Study on optimized safety system modeling for small-scale passive reactor

Yun Sik Sung, Sung Won Lim, Yong Won Choi, Un Chul Lee
Dept. Nuclear Engr. Seoul Nat'l Univ., Shillim-dong, Kwanak-gu, Seoul, 151-744
Tel:82-2-880-8332, Fax:82-2-889-2688, Email:creepsing@gmail.com

1. Introduction

Small scale reactor is one of the most important issues in this low-carbon and green energy development era of 21st century, since small scale reactor enables (a) local heating, (b) desalinating, and (c) local electric power generating, which can avoid power loss arising out of long-distance power transmission

This study is about safety system (especially about PRHRS, Passive Residual Heat Remove System) of REX-10; one model of small scale passive reactor and its goals are (a) to research on characteristics of safety system of small scale reactors compared to conventional PWR or research reactors like SMART, (b) to nodalize the system and (c) to optimize the safety system through simulation and analysis of virtual accident. RELAP5/MOD3.3[1] will be used for analysis tool of accident simulation.

2. Methods and Results

2.1 Nodalization and Steady state

Following figure shows the nodalized REX-10 including PRHRS for RELAP code.

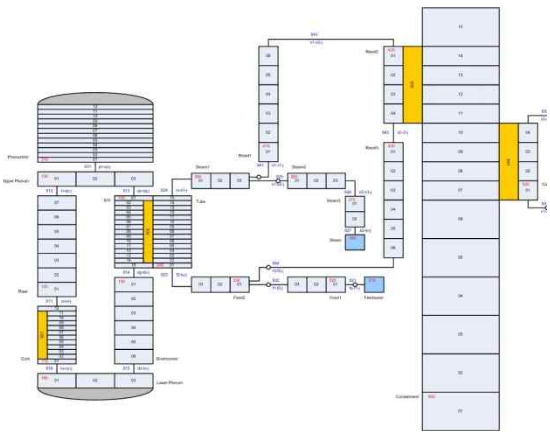

Fig. 1. Nodalization of REX-10

Design parameters of REX-10 are listed below, and especially some parameters of PRHRS are quoted but scaled-down from SMART because those for PRHRS have not been specified yet.

Table. 1. Design parameters of REX-10 and SMART

	REX-10	SMART
Overall		
Thermal Power	10(MWth)	330(MWth)
Service years	20	60
Geometry(RPV)		
outer diameter(m)	2.272	4.6
Height(m)	4.635+1.545	10.625
Thickness(m)	0.075	0.264
Primary Circuit		
Cooling mode	NC	FC
Cooling medium	Water	Water
Operating Pressure(MPa)	2.0	14.7
Secondary Circuit		
Type of S/G	Helical-coiled	Helical-coiled
Number of H/X	1(overall) 4(separate)	12 cassettes
Thermal capacity	10MW	27.5/cassette
Steam Pressure(MPa)	0.55	3

In previous study[2], it has been verified that natural circulation of coolant in nominal state successfully made a path and was stabilized after about 1000sec. Also core inlet temperature and outlet temperature are set by 439.67K and 475.25K respectively. Coolant flow rate was 63.57kg/s and its pressure in primary circuit was 1.9876MPa respectively.

Below shows stabilized state of REX-10

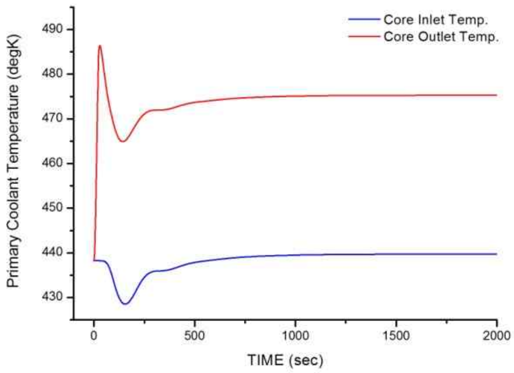

Fig. 2. Temperature of core intlet(blue) and outlet(red) in time of nominal state

