Consideration of the Construction Code for TBM-body in ASME BPVC

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1. Introduction

Helium Cooled Ceramic Reflector (HCCR) Test Blanket System (TBS) has been designed to research on the functions of breeding blanket by KO TBM team. The functions has three subjects as 1) Tritium breeding, 2) Heat conversion and extraction, and 3) Neutron and Gamma-ray shielding. This system comprises TBM with shield and its ancillary systems. TBM with shield, which is called TBM-set, has TBM body, shield and connecting support, as shown in Fig. 1.

For the process of design, it is needed to select the appropriate construction code as the design criteria. ITER Organization (IO) has proposed that RCC-MR Edition 2007 ver. shall be used for TBM-shield. Because the TBM-shield is connected to the vacuum boundary. For the other part of TBM-set, TBM-body, there is no constraint on the selected code, and the manufacturer can appropriately select the construction code to apply design and fabrication parts.

KO TBM Team has considered whether it is appropriate to choose any code for TBM-body. One of the things is ASME code [1]. The advantage of ASME choice is suitable to the domestic status. In the domestic nuclear plant, ASME or KEPIC code [2] is used as regulatory requirements. Based on this, it is possible to prepare a domestic fusion plant regulatory. In addition, the technical assessment of welding, fabrication, etc. is involved in the production process. Therefore, it is necessary to select code for the domestic industry status.

In this paper, ASME code is briefly introduced, and the TBM-body is classified for selecting the ASME section. With the classification of TBM-body, the appropriate section is determined.

2. ASME Section III and VIII

ASME Boiler and Pressure Vessel Code (BPVC) is a international standard that regulates the design and construction on boilers and pressure vessel by American Society of Mechanical Engineers (ASME). ASME BPVC comprises several sections [2]. Among these sections, section III and section VIII are related to the TBM-body which may be categorized as the pressure vessel.

Section III is the rules for nuclear facility components and consists of five divisions. Division 1 is the part for the components and comprises several subsections that are classified by the level or type of components. Division 2 and 3 are the parts of concrete containments and of spent nuclear fuel and radioactive material and waste, respectively. Division 4 is the part of fusion energy devices. However, since this division is still in development, it cannot be used. Division 5 is the part for high temperature reactors.

Section VIII is the rules for only pressure vessels and consists three divisions. These division are classified according to the design method. The differences between section III and section VIII is whether or not considered for high temperature operation condition and irradiation condition. Section III contains the rules for high temperature operation condition and irradiation effects. When ASME BPVC section is selected, not only the safety class, quality group, and seismic category of the target, but also the operation condition are considered.

3. Classification on the TBM component

As previously mentioned, the TBM-body should be classified according to safety class, quality group and seismic category to select an ASME BPVC section. In nuclear plant, the criteria on the class of components is based on the 10CFR 50 Appendix A in United States Nuclear Regulatory Commission (NRC) [3]. Safety class criteria follows ANSI/ANS 51.1-1983 [4]. Quality group is based on the NRC regulatory guide 1.26 [5], and seismic category follows NRC regulatory guide 1.29 [6].

In ITER project these classifications for TBM-body follow the ITER criteria, and the result is shown in Table 1. The safety class of the TBM body is Non-SIC (Safety Importance Class) by the ITER Safety Importance Class (SIC) criteria [7]. The Quality class is quality class 1 (QC1) by the Quality Classification Determination [8]. QC1 means that this component has failure potential for 1) a loss of plasma operations for more than 3 weeks, 2) severe adverse impact on the health or safety, 3) environmental damage. Seismic category is SC2 by the ITER Seismic Nuclear Safety

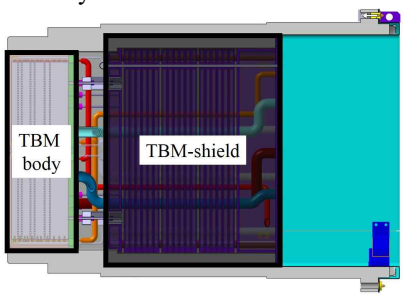

Fig. 1. HCCR TBM-set configuration

Table 1 Classification of the TBM body and TBM-shield.

	Safety class	Quality class	Seismic category
TBM body	Non-SIC	QC-1	SC2
TBM shield	SIC-1	QC-1	SC1 (S)

Table 2 Application of ASME BPVC in nuclear plant.

Safety class	Quality class	Seismic class	ASME BPVC (Sec., Subsec.)
1	A	1	III, NB / NH / NF
2	B	1	III, NC
3	C	1	III, ND / NG
Non-safety	D	Non-Seismic	VIII

Approach [9]. SC2 component has non-damage to the safety and functional requirements of SC1 equipment in the event of an earthquake.

To select an appropriate division or subsection, operation conditions for the TBM-body is also considered. The loadings on the TBM-body are pressure, thermal, electric-magnetic and gravity. Among these loadings, thermal loading is largest and the maximum temperature of TBM-body is about 550 degree. This high temperature may cause creep behavior of the material. And thermal loading is applied in the form of cyclic loading by plasma heat flux and nuclear heating. From this operation condition, the creep-fatigue behavior is also considered for TBM-body.

4. Applying ASME code to TBM

Based on the previously defined class and driving conditions, ASME BPVC is selected for TBM-body. Before selecting ASME BPVC for TBM-body, application of ASME BPVC in the nuclear plant is described in table 2. ASME BPVC section for TBM body could be determined from comparing Table 1 with Table 2. According to safety class, TBM-body may be defined as normal pressure vessel and ASME BPVC section VIII may be selected for TBM-body class. But section III in ASME BPVC may be determined for TBM-body from quality group and seismic category. Though the safety class of TBM-body is low class, section III is selected for the overall design criteria.

According to the operation conditions of TBM-body, high temperature condition and irradiation effects are considered. Subsection NB is the rules for class 1 components and subsection NH is the rules for class 1 components in elevated temperature service. Therefore, section III division 1 subsection NH is selected as the construction code of TBM-body.

5. Conclusions

In this paper, the construction code of TBM-body was determined in ASME BPVC. For the determination of code, the structure of ASME BPVC was introduced and the classification for TBM-body was conducted by the ITER criteria. And the operation conditions of TBM-body that contained creep and irradiation effects was considered to determine the construction code. In future work, the design criteria in section III division 1 subsection NH of ASME BPVC will be applied to the process of design for TBM-body and the research on the verification of applying code to complex TBM shape will be conducted.

Acknowledgment

This work was supported by R&D Program through National Fusion Research Institute (NFRI) funded by the Ministry of Science, ICT and Future Planning of the Republic of Korea (NFRI-IN1603).

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