HCCR TBS steady state calculation by using GAMMA-FR & MELCOR

Hyung Gon Jin [a*], Mu-Young Ahn[b]
[a]*Korea Atomic Energy Research Institute, Republic of Korea*
[b]*National Fusion Research Institute, Republic of Korea*
[*]*Corresponding author: jhg@kaeri.re.kr*

1. Introduction

KAERI has participated in the development of HCCR (Helium Cooled Ceramic Reflector) TBS (Test Blanket System) as a member of the KO TBM Team. Conceptual design review had been done in 2015 and after chit resolution procedure, the final approval was achieved in March 2016. Currently, the largest issues of HCCR TBM safety analysis are validation of in-house safety analysis code (GAMMA-FR) and reflecting the design changes after CDR to the safety analysis input deck to prepare PDR (Preliminary Design Review). In this paper, current status of HCCR TBS's GAMMA-FR and MELCOR nodalization is given and hydraulic steady state calculation results are compared [1][2].

2. HCCR TBS and Nodalization

2.1 HCCR TBS

The HCCR-TBS comprises TBM with shield, i.e. TBM-set and its ancillary systems such as Helium Cooling System (HCS), Tritium Extraction System (TES), Coolant Purification System (CPS), Pipe Forest (PF), Ancillary Equipment Unit (AEU), Neutron Activation System (NAS), Tritium Accountancy System (TAS) and Instrumentation & Control (I&C). The HCCR-TBS schematic is shown in [3].

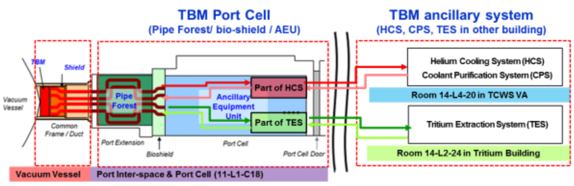

Fig. 1 Schematics of HCCR-TBS

2.2 Nodalization

HCCR TBS design is evolving, especially some design parameters such as flow area and volume can impact safety analysis results, and therefore nodalization should be updated accordingly. After reflecting the CDR chit resolution and resent design modification, CATIA design has been changed as version 0.24 at the moment. Figure 1 is nodalizaton for CDR and Figure 2 is the updated one. Key update is increase of detail in TBM and CCWS-1 loop.

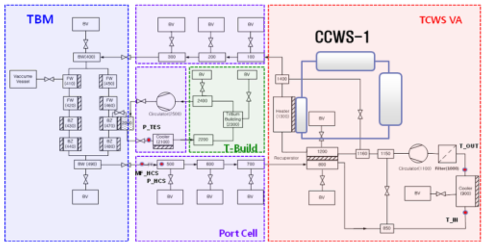

Fig. 2. HCCR TBS CDR Nodalization

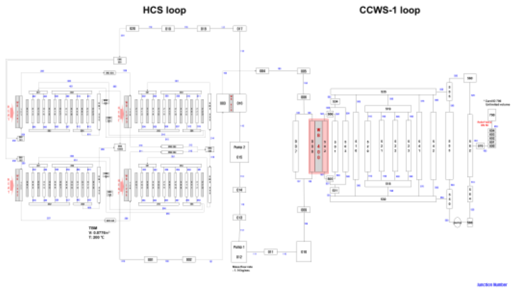

Fig. 3. HCCR TBS Updated Nodalization

3. Results

In this section some of the calculation results are presented. For GAMMA-FR code validation, code to code validation has been schedules by using MELCOR with respect to the same accident cases. For that GAMMA-FR and MELCOR use same HCCR TBS geometry, boundary conditions and initial conditions. Hydraulic steady state calculation, which has no heat transfer within the calculation domain, was done and Figure 4 (GAMMA-FR) and Figure 5 (MELCOR) are mass flow rate plots at the representative fluid junctions. HCS in HCCR TBS shall provide the primary coolant at the nominal mass flow rate (1.14 kg/sec). Each result shows almost the same pattern with each other.

