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Control rods reactivity worth calculation using deterministic and Monte Carlo approaches for an MTR type research reactor

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Abstract

Reactivity worth of control rods as a main parameter in different nuclear reactor fields such as safety, design, and operation that could be calculated or measured with different experimental and theoretical methods. Reliable answers in calculations necessitate taking into account different characteristics such as geometries, materials, temperatures, spatial nodes, libraries, and energy groups. Reactivity worth of different core states of a Material Testing Reactor (MTR) is calculated using MCNPX 2.6.0 code and MTR_PC package as Monte Carlo and deterministic approaches respectively. It is seen that the MTR_PC and MCNPX results has considerable differences up to 51%. Therefore, an exhaustive study is done concentrating on different involved parameters. Precise modification of inputs, applying one common library in the two approaches, correcting spatial nodes, and employing more energy groups in the deterministic approach are performed. It is determined that the effect of the spatial nodes is much more important than the other parameters in the deterministic method. Finally, results of two approaches are found to be satisfactory as discrepancy is less than 11%.

Keywords: Reactivity worth, Material Testing Reactor, Deterministic and Monte Carlo approaches, Library, Energy group, Spatial node

1. Introduction

A nuclear reactor must be loaded with fuels more than needed for criticality. This is due to the reduction of effective multiplication factor (K_{eff}) during operation because of some processes such as fuel burnup and generation of fission products. Then, the existence of some additive fuels as excess reactivity for compensation of these negative effects is required. Furthermore, having negative reactivity for regulation, control and operation of nuclear reactors is necessary which is provided by control rods.

Therefore, knowing the accurate reactivity worth of safety rods is very important in reactor design and operation. The reactivity worth of control rods is affected with their relative position, withdrawal from core, position in the reactor core, burnup, operation history, surrounded materials and xenon concentration. Recalculation and reassessment of the control rods reactivity worth are necessary when major core configuration variation such as shuffling occurs [1, 2, and 3]. Reactivity worth of one safety rod is highly depends on the presence of another safety rod in surroundings. This phenomenon is also called shadowing. The degree of shadowing is dependent on essentially the three-dimensional arrangement of the control rods and on the core geometry, particularly on the height-to-diameter ratio [4]. The importance of shadowing effect is distinctive in calculation of single safety rod such as a work done in the Greek Research Reactor (GRR-1) [**Error! Bookmark not defined.**].

Two well-known theoretical methods for reactivity worth calculation are Monte Carlo (MC) and deterministic approaches using MCNP code and WIMS & CITATION codes respectively [5, 6, and 7].

The calculation of excess reactivity, safety rod worth, beryllium plate worth, shutdown margin, delayed neutron fraction, prompt neutron reproduction time and neutron flux (ϕ) values for a cold and clean core with High Enriched Uranium (HEU) is done in Nigeria's Miniature Neutron Source Reactor (MNSR). These quantities are calculated using MC and deterministic codes of MCNP4C and EXTERMINATOR respectively in which some of the results are compared with the experimental values. The difference of prompt neutron reproduction time and shutdown margin of the two approaches is notable [8]. In other research work, there

Table 1. Main characteristics of the TRR core.

Quantity	Value	Quantity	Value
U mass in each plate (g)	76	No. of plates in each SFE	19
U-235 mass in each plate (g)	15	No. of plates in each CFE	14
U density (g/cm^3)	4.76	U enrichment (%)	19.75
Meat	U_3O_8-Al	Fuel plate dimensions (cm)	65.5*6.7*0.15
Shim safety rods material	Ag-In-Cd	Meat dimension (cm)	61.5*6*0.07
Regulating rod material	SS-314/L	Clad dimension (cm)	0.04
Clad material	AL-6061	No. of Shim safety rods	4
Coolant and moderator	Light water	No. of control rods	1
Coolant width (cm)	0.27		