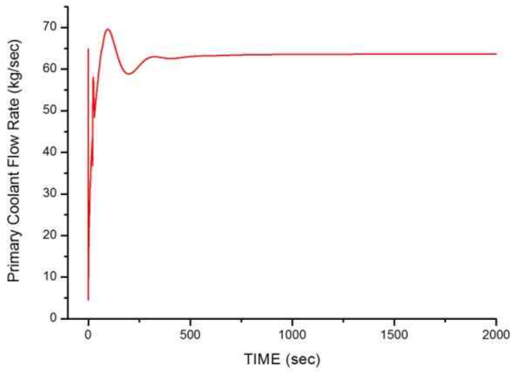

Fig. 3. Primary coolant flow rate in time

2.2 Accidental situation and activation of PRHRS

After the system is stabilized, in order to make an accident, feed water flow was cut down to 50% which is 3.1kg/s. Consequently, heat reduction also decreased and, as shown in fig.4, pressure of primary circuit drastically went up to trip condition; 2.2MPa, it's set by 110% of nominal pressure. When trip occurred, PRHRS was connected to secondary circuit instead of feed and steam line and core power was cut down to 6% of nominal state. After PRHRS started to drain heat, pressure sufficiently went down and temperature also did. Temperature of PRHRS went up to 461K and smoothly down to steady. Containment tank, the final heat sink was heated up constantly. So its size had to be sufficiently big. In this simulation, water in CT was boiled at about 32800sec.

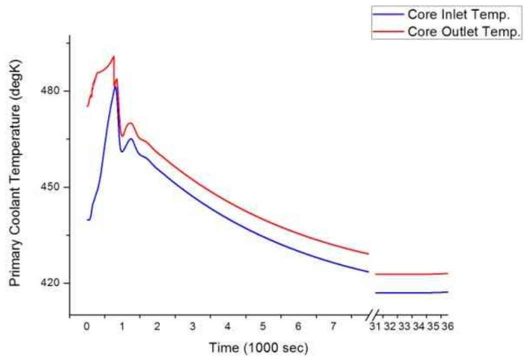

Fig. 4. Temperature of core intlet(blue) and outlet(red) in time of accidental state.

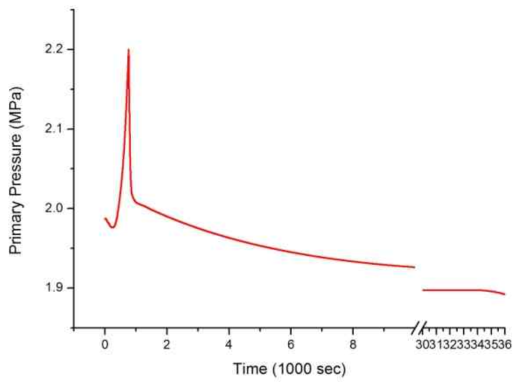

Fig. 5. Pressure of Primary circuit in time. Pressure goes up to 2.2MPa

3. Conclusion

PRHRS of REX-10 has no specified design yet. This study can be a basis for future specification of PRHRS of REX-10. We could figure out the initial condition of PRHRS roughly that would work. However, containment tank's condition that makes no vapor in it and detailed specification of PRHRS considered also on economic side remain issues for further study on this subject.

REFERENCES

[1] Tomislav Bajs, Davor Grgić, Velimir ŠŠegon, Luca Oriani, Lawrence E. Conway, Development of relap5 nodalization for IRIS non-loca transient analyses
[2] Sung Won Lim, Yong Won Choi, Un Chul Lee, Study on verification of natural circulation for small scale reactor with passive system.
[3] In Young Kim, Sung Won Lim, Un Chul Lee, Study on verification of natural circulation for the Regional Energy Reactor REX-10 using RELAP5/MOD3.3