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Modal and Spectra Response Analysis for Seismic Events in the Conceptual Design of Korean HCCR TBM-set

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1. Introduction

Korea has designed a Helium Cooled Ceramic Reflector (HCCR) Test Blanket Module (TBM) including TBM-shield, which is called TBM-set to be tested in ITER. According to the ITER TBM Port Plug (TBM PP) System Load Specifications, seismic events were selected as SL-1 (seismic level-1), SL-2 (seismic level-2), and SMHV (seismes maximaux historiquement vraisemblables). Spectra analysis for seismic event of SL-1, SL-2, and SMHV were carried out using ANSYS based modal analysis. In modal analysis the 90 % over of total mass was extracted, and the total of 50 modes was obtained.

For each event, the obtained Tresca stress was evaluated to confirm the design integrity, by comparing the resulting stress to the design criteria. Tresca strain and the displacement were also estimated for HCCR TBM-set. From the seismic event analysis, it is concluded that maximum stresses by the seismic events meet the design criteria, and the displacements are lower than the designed gap from TBM PP frame.

2. Modal and Spectra Response Analysis and Results

HCCR-TBS, including the TBM-set, port cells in ITER was known to the #18 port at “F” location as shown in Fig. 1 [1].

Considering seismic events were SL-1, SMHV, and SL-2, conditions: SL-2 of 4% damping rate is the case of the strong seismic event defined by a vertical and horizontal acceleration. SL-1 is a weak seismic event assumed to be equal to (SL-2)/3 with 3% damping rate. And SMHV is the most penalizing earthquakes expected to occur over a period of about 1000 years, and it is assumed to be 0.73×SL-2 with 4% damping rate.

To carry out the seismic events analysis, “F” location of FRS (floor response spectrum) curve in *x* (radial)-, *y* (toroidal)-, and *z* (vertical)- direction of the broaden spectra curve was used [1], and the SSRS (square root of the sum of the squares) from ANSYS [2] was used as combination of results in spectra analysis for the seismic events analysis.

2.1Modal Analysis Results

Modal analysis was performed with ANSYS to extract the natural vibration modes, and the reference [3] was stated that it was need to verify that the ratio effective mass to total mass associated to the combined modes is > 90% of total mass from the modal analysis.

Based on the recommendation, total of 50 modes were obtained from the modal analysis, and the results gave that 95.6 % of mass in *x* (radial)-direction, of 92.3 % of mass in *y* (toroidal) -direction, and 90.0 % of mass in *z* (vertical) -direction were obtained. And all the modes results were applied to the spectra response analysis for the seismic events.

Figure 2 shows the over deformed configuration of ×100 scale in each mode of frequency from the results.

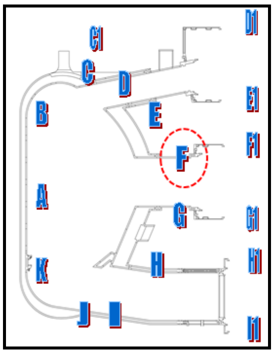

Fig. 1 Schematic diagram of the considering #18 port at “F” location of seismic analysis [1]

Mode 1	61.450 Hz	Mode 50	1555.3 Hz

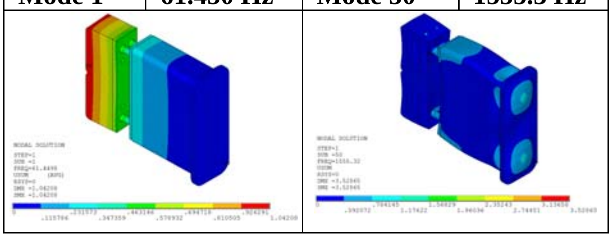

Fig. 2 The over deformed configurations by frequency from the modal analysis

2.2 Spectra Analysis Results for Seismic events

2.2.1 SL-1 Event

The combined the results from the three separate excitation using SRSS (square root of the sum of the square) rule should be combined with the component weight [3].

Figure 3 shows Tresca stress distribution with the over deformed configuration (×100) from the results of SL-1 event which is (SL-2)/3 with 3% damping rate. The analysis procedure was followed by the reference [3,5].

The maximum stress was occurred at the lower right key region as shown in Fig. 4. The Maximum Tresca stress is 63.9 MPa, and it was satisfied the design requirement of allowable stress (1.5S_m, 189 MPa) of Eurofer at 550 °C [6]. The maximum Tresca strain is 0.0343%, and the total maximum displacement of vector summation was 1.6 mm.