is an acceptable compromise in safety rods reactivity worth of MNSR using WIMS & CITATION in comparison with experiment [9]. Another research is done for calculation of K_{eff} and ϕ in the Portuguese research reactor. The reactor core with 1 MW nominal power is immersed in water. The calculations are done using CITATION & WIMSD5 codes and the MCNP4C code. The results of the two applied codes are compared with each other along with experimental values in which considerable differences are seen in the calculated results [10]. Another research work is done using WIMS & CITATION codes and MCNP4C code for calculation of the Egyptian research reactor No. 2 in which there is an acceptable agreement between the approaches [11]. The reactivity worth of the safety rods and shutdown margin in Greek Research Reactor-1 (GRR-1) are calculated and measured in another research work. This reactor with 5 MW nominal power uses plate type fuels, light water for moderator and coolant, and beryllium as reflector. The studied quantities are calculated using deterministic codes of SCALE and CITATION along with the MC code of TRIPOLI. The results of applied methods are validated through experiment and In-hour equation. The results of the MC method are acceptable where the deterministic method results depend on the other parameters such as shadowing effect of other control rods and energy groups [**Error! Bookmark not defined.**]. The neutronic parameters of K_{eff}, control rod worth and averaged region group fluxes are investigated and compared for four different models of core using MC, discrete ordinate (Sn), Pn approximation, and point transport. The acceptable compromise between the results will exist after applying the required corrections which is satisfactory [12].

The reactivity worth and shutdown margin of control rods using two different tools of MCNPX code and MTR_PC package are calculated for the Tehran Research Reactor (TRR). Calculations are done for the cold and clean condition of First Operating Core (FOC) in which up to 51% differences were seen which are considerable [13, 14]. Another research is done on the effect of spatial nodes on control rods reactivity worth using MCNPX code and MTR_PC package. Although its ability for acceptable justification of differences, it was not comprehensive [15]. So, because of the importance of reactivity worth of the control rods, the backbone of this research is focused on the detailed analysis of reactivity worth calculation using two different approaches and overcoming the discrepancies. The MCNPX code and MTR_PC package have been used as our MC and deterministic tools. Indeed, in our case study, the differences of the calculated control rods worth between the deterministic and MC approach in subcritical states (see section 3) are too high. For understanding the reason of the remarkable mentioned differences, a thorough analysis including geometries, materials, temperatures, spatial nodes, libraries, and energy groups is done.

2. Material testing reactor

The Tehran Research Reactor (TRR) is chosen as a case study for a medium power Material Testing Reactor (MTR) type with HEU plate-type fuel which started operation from 1967. Following the Reduced Enriched for Research and Test Reactor program (RERTR) [16], the enrichment of fuels reduced from 93 to 20% in 1991. Some of the main characteristics of the FOC are calculated using the MTR_PC package and given in the Safety Analysis Report (SAR) of this reactor [17].

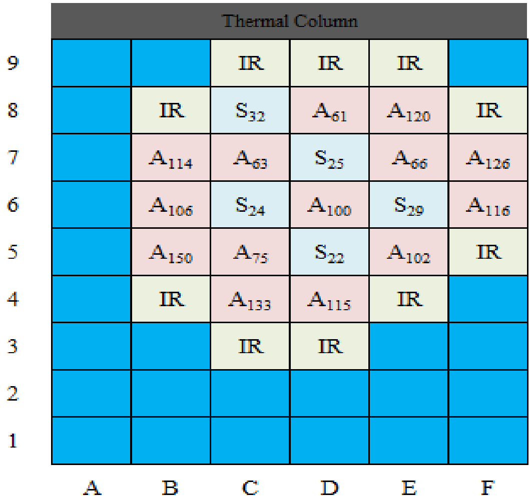
The reactor core is upon an array of 9×6 holes grid plate that its performance is holding core components and passing coolant through it. The core and assemblies are in a pool filling with approximately 9.5 m height water. As can be seen in Fig. 1, the main components of the core are Standard Fuel Element (SFE, Ai), Control Fuel Element (CFE, Si), Irradiation position (IR), and graphite box (GR). The important characteristics of core are given in Table 1.

3. Materials and methods

The full core simulation is done using the MCNPX code and MTR_PC package. The upper view of the FOC configuration is shown in Figure 1 [18]. This configuration is used for calculation of the different core states. The states are defined based on insertion or extraction of control rods in the core.

The core reactivity worth for 13 different states is calculated using the MTR_PC package [19]. The MCNPX calculations are without considering thermal column or beam tubes. The standard deviation of all of the MCNPX results is less than 30 pcm (See Table 2).

The existence of some differences is acceptable in terms of the two different approaches in solving problems. But, as shown in Table *2*, the differences in subcritical states (states 3-13) are in the range of 23 to 51% which are striking and could not be legitimatized. For understanding these remarkable differences reason, a comprehensive investigation is done including geometries, materials, temperatures, spatial nodes, libraries, and energy groups. The geometries, materials,



	Thermal Column					
9			IR	IR	IR	
8		IR	S_{32}	A_{61}	A_{120}	IR
7		A_{114}	A_{63}	S_{25}	A_{66}	A_{126}
6		A_{106}	S_{24}	A_{100}	S_{29}	A_{116}
5		A_{150}	A_{75}	S_{22}	A_{102}	IR
4		IR	A_{133}	A_{115}	IR	
3			IR	IR		
2						
1						
	A	B	C	D	E	F

Figure 1. First operating core of the TRR.

