Prediction of Reaction Forces on the HTS Supports

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1. Introduction

The HTS (Hydraulic Transfer System) is a facility to produce a variety of radioisotopes in the KJRR (KI JANG Research Reactor) for the industrial, scientific and medical fields. In the HTS, the hydraulic force provided by the pumps transfers the target in which the specimens are sealed. Thus, the piping system is installed and supported in the reactor pool and the service pool as shown in Fig. 1.

the structures installed in the pools shall not be broken under the designed structural loadings. Especially, the seismic loading is considered as the severest loading in the HTS. The piping system in the pools corresponds to the seismic category II; therefore, the structural integrity shall be confirmed through the analytical approach. Furthermore, the reaction forces shall be predicted for designing the embedded plate on the pool lines.

Based on the OBE (Operating Basis Earthquake) exclusion design for the KJRR, the SSE (Safety-Shutdown Earthqauke) is applied, and the reaction forces on the supports for the HTS pipings are calculated by the response spectrum analysis.

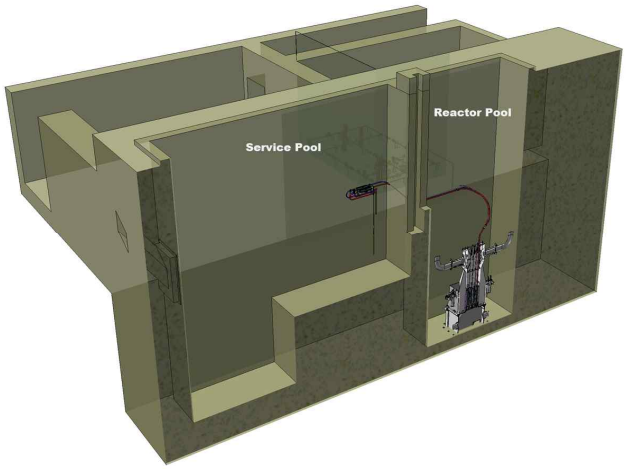

Fig. 1. HTS Layout

2. Numerical Analysis

The numerical analysis is conducted by using commercial tool ANSYS [1]. In order to construct the finite element model, the pipe elements are used for the pipings, and the hexahedral elements are applied to the supports. Meanwhile, the components having the complex geometric configuration are substituted into the concentrated mass.

The pipings which is classified by the seismic category II is submerged, additional mass shall be applied to the pipe elements to consider the hydraulic mass effect [2]. Because the water inside and outside the piping exists, and density for pipe is changed as shown in Table 1.

Table. 1. Applied Hydraulic Mass

	Large pipe	Small Pipe
Size	IR : 15.5 mm OR : 18.5 mm	IR : 6.92 mm OR : 10.65 mm
Pipe mass	0.8876 kg/m	0.5703 kg /m
Added mass (outer)	1.075 kg/m	0.3563 kg/m
Added mass (inner)	0.7648 kg/m	0.1504 kg/m
Total mass	2.7176 kg/m	1.0771 kg/m
Modified density	8480 kg/m^3	5231 kg/m^3

The FRS (Floor Response Spectrum) is applied by earthquake loading, and the value corresponding to the critical damping ratio 4 % based on the NUREC 1.61 [3]. For the conservatism, the enveloped spectrum for the horizontal directions (East-West and South-North) is generated as shown in Fig. 2.

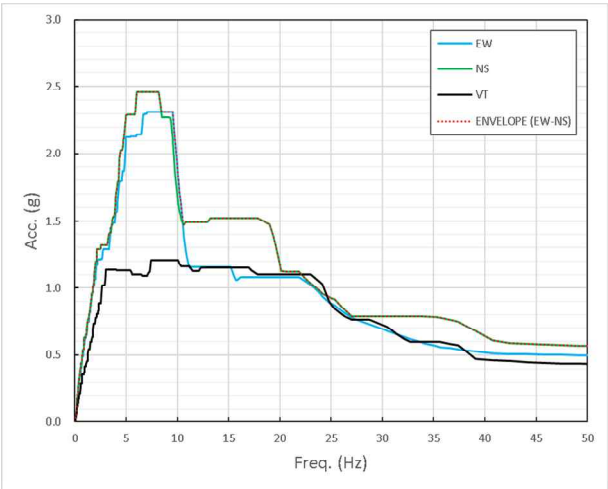

Fig. 2. Enveloped Floor Design Response Spectra

3. Results and Discussion

The response spectrum analysis is carried out, and the SRSS (Square Root of the Sum of the Squares) mode

combination is used. In the reactor pool, the locations where the reaction forces on the piping supports are calculated is shown in the Fig.3, and the reaction force locations in the service pool is shown in the Fig. 4.

