EBR II Unprotected Loss of Heat Sink prediction and preliminary test using MARS-LMR code

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1. Introduction

A preliminary study for applying the Best-Estimate plus uncertainty quantification (BEPU) to Design Extension condition(DEC) of Prototype GEN-IV Sodium Cooled Fast Reactor(PGSFR) is being performed. In order to assess the uncertainty quantification of the MARS-LMR code, the code has been improved by modifying the source code to accommodate calculation process required for uncertainty quantification. In the present study, a transient of Unprotected Loss of Heat Sink (ULOHS) is selected as typical cases of as Anticipated Transient without Scram(ATWS) which belongs to DEC category. The input generation and preliminary analysis were performed using the MARS-LMR code to understand the general behavior of EBR-II ULOHS

2. Analysis and Method

2.1 The description of EBR-II reactor

The Experimental Breeder Reactor II(EBR-II) plant is located in Idaho and designed and operated by Argonne National Laboratory from 1964 to 1994. EBR-II is Sodium cooled, pool-type fast reactor operating at a thermal power of 62.5MWt and an electric power of about 20MWe. The corresponding reactor, secondary, and steam system flow rates are roughly 485, 315, and 32 kg/s. respectively. A schematic of the EBR-II plant, as is shown in fig. 1, the reactor core is submerged in the primary tank which contains approximately 340 m^3 of liquid sodium. The two primary pumps draw sodium from cold pool and provided sodium into the two inlet plena. Subassemblies in the inner core regions received sodium from the high-pressure inlet plenum and the blanket and reflector subassemblies in the outer blanket region received sodium from the low-pressure inlet plenum. The coolant from the core outlet directly flowed to the Z-pipe, which connected the core outlet and the intermediate heat exchanger (IHX) inlet. The hot sodium was transferred to the intermediate cold sodium due to temperature difference, and then exited the IHX back into the cold pool. The IHX is a tube-shell unit with the primary flow on the shell side.

2.2 Modelling of EBR II ULOHS test

The ULOHS test was performed to demonstrate the effectiveness of EBR-II's a natural feedback feature.

Also starting from full power and flow, EBR-II ULOHS test was initiated by stopping the secondary sodium coolant flow with adequate cooling without control rod insertion or operator insertion.

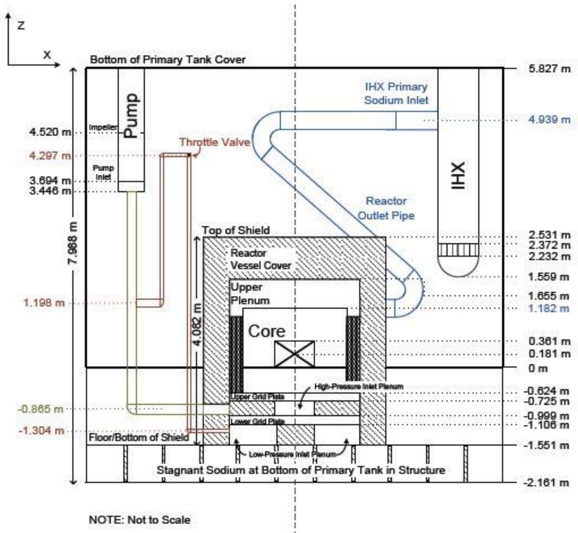

Fig. 1. Schematic of the EBR II primary system [1]

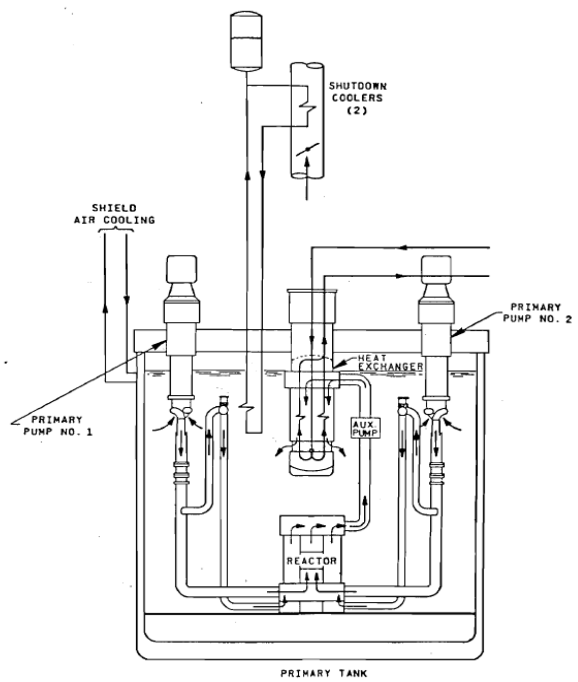

Fig. 2. EBR-II Primary Tank Sodium Flow Paths [1]