Table 2. Calculated reactivity worth for the TRR first operating core.

State	Rods out of core (%)					Reactivity (pcm)		Difference (%)
	S_1	S_2	S_3	S_4	RR	MTR_PC [**Error! Bookmark not defined.**]	MCNPX [**Error! Bookmark not defined.**]	
1	100	100	100	100	100	6916	6962	0.67
2	100	100	100	100	0	6364	6455	1.42
3	0	0	0	0	100	-12541	-15420	22.96
4	100	0	0	0	100	-6009	-7692	28.02
5	0	100	0	0	100	-6279	-8747	24.97
6	0	0	100	0	100	-7451	-9475	27.17
7	0	0	0	100	100	-7580	-9581	26.39
8	0	100	0	100	100	-2505	-3691	47.36
9	0	100	0	100	0	-3249	-4412	35.81
10	100	0	100	0	100	-2335	-3534	51.33
11	100	0	100	0	0	-2956	-4159	40.70
12	0	0	100	100	100	-2630	-3883	47.65
13	0	0	100	100	0	-3095	-4180	35.05

and temperatures are rechecked in two approaches and there were not any substantial effect on the results. The results did not change considerably after several exact surveys of the MCNPX input. These surveys including geometries, libraries and decreasing the output relative errors via increasing the number of histories. Furthermore, regarding the relatively good agreement of the MCNPX results with experimental data, it seems that the above mentioned discrepancies come from the deterministic approach. The main regions in deterministic approach are fuel, absorber, graphite, and water of the core-periphery because of high importance of neutrons in these regions. The used method for scrutinize the effects of spatial nodes, libraries, and energy groups in the MTR_PC package for these important regions is given in the following sections.

3. 1. Spatial nodes optimization

Mean free path is the average of the total distance that neutron travels before undergoing any interaction. This quantity is the inverse of macroscopic cross-section of the interactions. Thus, the choice of spatial nodes in the nuclear reactor calculation codes in any region must be done considering the value of the mean free path and proportion of the mesh length to the adjacent region. Furthermore, the optimum choice of the spatial nodes is where noticeable variation in answers would not occur with increasing it. For solving diffusion equation by finite difference method, the distance between the adjacent mesh points should be small in comparison to a neutron mean free path in that region [20].

As a general role, the finite difference discrete ordinate codes require finer spatial mesh in comparison with the diffusion codes which using finite-difference [**Error! Bookmark not defined.**]. Spatial nodes in the finite element diffusion codes must be in the order of the smallest diffusion length. But for solving the transport equation with the Sn method, the used spatial nodes in discrete coordinates must be in a way that the distance between points would be less than the neutron mean free path. Moreover, the proportion of the mesh length in the two adjacent regions should not be differed by more than 3 or 4 [21]. Due to the above criterion, mesh length proportion of 3 or 4 is chosen for solving the diffusion equation of two adjacent regions.

a) Standard Fuel Element, SFE

The upper view of one SFE in given in Figure 2. SFE_FUE and SFE_FRA in Figure 2 are given for homogenous standard fuel and clad. The reactivity variation in the FOC with spatial nodes is shown in Figure 3.

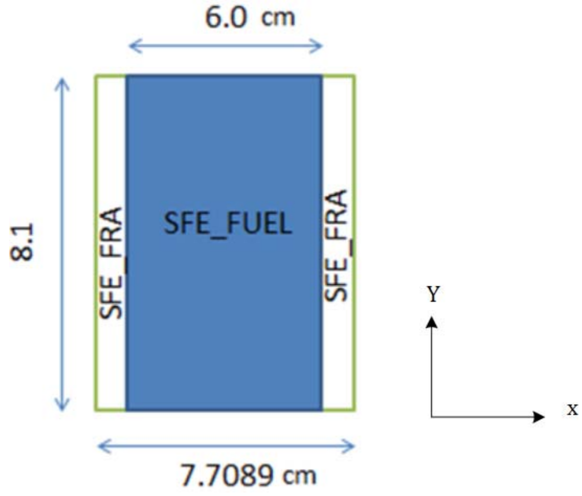


Figure 2. Upper view of SFE.