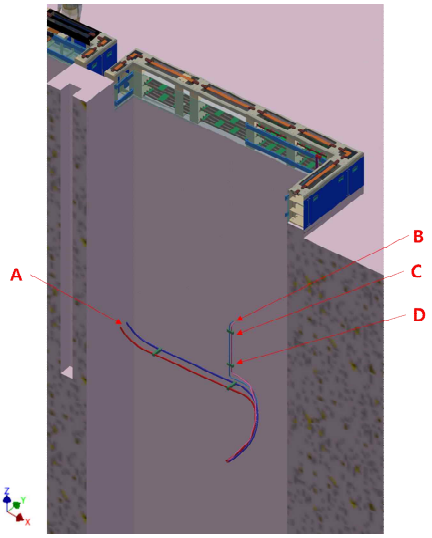

Fig.3. Locations for Predicting the Reaction Force in the Reactor Pool

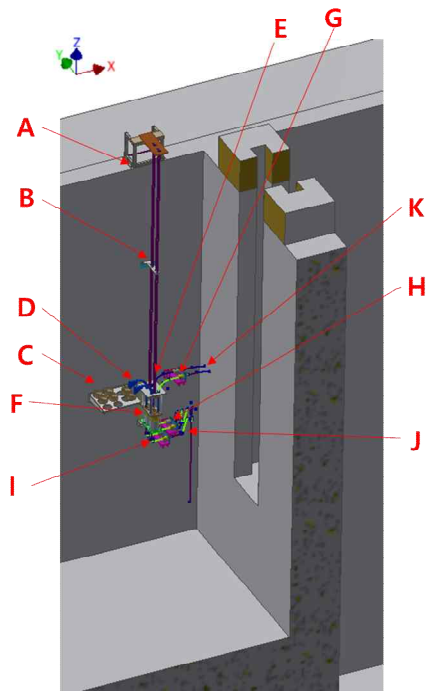

Fig.4. Locations for Predicting the Reaction Force in the Service Pool

The reaction forces onthe locations as shown in Fig. 3 and 4 are summarized in the Table 2 and 3. where, the predicted reaction forces are about twice value for the viewpoint of the conservative design.

Table. 2. Reaction Forces in the Reactor Pool

Position	F_x (N)	F_y (N)	F_z (N)	M_x (N·mm)	M_y (N·mm)	M_z (N·mm)
A	630	6	54	3327	-3279	7605
B	0	204	141	285	27	57
C	0	12	471	1119	1434	93
D	15	102	282	855	39030	55719

Table. 3. Reaction Forces in the Service Pool

Position	F_x (N)	F_y (N)	F_z (N)	M_x (N·mm)	M_y (N·mm)	M_z (N·mm)
A	0	-3	921	49056	5793	1578
B	-9	159	441	-4065	984	729
C	3546	288	18510	2020650	470517	1619841
D	291	252	3831	-69714	-81849	44250
E	-105	-54	3945	-67167	152469	-13227
F	195	-18	10821	-61194	19152	29250
G	0	0	1812	-163560	-36114	8073
H	0	591	2094	-203535	750	-18948
I	9	-624	1617	-107886	-25533	-1824
J	321	303	348	191295	284301	107637
K	684	-3	927	-44613	13482	156

3. Conclusions

The predicted reaction forces are originated by the seismic loading. This design information is used to determine the sizing design of the embedded plate to support the HTS components. Finally, the structural integrity of the submerged HTS system will be ensured under the earthquake.

REFERENCES

[1] ANSYS 19.2 User's Guide.
[2] Robert D. Blevins, 1979, "Formulas for Natural Frequency and Mode Shape",Van Nostrand Reinhold Company Ltd. Canada
[3] US, NRC, Damping Values for Seismic Design of Nuclear Power Plants, Regulatory Guide 1.61