The Multi-Dimensional Analysis Method Development for Sodium Pool of SFR using MARS-LMR CODE

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1. Introduction

KALIMER-600 (Korea Advanced Liquid Metal Reactor), which is pool type of SFR (Sodium-cooled Fast breeder Reactor), has been developed by KAERI (Korea Atomic Energy Research Institute). The sodium circulates mainly by the force of natural convection during operation of SFR [1]. In this phenomenon, the distribution of temperature, pressure and mass flow are required in order to evaluate operation the whole of system. In this study, SFR is analyzed in multi-dimension by MARS-LMR CODE which is developed by KAERI for analysis of thermal hydraulic system.

2. Methods and Results

In this section the method for modeling used MARS-LMR CODE of KALIMER-600 are described.

2.1 Multi-Dimension Modeling

In the previous study, KALIMER-600, which is consisted with a lot of components in RV(Reactor Vessel) such as IHX(Internal Heat Exchanger, DHX(Decay Heat Exchanger), UIS(Upper Internal Structure) and Pump, was analyzed by MARS CODE in 1-dimension[K.S.Ha et al.]. Therefore, it is not able to describe some phenomena. For example, some part of the hot sodium which has passed core is met UIS, IHX or Pump. Thus, the heated sodium flow pattern can be changed because of those. Therefore, multi-dimensional analysis is needed to show more detail phenomena. The magnitude of 3-dimension hot pool which is flow area was calculated in previous study. Through using of multi-dimensional input, it is able to modify to cylindrical geometry pool. The multi-dimensional nodalization of KALIMER-600 is presented in Fig.1 which is coordinated in radius(r), angle(Θ) and axial (z) direction each of intervals are 3,8 and 7.

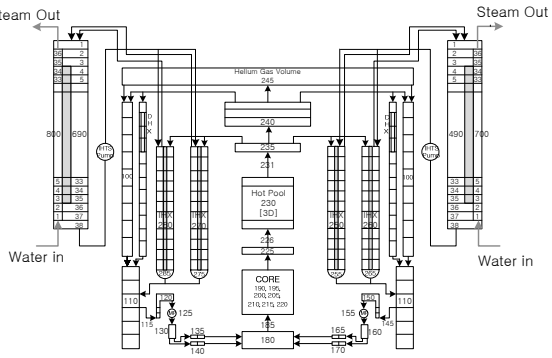

Fig.1. The multi-dimensional nodalization of KALIMER-600.

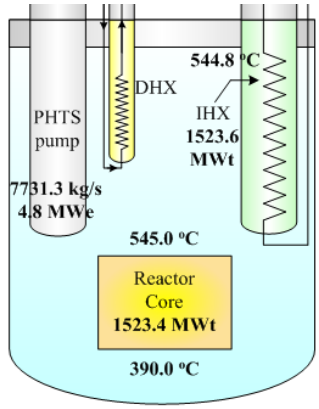

Fig.2. Heat balance of PHTS(Primary Heat Transport System) in KALIMER-600 [1].

2.2 The Temperature Distribution

Particularly, it is necessary to predict the hot pool coolant temperature distribution with sufficient accuracy to determine the inlet temperature conditions for the IHXs because the temperature distribution of a hot pool can alter overall system response [2].

Fig.3 is indicated the temperature distribution and comparison between 1-dimensional and multi-dimensional result which have some difference the approaching steady state. First, upper lines group is 1-dimensioal method and bottom lines group is multi-dimensional method. After 180seconds, average temperature of 1-dimensional analysis is about 824K.

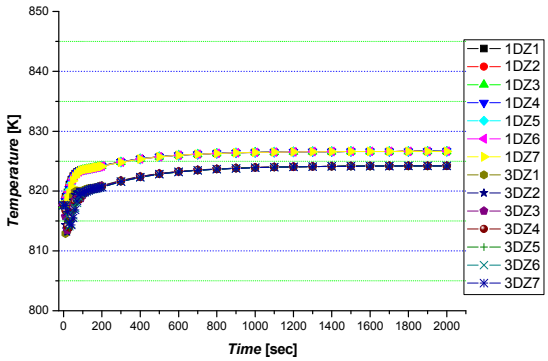

Fig.3. Comparison of the temperature distribution at each node between 1-dimension and 3-dimensional analysis (Z is axial direction).

However, in case of multi-dimensional method, it is about 240K after 1100seconds. Because the sodium flow direction is only one direction to up side in 1-dimensional method, while it is 5~6 directions in 3-dimension pool. It means 3-dimension pool is needed more time to be stable than 1-dimensional method. Otherwise, the gap values of two methods are continuously closed.

Moreover, the upper lines of Fig.4 are temperature of 1-dimesional analysis method and bottom lines are temperature of multi-dimensional analysis method consisted inlet Z1 and outlet Z7 to axial direction. Beginning of graph, 1-dimension result show only increasing temperature, whereas the result of 3 dimension pool is decreasing and increasing. The reason why this phenomenon is different boundary condition between 1 and 3 dimensional method. Additionally, as it is mentioned, two methods have different number of flow direction.

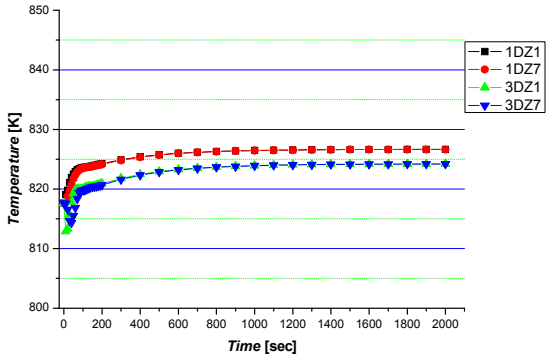

Fig.4. Comparison of the temperature distribution inlet Z1 and outlet Z7 node between 1-dimension and 3-dimensional analysis (Z is axial direction).

3. Conclusions

KALIMER-600 is operated under steady state condition without any problem. Otherwise, through the multi-dimensional modeling, we are concerned to be more accurate in performing the analysis and to provide realistic data.

In this study, the hot pool is divided to upper hot pool is mixing of sodium before IHXs, and down hot pool is between core and upper hot pool. The parts of hot pool should be described as one component, furthermore, the result data shows tiny difference from 1-dimensional method that is why checking up the boundary conditions and initial conditions are needed, which are further works. s

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