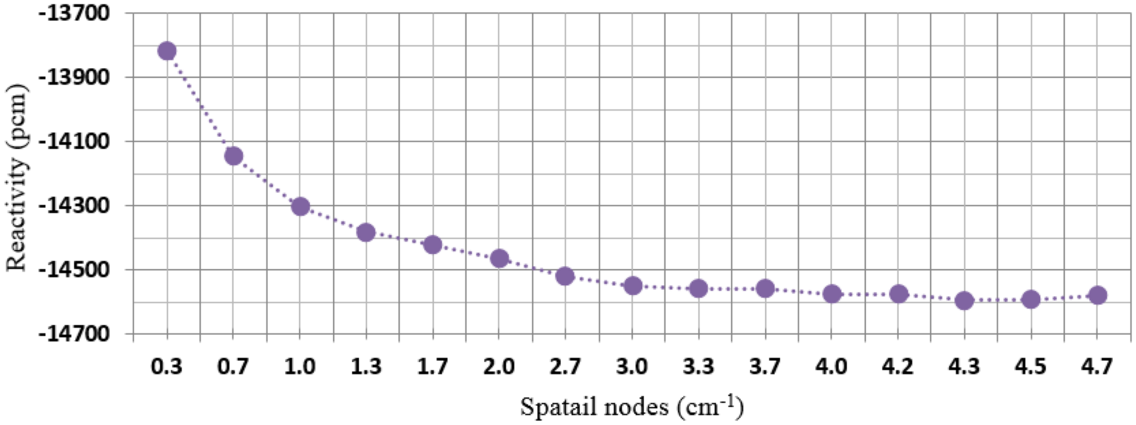


Figure 3. Reactivity variation of the TRR first operating core with the spatial nodes in the X direction of SFE.

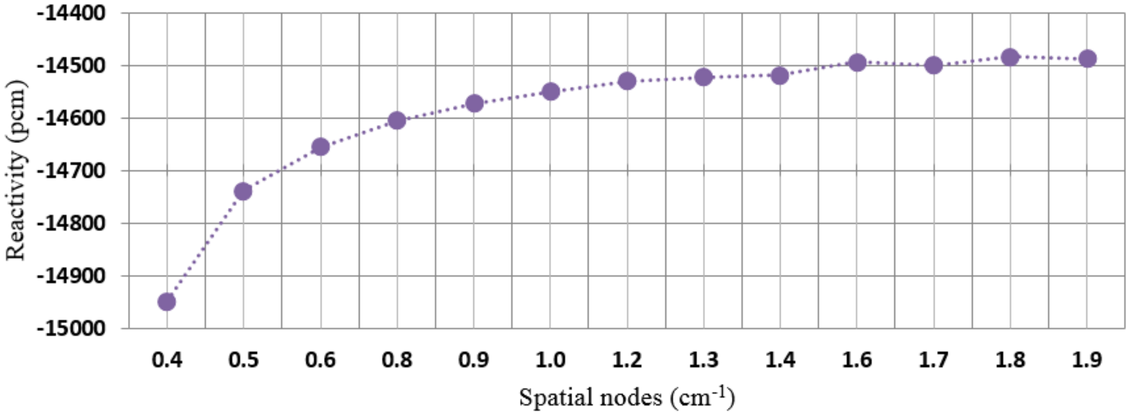


Figure 4. Reactivity variation of the FOC with periphery water spatial nodes in the X direction.

The abscissa in Figure 3 is spatial nodes for the 14 SFEs of the FOC. The increasing of spatial nodes is caused to distinctive decrease in the core reactivity worth. Then, given the noticeable reactivity variation in the FOC, the spatial nodes in this region is of prime importance.

b) Periphery core water

Periphery core water has an important role for returning the exited neutrons to the reactor core and enhancing neutron economy. The effect of spatial nodes in the periphery of the core regions, column A in Figure 1, is studied.

As could seem from reactivity variations in Figure 4, with increasing spatial nodes up to about 5 times, the core reactivity increases from -14950 to -14500 pcm. This variation is an illustration of the periphery core water importance in calculation.

