

Interface between Core/TH Model and Simulator for OPR1000

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1. Introduction

OPR1000 simulator for ShinKori-Unit 1, which will be operated at 2815MWt of thermal core power, is being developed while the ShinKori-Unit 1&2 is being built. OPR1000 simulator adopted the RELAP5 R/T code, which is the adaptation of RELAP5 and NESTLE codes to run in real-time mode with graphical visualization, to model Nuclear Steam Supply System (NSSS) Thermal-Hydraulics (TH) and Reactor Core. The RELAP5 is an advanced, best-estimate, reactor TH simulation code developed at Idaho National Engineering and Environment Laboratory(INEEL) and the NESTLE is a true two-energy group neutronics code that computes the neutron flux and power for each node at every time step. As a simulator environment, the 3KEYMASTER™, a commercial environment tool of WSC is used.

2. Core Modeling

2.1 Cross Section Processing Utility

A cross section processing utility was developed to process the large quantity of information received from the DIT/ROCS models into the form needed by Nodal Neutron Kinetics Module (NNKM). Figure 1 illustrates the procedure for processing the RELAP5 NNKM cross section data.

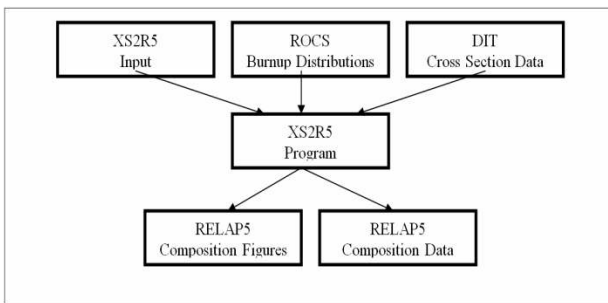


Fig. 1. Flow Chart for processing the RELAP5 NNKM cross section data.

2.2 Neutronics Modeling

Each zone is subdivided into a number of regions and defines averages of volume and heat structure quantities for each region of a zone. After the control rod positions are computed, the control fraction for each axial level is computed.

Once the control fractions are computed on each axial level, the neutron cross sections for each level can be computed.

The neutronics model of OPR1000 for ShinKori Unit 1 simulator divided the total core into 12 axial slices and 177 radial meshes based on fuel assemblies, and 5 thermal-hydraulic volumes as shown in the Fig 2.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68
69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85
86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102
103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119
120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136
137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153
154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170
171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187
188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204
205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221
222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238
239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255
256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272
273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289

Fig. 2. Nodalization diagram of the Core for NNKM

3. TH Modeling

RELAP5 R/T input deck of OPR1000 for ShinKori Unit 1 has been developed based on RELAP5 for Ulchin Unit 3&4. The differences from RELAP5 input for Ulchin Unit 3&4 are as follows. First, boron concentration is added to hydrodynamic components such as pipe, branch, pump, pressurizer and etc.. Second, a multi-dimensional nodal neutron kinetics model is used for Core modeling rather than a point kinetics model. Third, heat structures adjacent to core are changed accordingly. Fourth, the pressurizer nodes divided into 8 parts. Fifth, Several new items which are introduced in OPR1000 such as over pressure protection devices (PSV, SDS), ADVs, MSSVs are added. Sixth, bypass valves, feed water and spray/aux spray lines are included. Fig. 3. shows RELAP5 R/T Nodalization for OPR 1000 for Shinkori Unit 1.

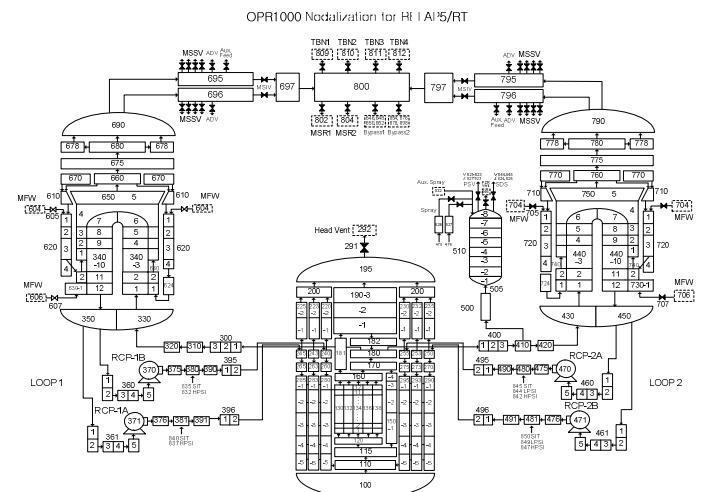


Fig. 3. RELAP5 R/T Nodalization for OPR1000

4. Interface between Core/TH Model and Simulator Environment for OPR1000

4.1 Interface Method

Communication between RELAP5-3D and 3KEYMASTER™ environment is controlled via the R3K Interface layer which provides the following functions and features:

- Execution control functions setting-up parameters for RELAP execution control, including model time, making time-step advancements, managing snap/reset functions, reading and writing restart files.
- Performing setup mode functions this includes establishing steady state/transient modes, setting components to be run, printing major edits, and setting debug mode on/off
- Generating a list of memory variables and exporting specified variables. Shared memory is stored in 3KEYMASTER™.
- Providing control over various model features, such as input/output parameters, specifying heat capacity of materials, fouling factors and form-loss coefficients at specified junction
- RELAP5 components can be replaced and model time changed after restart

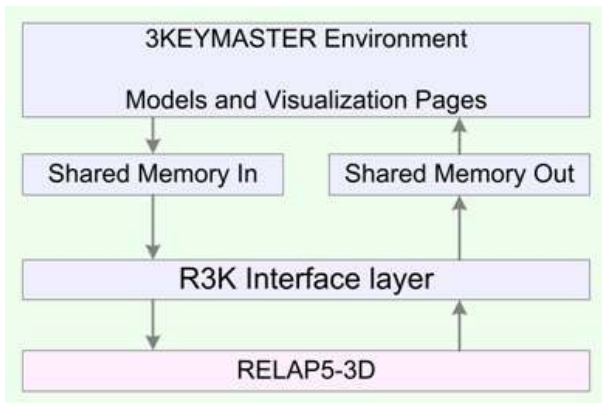


Fig. 4. R3K Interface Layer and Execution Control

R3K is an interface program for data transfer and execution control between RELAP5 code and 3KEYMASTER™, but it doesn't affect the calculation algorithm in RELAP5.

3KEYMASTER™ has access to RELAP5 output through shared memory (r3kexport.share) and the output ranges are provided with r3k.medit file written by user. Output includes all of minor edits in standard RELAP5. In the same way, 3KEYMASTER™ provides RELAP5 with input through shared memory (r3kimport.share) and the input ranges are provided with r3k.tdcomp file written by user.

R3K sets up execution environments using configuration file (r3k.config) and this file should be placed in execution folder (Development).

4.2 Execution in Simulator Environment

To execute RELAP5 R/T in 3KEYMASTER™ environment, the following files are needed:

- Execution file (relaptaxk.exe)
- Property data (tpfh2o, tpfh2on)
- Steady-state input file (skn1.i) & Null-transient input file(restart.i)
- Configuration file (r3k.config) & Input/Output variable file(r3k.medit, r3k.tdcomp)
- 3KEYMASTER™ execution environment files (sim.user, server.user)

Steady-state test result at full power is as shown in the picture below after interfacing between Core/TH model and 3KEYMASTER™. Several variables are compared with the design data values and it is shown that most variables satisfy the allowed error range in simulator.

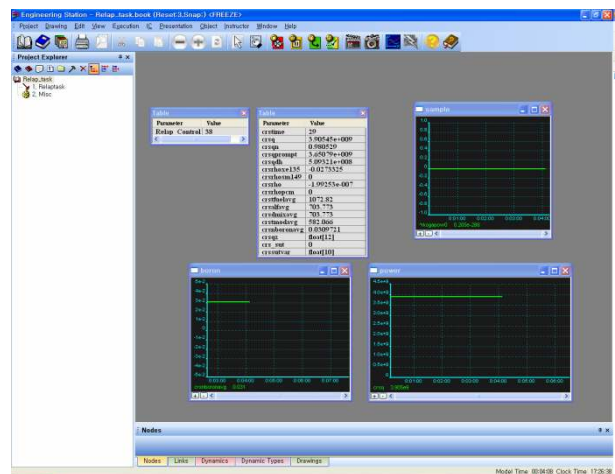


Fig. 5. Result of Interface between Core/TH Model and Simulator Environment.

5. Conclusions

The Core and TH model of OPR1000 for ShinKori Unit 1 are developed respectively using RELAP5 R/T and interfaced with 3KEYMASTER™ of simulator environment, via R3K, an interface program which manages data transfer and execution control, but doesn't affect the calculation algorithm in RELAP5. BOP model which is being developed in 3KEYMASTER™, will be integrated to Core/TH model in the future.

REFERENCES

- [1] J. H. Hong, M. S. Lee, S. H. Lee, J. K. Suh and D. H. Hwang, "Development of Neutronics Model for Shinkori Unit 1 Simulator", Transactions of the Korean Nuclear Society Spring Meeting, Gyeongju, Korea, May 29-30, 2008, p. 871-872.
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