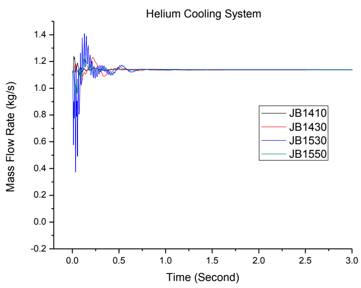

Fig. 4. Mass flow rate (GAMMA-FR)

Over shooting can be observed at the early stage of this calculation, however, it is due to the initial condition and with 2 seconds both codes arrived at steady state.

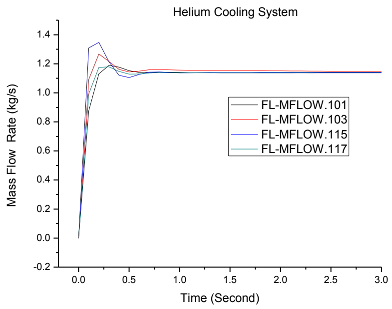

Fig. 5. Mass flow rate (MELCOR)

CCWS-1 (Component Cooling Water System) is connected ITER sub-system, which is important in terms of safety perspective such as tritium migration. Due to the category I chit of CDR, this loop should be included in HCCR TBS transient analysis, however, this system is simplified as much as enough to catch physical behavior of the accident.

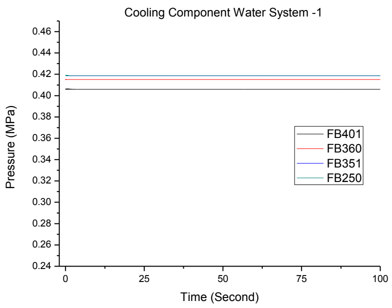

Fig. 6. CCWS-1 Pressure (GAMMA-FR)

.

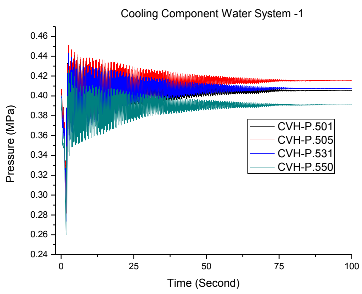

Fig. 7. CCWS-1 Pressure (MELCOR)

Figure 6 and 7 are pressure trend at given points of the loop. GAMMA-FR has many data about this system and initial condition was almost identical with steady state results. On the other hand, MELCOR shows intensive oscillation at the beginning of the calculation. It can be avoided with GAMMA-FR initial condition. Primary propose of this calculation is to confirm steady state condition of the system, in that sense, those oscillation have not much meaning. Design pressure of CCWS-1 (0.41 MPa) can be observed (FB401 in Fig.6, CVH-P 531 in Fig 7) in the diagrams and neighbor volumes show reasonable agreement according to pressure drop.

3. Conclusions

Hydraulic steady state calculation has been done with GAMMA-FR and MELCOR, which results show good agreement with each other code. Further step, which need to be done before the accident analysis, is steady state calculation with heat transfer from first wall of TBM and radiation contribution of each sub model. These works are on-going and those outcomes are going to be used as one of code validation cases.

4. Acknowledgement

This work was supported by the R&D Program through the National Fusion Research Institute (NFRI) funded by the Ministry of Science, ICT and Future Planning of the Republic of Korea (NFRI-IN-1603).

REFERENCES

[1] M.-Y. Ahn et al., Current status of accident analysis for Korean HCCR TBS, Fusion Eng. Des. 89 (2014) 1289-1293
[2] D.W. Lee, et. al., "Current Status and R&D Plan on ITER TBMs of Korea," Journal of Korean Physical Society, 49 S340-S344 (2006).
[3] Hyung Gon Jin, "HCCR-TBS Accident Analysis Report" ,QQL5TP V1.0 (2015)