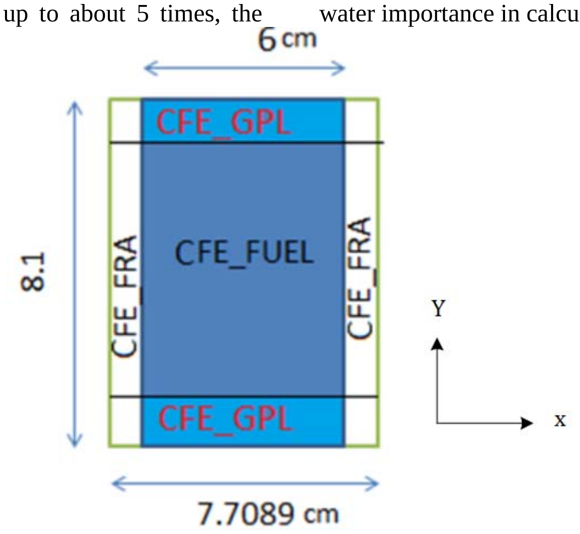


Figure 5. Upper view of CFE

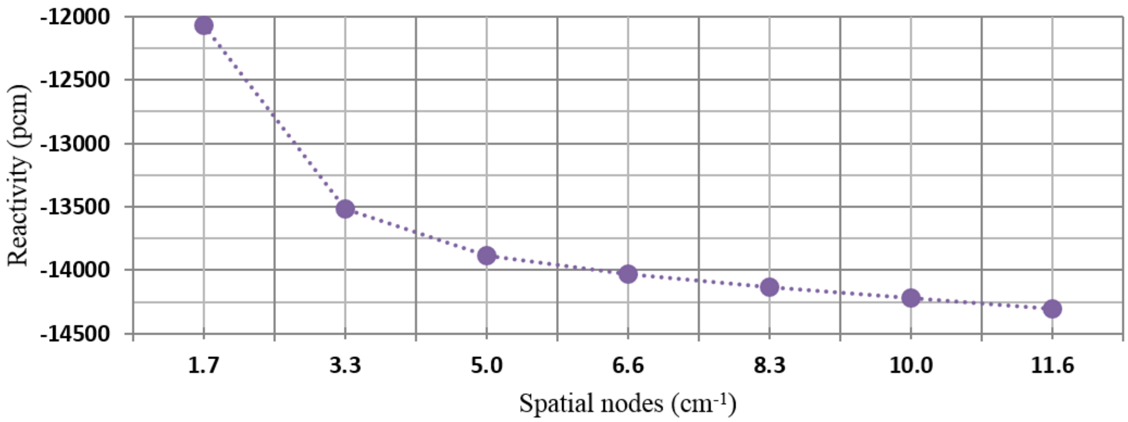


Figure 6. Reactivity variation of the TRR first operating core with the CFE spatial nodes in the Y direction.

c) Control Fuel Element, CFE

Four positions of the reactor core are appropriated to the CFEs which are regions with the highest neutron worth. The effect of spatial nodes in the presence of neutron absorber plates is very striking. The upper view of one CFE with dimensions in cm is given in Figure 5.

CFE_FRA, CFE_FUE, and CFE_GPL in this figure are clad, homogeneous fuel and frame regions respectively. Due to this element importance, the FOC reactivity worth variation with spatial nodes is studied and given in Figure 6.

As could be seen from Figure 6, the increasing of spatial nodes has led to a distinctive increase in the core reactivity worth. The appropriation of more importance Table 3. The columns MTR_PC-1 and MTR_PC-2 are the MTR_PC package results before and after applying

Table 3. Taking into account this parameter in the calculations has led to the decrease of the differences between the two approaches from 15-40% to less than 11% for before and after optimization respectively.

3. 2. Library effect

to the absorber region in solving the transport equation is needed due to the illustrated phenomenon.

The spatial nodes in other regions such and axial direction of the core and perimeter, the upper and lower core layers of periphery water, more distant from core water and clad have not considerable effect on the reactivity worth of the core. Then, assigning the minimum of spatial nodes for those regions is sufficient.

d) Spatial node effect on the TRR first operating core

After considering the spatial nodes in all regions, the reactivity worth of 13 different states for the FOC is carried out using the MTR_PC package and the results are given in the optimization of spatial nodes respectively.

The substantial effect of spatial nodes is seen in The MCNPX 2.6.0 code uses the ENDF VII library cross-section as its default library. The WIMS code of the MTR_PC package uses WIMS5b library. However, the designer of the TRR has used WIMSD4 code along with a library named WIMSD4 inside the package [16].