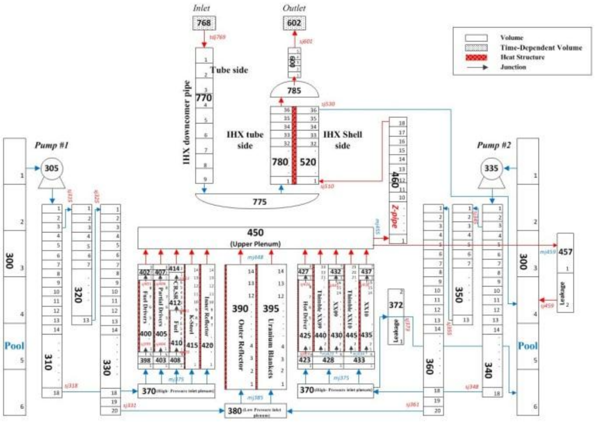

Fig. 3. Node diagram of MARS-LMR for EBR-II

Fig 3 shows the node diagram of MARS-LMR for the EBR-II ULOHS. The sodium cold pool and two primary pump are modeled as pump the primary coolant to the inlet plenum. The inlet plenum is divided into a high pressure plenum and a low pressure plenum. The subassemblies in the reactor core are divided into ten flow channels. The two flow channels are modeled as the uranium blanket and outer reflector connected to the low pressure plenum. The other flow channels are connected to the high pressure inlet plenum. The coolant heating up in the core flows up into upper plenum and enters into Z-pipe, which connected the the intermediate heat exchanger (IHX) shell side inlet. IHX tube side outlet is modeled as boundary condition.

2.3 Simulation and analysis of results in MARS-LMR code

The MARS-LMR Code was used to simulate a transient test involving unprotected loss of heat sink. The transient calculation was conducted assuming a stoppage of secondary sodium flow. Main experimental results were taken into account in the reference paper [3]. Therefore the calculated results correspond to the blind test because there are not enough experimental results. Table 1 shows considerations of MARS-LMR calculation for EBR-II ULOHS.

Table 1. Main considerations for calculation

Case No.	Usage of Heat Loss
Case 1	No usage of heat loss
Case 2	Usage of heat loss: Air cooler, Other Primary system

The calculations were to be initiated by linearly reducing the secondary sodium flow rate from its initial value to about 1.67 kg/sec in 200 sec.

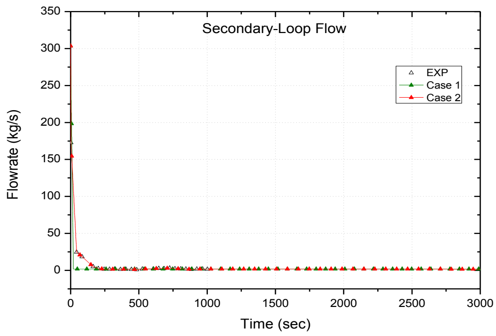

Fig. 4. Secondary-Loop flow rate

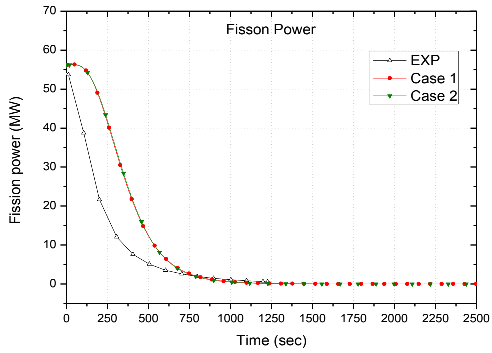

Fig. 5. Fission power

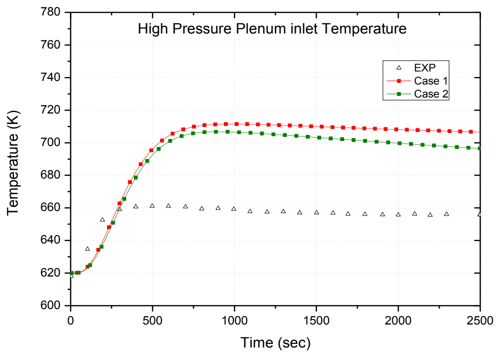

Fig. 6. High Pressure Plenum inlet Temperature

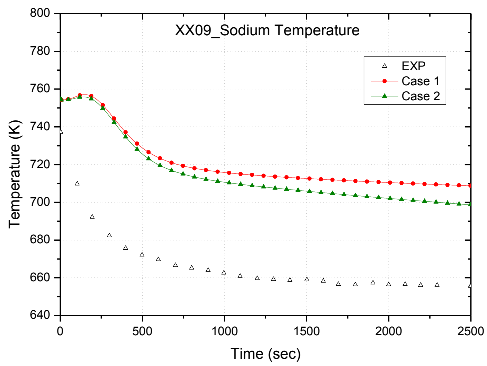

Fig. 7. XX09 TTC Sodium Temprature

3. Conclusions and future Works

A preliminary analysis is carried out with the MARS-LMR code for EBR-II ULOHS. The results of code calculation for EBR-II ULOHS were in over-estimated results compared to the experimental results

The reason of these predictions will be identified and an advanced simulation will be performed in further studies. Currently, EBR II input is modeled as one-dimensional, but multi-dimensional modeling for the detailed analysis of sodium pool is necessary. Additional modification and validation will be performed in respect of boundary conditions.

Acknowledgments

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REFERENCES

[1] T. Sumner, T.Y.C. Wei, Benchmark specifications and data requirements for EBR-II shutdown heat removal tests SHRT-17 and SHRT-45R ANL-ARC-226, Argonne National Laboratory, 2012.
[2] KAERI, MARS code manual volume II, KAERI/TR-2811/2004, 2009.
[3] E.E. Feldman et al, EBR II Unprotected Loss of Heat sink predictions and preliminary test results, 1987