. As the core coolant temperature rapidly increases, positive density reactivity is inserted. Even though the density reactivity has a positive value, the negative reactivity feedbacks of radial expansion, axial expansion, and Doppler make the net reactivity negative large enough as shown in Fig 2. Thereafter the peak coolant temperature continuously decreases due to the decrease of the reactor power and the increase of the natural circulation flow through the core. As a result, the peak coolant temperature for ULOF is 594.82 ℃ when one PHTS pump trips. The peak coolant temperature is 707.78 ℃ when two PHTS pumps trip. The peak coolant temperature is 886.15 ℃ when three PHTS pumps trip.

4. Conclusions

A preliminary safety analysis of ULOF using MARS-LMR code has been carried out for the TRU burner reactor. There is no propagation to a severe accident by the negative reactivity feedbacks. It would be expected that a significant mechanical energy release is to be practically eliminated by countermeasures for prevention and mitigation against ATWS. Furthermore, the heat capacity and operating logic of DHRS will be studied in ATWS.

ACKNOWLEDGEMENTS

This work was supported by the nuclear R&D program supported by the Ministry of Science, ICT and Future Planning of the Republic of Korea (NRF-2012M2A8A2025624).

REFERENCES

[1] J. Jeong et al., Design Information Document for Safety Analysis, SFR Design Division, KAERI, 2018.

Table I: Steady State Comparison of Design Value and Calculated Value with MARS-LMR Code

Parameters	Design	MARS-LMR
Power (MWt)	3800	3800
Flowrate in a Core (kg/s)	19786	19815.3
Core Outlet Temperature (℃)	510.0	512.488
Core Inlet Temperature (℃)	360.0	361.501
Cover Gas Pressure (Pa)	150000.0	154083.0
Inlet Plenum Pressure (Pa)	676738.0	685069.4

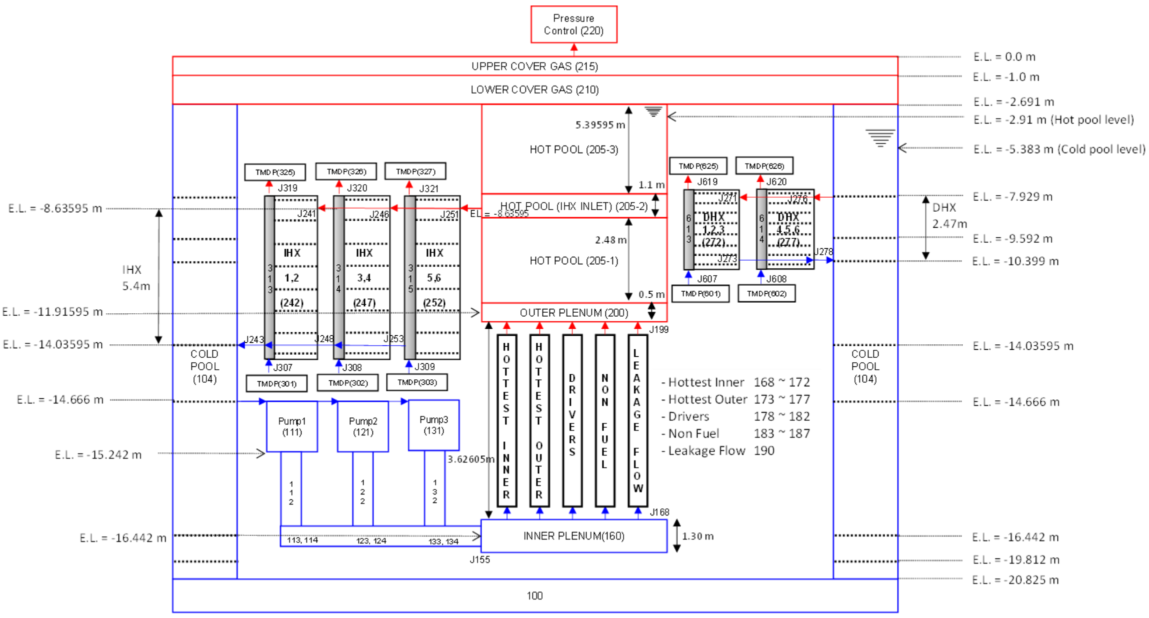
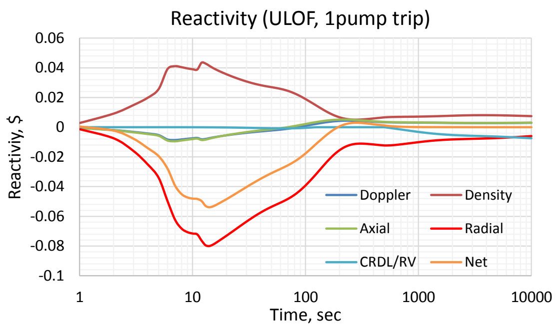
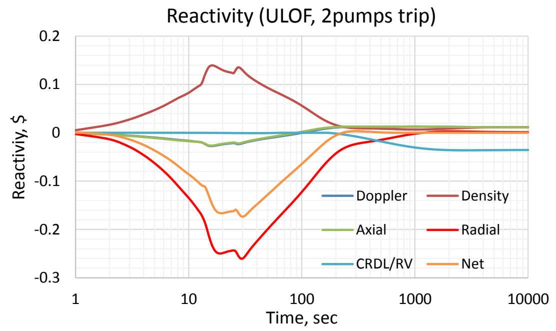