For investigating the library effect, the reactivity worth of the 13 core states is calculated using the existed libraries inside the MTR_PC package. These libraries include ENDFb7, IAEA, Jeff31, and Jendl3. The comparison of the calculated reactivities using the MCNPX code and the MTR_PC package is given in Table 4.

Table 3. Calculated reactivity of the TRR first operating core with MCNPX and MTR_PC

State	Reactivity (pcm)			MTR_PC-2 difference with (%)	
	MTR_PC-1 [**Error! Bookmark not defined.**]	MCNPX [**Error! Bookmark not defined.**]	MTR_PC-2	MTR_PC-1	MCNPX
1	6916	6962	6785	-1.90	-2.55
2	6364	6455	6361	-0.05	-1.45
3	-12541	-15420	-14367	14.56	-6.83
4	-6009	-7692	-7201	19.84	-6.39
5	-6279	-8747	-7802	24.26	-0.57
6	-7451	-9475	-8879	19.17	-6.29
7	-7580	-9581	-8821	16.37	-7.93
8	-2505	-3691	-3458	38.06	-6.31
9	-3249	-4412	-4201	29.30	-4.79
10	-2335	-3534	-3269	39.99	-7.49
11	-2956	-4159	-3765	27.38	-9.47
12	-2630	-3883	-3438	30.74	-11.45
13	-3095	-4180	-3862	24.77	-7.61

Table 4. Absolute and relative difference of the reactivity for different libraries.

		State	1	2	3	4	5	6	7	8	9	10	11	12	13
		MCNPX	6962	6455	-15420	-7692	-7847	-9475	-9581	-3691	-4412	-3534	-4159	-3883	-4180
The difference with the MCNPX	WIMS5b	Absolute (pcm)	-177	-94	1053	491	45	596	760	233	212	265	394	445	318
		Relative (%)	-0.03	-0.01	-0.07	-0.06	-0.01	-0.06	-0.08	-0.06	-0.05	-0.07	-0.09	-0.11	-0.08
	WIMSD4	Absolute (pcm)	1058	1215	143	468	43	291	537	365	322	552	564	806	694
		Relative (%)	0.15	0.19	-0.01	-0.06	-0.01	-0.03	-0.06	-0.1	-0.07	-0.16	-0.14	-0.21	-0.17
	ENDFb7	Absolute (pcm)	-55	15	1258	506	79	653	909	333	322	429	522	577	455
		Relative (%)	-0.01	0	-0.08	-0.07	-0.01	-0.07	-0.09	-0.09	-0.07	-0.12	-0.13	-0.15	-0.11
	IAEA	Absolute (pcm)	-34	52	1247	583	242	712	864	211	298	422	525	571	481
		Relative (%)	0	0.01	-0.08	-0.08	-0.03	-0.08	-0.09	-0.06	-0.07	-0.12	-0.13	-0.15	-0.12
	Jeff31	Absolute (pcm)	-150	-91	934	335	-7	511	708	184	214	309	311	428	302
		Relative (%)	-0.02	-0.01	-0.06	-0.04	0	-0.05	-0.07	-0.05	-0.05	-0.09	-0.07	-0.11	-0.07
	Jendl3	Absolute (pcm)	-435	-437	388	-198	-499	4	167	-282	-237	-251	-179	-72	-200
		Relative (%)	-0.06	-0.07	-0.03	0.03	0.06	0	-0.02	0.08	0.05	0.07	0.04	0.02	0.05

For a better survey, the absolute differences of the studied libraries with respect to the MCNPX as reference are shown in Figure 7. The abscissa with a thick dark line is the MCNPX results.

In Figure 7, all of the mentioned studied states have equal circumstances and the only difference for them is used libraries. The accurate analysis of the obtained results, shows that the Jeff31 results have the best confidence with the ENDF7 library results which is used in the MCNPX code.

For more investigation of the library effect on the results, the Jeff31 cross-sections extracted for all of the MCNPX input materials using the NJOY code. The NJOY code is a nuclear data processing code that is used to convert the ENDF and JEFF libraries to ACE format. The following modules of NJOY code are invoked: MODER, RECONR, BROADR, PURR, THERMR, and ACER [22]. After equalizing the MCNPX and MTR_PC libraries, the reactivity worth of the above 13 states is calculated again and the results are shown in Table 5. In Table 5, the MCNPX, MCNPX-1 and MTR_PC-3 columns are for the ENDF7, Jeff31 and Jeff31 libraries respectively. The relative differences of the original MCNPX results with new calculations are given in the two last columns.

