# Simplified Model of the Upper Internal Structure in PGSFR

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#### 1. Introduction

The upper internal structure (UIS) is attached to the rotating plug of the reactor head and cantilevered downward into the reactor hot pool. Its-bottom end is located just above the top of the core assemblies during power operation. The principal functions satisfied by the UIS are to support the control rod drivelines laterally and protect the drivelines from sodium flow induced vibration. The other function is to support the above core instrumentation drywells.

Among the above structures, the core instrumentation drywells are excluded in the finite element model. Fig. 1 shows the design configuration of the UIS in PGSFR [1]. The purpose of this study is to construct the simplified stick model for the UIS. In order to verify the simplified stick model, the modal analysis of the 3D FE model is performed and then the modal characteristics of the simplified stick model are compared with the 3D FE model.



Fig. 1 Design configuration of the UIS in the PGSFR

## 2. Modeling of the UIS

### 2.1 3D FE Model

The detailed 3D configuration including the control rod drivelines of the inside is modeled to identify the vibration characteristics of the UIS. Fig. 2 shows the 3D FE model of the UIS, which is the cantilever type structure that all nodes of the top surface of the UIS are constrained in the boundary condition. Fig. 3 represents the modal analysis result of the 3D FE model, which shows the dominant four modes extracted from the modal analysis [2]. Table 1 shows the natural frequencies and mode shapes of the 3D FE model. The natural frequencies for the first and second modes are calculated as 11.68 Hz and 12.4 Hz, respectively.



Fig. 2 3D FE model of the UIS



Fig. 3 Modal analysis result for the 3D FE model

Table 1 Natural frequencies and mode shapes for the 3D FE model

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Mode	Natural Frequencies (Hz)	Mode Shapes	
1st	11.677	Shell cylinder structure 1 <sup>st</sup> bending	
2nd	12.397	Shell cylinder structure 2 <sup>st</sup> bending	
3rd	20.409	Control rod 1 <sup>st</sup> bending	
4th	20.417	Control rod 2 <sup>st</sup> bending	

# 2.2 Simplified Stick Model

The simplified stick model is constructed to have the similar natural frequencies with the first and second modes of the 3D FE model in the scope of maintaining the dynamic characteristics such as the natural frequency and the mode shape. The UIS shell and the inside control rod drivelines are modeled using the beam element, which are divided into several parts to reflect the detailed geometrical information. The plates inside the UIS are modeled using the lumped mass element. The constructed model by the repeated analysis is shown in Fig. 4, which is composed of five nodes and four elements. Table 2 shows the concentrated mass and rotary inertia of mass based on the geometrical configuration of the plates. The analysis results of the simplified stick model are shown in Fig. 5 and Fig. 6. From these figures, we can see that the natural frequencies of the first and second modes are 11.77 Hz and 11.99 Hz, respectively.



Fig. 4 Simplified stick model of the UIS







Fig. 6 Modal analysis result of the simplified stick model (2<sup>nd</sup> mode)

# 2.3 Result and Discussion

The natural frequencies of the 3D FE model and simplified stick model are compared. Table 3 shows the comparison result of the above two models for the UIS in PGSFR. As shown in this table, the differences of the natural frequency in the first and second modes are calculated as 0.8% and 3.3%, respectively.

Table 2 Concentrated mass and rotary mertia of mass				
Node	Concentrated	Rotary Inertia of Mass (kg-m <sup>2</sup> )		
	Mass (kg)	I <sub>xx</sub>	I <sub>vv</sub>	I <sub>zz</sub>
1	5087	903.7	1731.1	903.7
2	1001.4	133.4	266.5	133.4
3	1452	133.4	266.5	133.4
4	1574.8	93.5	180	86.7
5	645.5	60.4	115.9	56

Table 2 Concentrated mass and rotary inertia of mass

Table 3	Comparison	result o	f the	natural	frequencies	s
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of the UIS				
Natural Frequency	3D Solid	Simplified	Difference	
	Model (A)	Model (B)	abs((A-B)/A*100)	
	[Hz]	[Hz]	[%]	
1st Mode	11.68	11.77	0.8	
2nd Mode	12.40	11.99	3.3	

## 3. Conclusion

In the seismic analysis of the reactor system, the accurate understanding of the dynamic behaviors of the UIS is one of the important things. In this analysis, the simplified stick model is constructed on the basis of the 3D FE model. From the analysis results, we can see that the modal characteristics of the 3D FE model and simplified stick model have a good agreement.

#### Acknowledgements

This study was supported by the National Research Foundation of Korea (NRF) grant funded by the Korean government (MSIP).

## REFERENCES

[1] PHTS Arrangement, SFR-200-DM-170-001, Rev.0, KAERI, 2015.

[2] ANSYS User's Manual for Revision 15.0, ANSYS Inc.