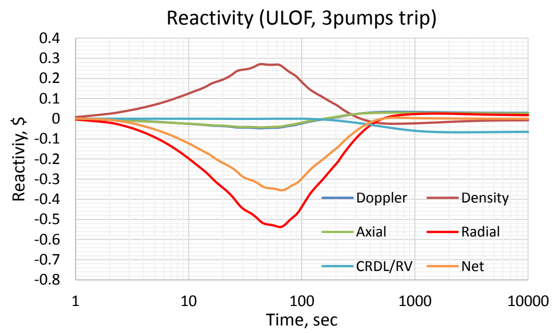
Fig. 1. Nodalization of TRU Burner Reactor



(a) 1 pump trip

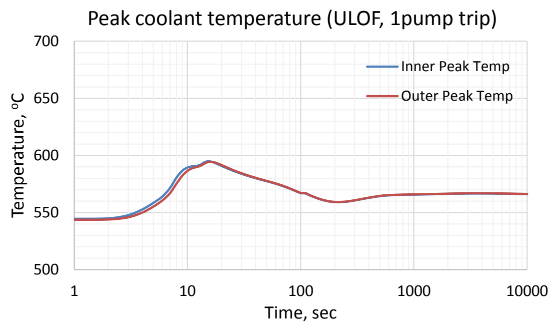


(b) 2 pumps trip

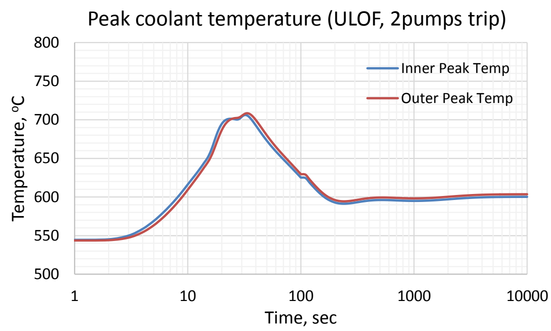


(c) 3 pumps trip

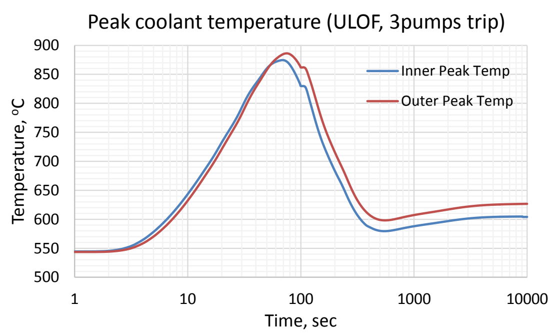
Fig. 2. Reactivity Behavior of ULOF



(a) 1 pump trip



(b) 2 pumps trip



(c) 3 pumps trip

Fig. 3. Peak Coolant Temperature Behavior of ULOF