As could be seen from Table 5, using the same libraries in the MCNPX and MTR_PC did not cause to equal results which is rational considering the different mechanisms of these two codes. In view of about 1-8% and 0-11% differences between two methods, these results affirm the impress of library for slight decreases in the two method differences.

3. 3. Energy groups effect

In solving the transport equation, the five energy groups are being used for the SFE and other infrastructures such as clad or coolant. Also, the 12 energy groups are used for treating the CFE and infrastructures such as clad and absorber regions. Furthermore, the 69 energy groups are being used for reflecting water. These energy groups are condensed to 3 when conducting the cell calculations in the CITATION. The used energy groups in the MTR_PC inputs are in accordance with Table 6.

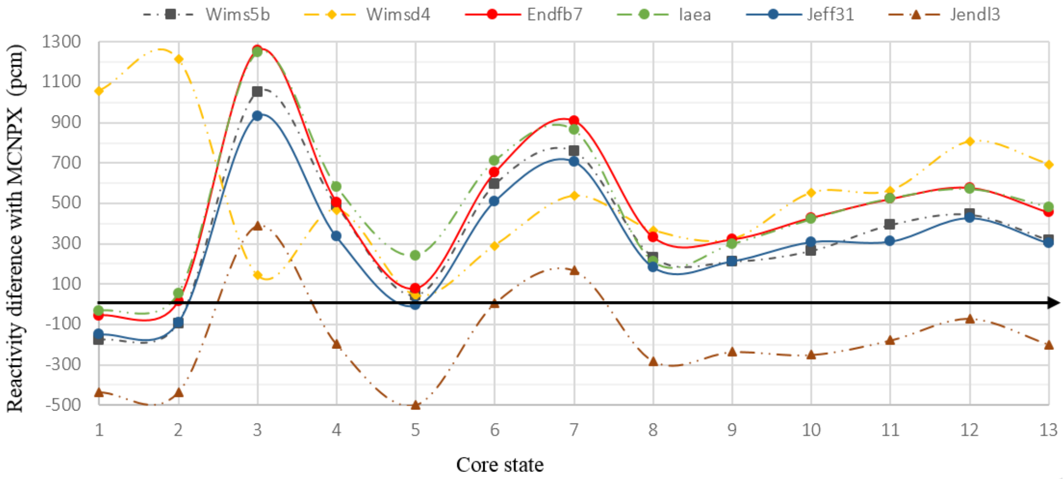


Figure 7. Relative difference of various libraries with MCNPX library.

Table 5. Calculated reactivity of the TRR first operating core with the MCNPX and MTR_PC

State	Reactivity (pcm)			MCNPX difference with (%)	
	MCNPX	MCNPX-1	MTR_PC-3	MCNPX-1	MTR_PC-3
1	6962	6940	6812	-0.32	-2.16
2	6455	6503	6363	0.75	-1.42
3	-15420	-15262	-14486	-1.03	-6.05
4	-7692	-7506	-7357	-2.42	-4.36
5	-7847	-7812	-7854	-0.44	0.08
6	-9475	-9282	-8964	-2.03	-5.40
7	-9581	-9475	-8837	-1.10	-7.39
8	-3691	-3633	-3508	-1.57	-4.98
9	-4412	-4268	-4199	-3.28	-4.85
10	-3534	-3419	-3225	-3.24	-8.74
11	-4159	-3958	-3848	-4.84	-7.48
12	-3883	-3755	-3456	-3.30	-11.01
13	-4180	-4220	-3878	0.96	-7.23

Table 6. The used energy groups

groups	3 groups	5 groups	6 groups	12 groups	Low energy limit (eV)
1	5	5	5	5	821e+3
2		15	15	15	5.530e+3
3				20	367.262
4				23	48.052
5				25	15.968
6			27	27	4
7				30	2.1
8				34	1.123
9	45	45	45	45	0.625
10				51	0.28
11		57	57	57	0.08
12	69	69	69	69	0.0

In Table 6, the transport equation is solved with 12 energy groups according to Table 6 at first. After that, the diffusion equation is solved according to 3 energy groups of the former sections for core calculations. Finally, the results of two different energy groups are given in Table 6 in which the MTR_PC-4 and the MTR_PC-5 are the SAR and 12 energy groups respectively.

As could be seen from Table 7, the differences between results are up to 8% and from 1 to 16% for SAR groups and 12 groups respectively. The comparison of results indicating the existence of bigger differences in more energy groups conditions. Then, this is impossible to assign the existed differences to energy groups.

