Trend Analysis for Key Parameters in SALUS

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1. Introduction

The SALUS (Small Advanced Long-cycled and Ultimate Safe SFR) is designed by KAERI to operate for about 20 years without refueling.

In this paper, a trend analysis for the key parameters (power, flow and temperature) in the SALUS was performed using the MARS-LMR code.

2. Methods and Results

2.1 SALUS Design

The design features of the SALUS are similar to Proto-type Gen-IV SFR (PGSFR). However, the SALUS is designed with a capacity of 100 MWe and the core configuration has been modified for extended fuel cycles with increased average discharge burn-up of 75GWd/MT. The reactor core takes advantage of breeding concept to reduce reactivity swing and to reach the target EFPD of 7300 days, so the enrichment of uranium is lower in the core center [1].

Table I shows the main design parameters of the SALUS.

Table I: Major Design Parameters of SALUS

Parameters	Design Value
Thermal Power, MW	268 MW
Core Inlet Temperature	360ºC
Core Outlet Temperature	510ºC
Core Inlet Flow Rate	1366 kg/s
Fuel Type	U-10Zr
No. of Fuel Assembly	112 ea
EFPDs	7300 days

The reactor core and associated coolant, control and protection systems shall be designed with an adequate margin to ensure that the specified acceptable fuel design limits (SAFDLs) are not exceeded during normal operation and during anticipated operational occurrences (AOOs). In the SALUS, the SAFDLs are defined as the cumulative damage fraction (CDF) and the peak cladding temperature to determine a fuel failure. The CDF shall be less than 0.05 and the fuel temperature shall be below the melting point [2].

2.2 Modeling and Initial Conditions

Only the core region and core inlet/outlet plenum of the SALUS were modelled using the MARS-LMR code [3]. Fig. 1 shows the nodalization used for this analysis.

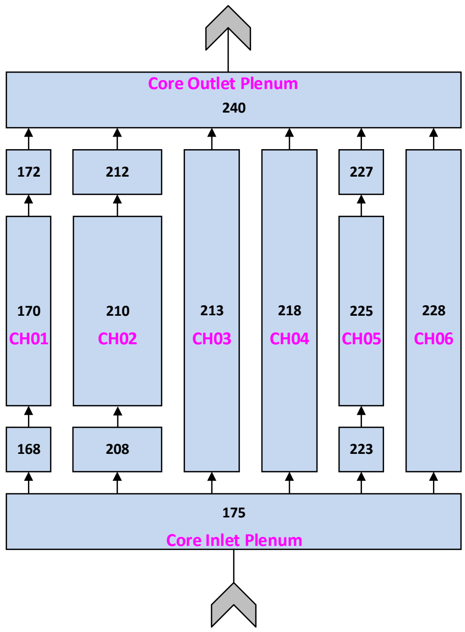

Fig. 1. MARS-LMR Nodalization for the SALUS Core

The core region consists of a hot fuel assembly (CH01), average fuel assemblies (CH02), reflector assemblies (CH03), shield assemblies (CH04), control rod assemblies (CH05) and a leakage region (CH06). The core inlet plenum and the core outlet plenum were connected to the boundary conditions.

In the nominal operating condition of the SALUS, the average power and flow rate at a fuel assembly (CH01) are 2.35 MWt and 11.3 kg/s, respectively. And the core inlet temperature is 360ºC. The conditions for the power, the inlet flow rate and the inlet temperature at the CH01 for this analysis are shown in Table II. They were selected taking into account the design conditions and the limiting conditions for operation (LCO) of the SALUS. TOP (transient overpower) and LOF (loss of flow) events were considered. These events lead to the most severe consequences in terms of the fuel integrity in the AOOs.

Table II: Initial Conditions in CH01

Index	Power	Flow	Temp.	Remarks
	MW(%[1)])	kg/s(%[1)])	ºC	
1	1.88(80)	13.5(120)	350	Min.
2	2.11(90)	12.4(110)	355	
3	2.35(100)	11.3(100)	360	Average
4	2.58(110)	10.1(90)	365	
5	2.82(120)	9.0(80)	370	Max.
1) % of average condition				

When analyzing the trend for each parameter, the remaining parameters are fixed to the average condition given in Table II.

2.3 Analysis Results

The CDF trends for each parameter during a TOP event are shown in Fig. 1. Under the given initial conditions, the most sensitive parameter to the CDF was found to be the inlet flow rate at CH01.

Fig. 2 shows the fuel temperature trends for each parameter during a TOP event. The power at CH01 was found to be the most sensitive parameter to the fuel temperature.