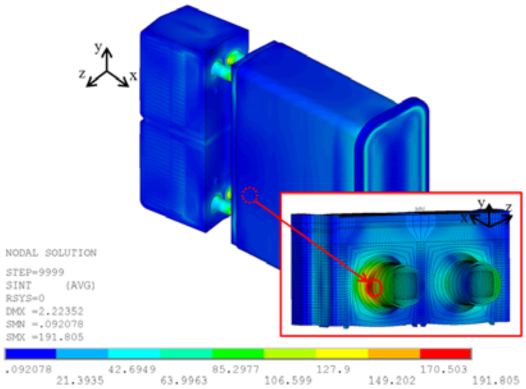

Fig. 3 Tresca stress distribution with the over deformed configuration from the SL-1 event (×100)

2.2.2 SL-2 Event

Figure 4 shows Tresca stress distribution with the over deformed configuration (×100) from SL-2 event analysis. The Maximum Tresca stress was 191.8 MPa, and it was over 1.5S_m (189 MPa) of Eurofer at 550 °C [6]. The maximum stress was occurred at the lower left key region as shown in Fig. 4.

The stress breakdown analysis [7] was carried out at the maximum stress region, and the result gave that the primary membrane stress is 49.05 MPa, and the sum of the membrane and bending stress is 100.8 MPa. The stress breakdown analysis result satisfies the design requirement.

The maximum Tresca strain is 0.103%, and the total maximum displacement of vector summation was 2.223 mm.

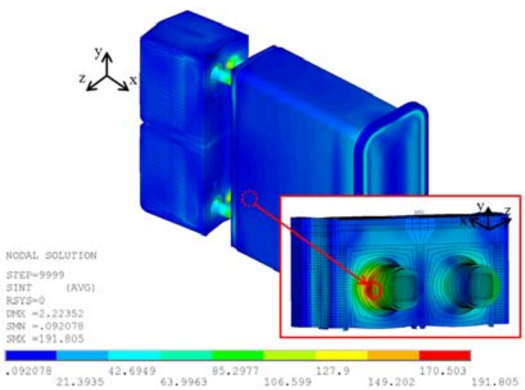

Fig. 4 Tresca strain distribution with the over deformation configuration from the SL-2 event (×100)

2.2.3 SMHV Event

Figure 5 shows SMHV event analysis result with the over deformed configuration (×100) which is 0.73×SL-2 with 4% damping rate. The Maximum Tresca stress was 140.1 MPa, and it was lower than 1.5S_m (189 MPa) of Eurofer at 550 °C which is satisfied the design requirement in RCC-MRx[6,7]. The maximum stress was occurred at the lower right key region. The maximum Tresca strain is 0.075%, and the total maximum displacement of vector summation was 1.63 mm.

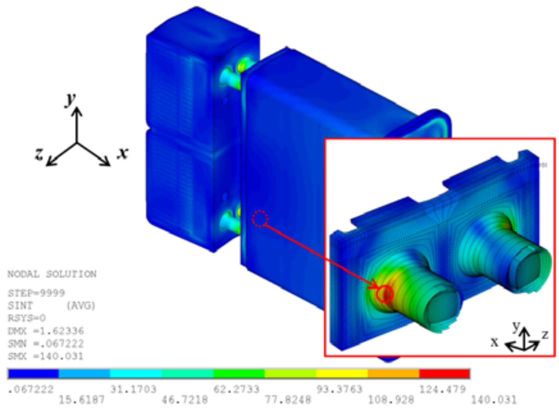

Fig. 5 Tresca stress distribution with the over deformed configuration from the SMHV event (×100)

3. Conclusions

The seismic analyses considering the modal and spectra analysis for seismic event of SL-1, SL-2, and SMHV were carried out using ANSYS. The 90 % over of total mass was obtained in the total of 50th mode results in modal analysis. Based on the modal analysis, the seismic analyses results gave that the maximum Tresca stress in SL-1 and SMHV events were lower than 1.5S_m and they were satisfied the design requirement. But the maximum Tresca stress in SL-2 was over 1.5S_m, and the stress breakdown analysis was carried out at the maximum stress region. The result from the stress breakdown analysis in SL-2 was lower than 1.5S_m, and it was satisfied the design requirement.

REFERENCES

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