The CDF and maximum fuel temperature trends for each parameter during a LOF event are shown in Fig. 3 and 4. Within the given initial conditions, the most sensitive parameters to the CDF and the fuel temperature were found to be the inlet flow rate and the power, respectively.

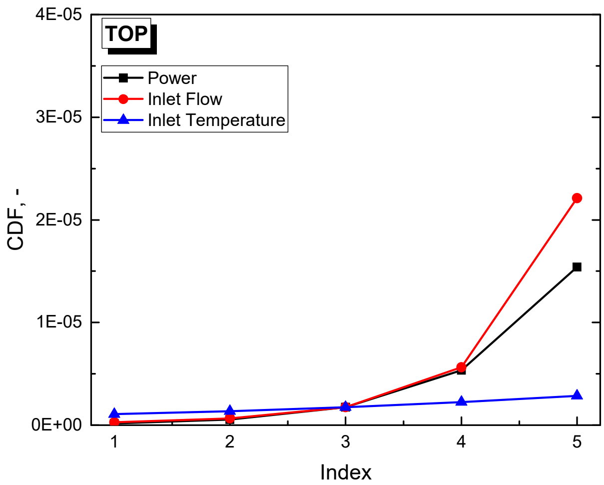

Fig. 2. CDF Trends (TOP)

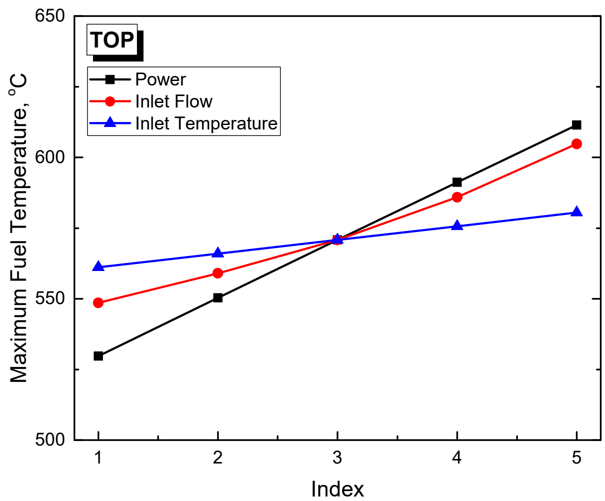

Fig. 3. Fuel Temperature Trends (TOP)

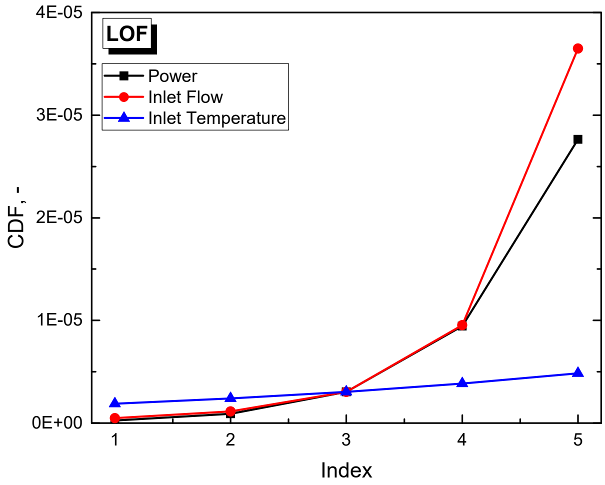

Fig. 4. CDF Trends (LOF)

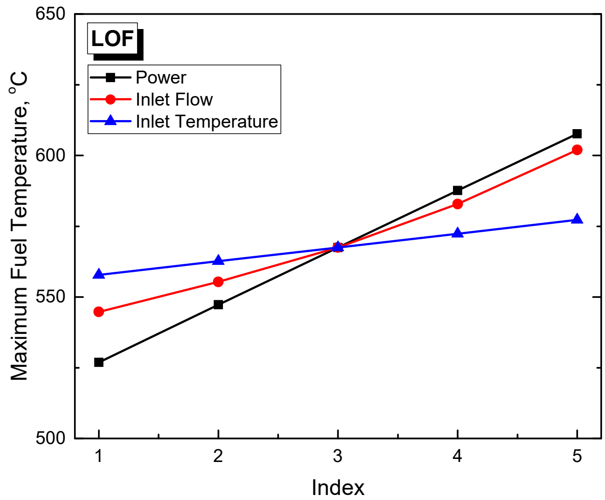

Fig. 5. Fuel Temperature Trends (LOF)

3. Conclusions

A trend analysis for the key parameters of the SALUS was carried out using the MARS-LMR code. The results of this analysis will be the basis for the setting of conservative initial conditions for the safety analysis of the SALUS.

ACKNOWLEDGMENTS

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