3. 4. Shadowing effect

Shadowing effect would cause to discrepancy of summation of individual control rods worths in comparison with together. In the other words, if the reactivity worth of control rods to be calculated separately and together, summation of individual reactivity worths being smaller or larger than together indicating anti-shadowing and shadowing effects. Some research work were done on this phenomenon in different reactors such as PARR-1, RSG-GAS and large GCFR [23, 24, 25 and 26].

Table 7. Calculated reactivity of the TRR first operating core with the MCNPX and MTR_PC.

State	Reactivity (pcm)			MCNPX difference with (%)	
	MCNPX	MTR_PC-4	MTR_PC-5	MTR_PC-4	MTR_PC-5
1	6962	6930	7007	-0.46	0.64
2	6455	6468	6553	0.21	1.53
3	-15420	-14356	-14203	-6.90	-7.89
4	-7692	-7273	-7046	-5.46	-8.41
5	-7847	-7798	-7722	-0.62	-1.59
6	-9475	-8921	-8733	-5.85	-7.83
7	-9581	-8816	-8638	-7.98	-9.84
8	-3691	-3600	-3354	-2.48	-9.15
9	-4412	-4241	-4097	-3.88	-7.16
10	-3534	-3260	-3061	-7.74	-13.38
11	-4159	-3823	-3600	-8.09	-13.44
12	-3883	-3451	-3250	-11.12	-16.31
13	-4180	-3844	-3640	-8.02	-12.91

Table 8. Individual control rods worth of the TRR.

Inserted Rods	Reactivity (pcm)
S1	-4987
S2	-4936
S3	-4068
S3	-4096
RR	-424

Table 9. Reactivity worth of control rods together.

state	Rods completely in core	Reactivity (pcm)
2	RR	-424
8	S1, S3	-10243
9	S1, S3, RR	-10986
10	S2 , S4	-10054
11	S2, S4, RR	-10550
12	S1, S2	-10223
13	S1, S2, RR	-10647

Table 10. Calculated control rods worth of the TRR.

Inserted Rods	Reactivity (pcm)		
	Individual	Together	Difference
S1 & S3	-9055	-10243	1188
S1, S3 & RR	-9479	-10986	1507
S2 &S4	-9032	-10054	1022
S2, S4 & RR	-9456	-10550	1094
S1 & S2	-9923	-10223	300
S1, S2 & RR	-10347	-10647	300

The worth of individual control rods of the TRR core is calculated using the MTR_PC package and given in Table 8.

These reactivity worths are calculated considering completely insertion of only one specific rod into the core when the other control rods in completely out.

The reactivity worth of different combinations of control rods could be extracted form states 2 and 8-13 of column MTR_PC-2 of table 3. The reactivity wroth of any state is the difference of completely extraction of control rods (state 1) and considered state which are given in Table 9.

The reactivity worths of individual and together conditions are given in Table 10 for a better comparison.

As could be seen from Table 10, there are noticeable differences between two considered conditions due to anti-shadowing effect. As the aim of this research is the investigation of the different core states reactivity wroth, this phenomenon does not have effect in the calculations.

4. Conclusion

The reactivity worth values of the TRR core states are calculated using the MTR_PC package and MCNPX 2.6.0 code. There were significant differences between MTR_PC reactivity worth values before optimization and the MCNPX results. Some difference is logistic due to the differences in calculation methods, used approximations and supposes. But, the existed differences are much more significant than normal and acceptable amounts which could be justified. Due to indispensable importance of reactivity worth values, the accurate investigation of this problem is done in order to dissolve this discrepancy.

Due to dependency of results on each approach methods, input data such as materials, geometries, and dimensions were rechecked at the first step for more consistency. In the next step, the detailed assessment of other effective parameters such as libraries, spatial nodes and energy groups for all regions is of interest. The designated spatial nodes in any region have distinctive effect on results which necessitate the modification and correction of this parameter. It is conducted by taking into account the characteristics of each region and neighbors'. The library effect is investigated with equalizing two codes libraries using NJOY code. The identical library in turn leads to approaching the results for some percentages. Finally the effect of energy groups is analyzed via considering 2, 4 and 6 energy groups for solution of diffusion equation. The differences is found to be dropped with increasing energy groups approximately some percentages. Shadowing effect given rises to a considerable difference in the reactivity worth of individual rods summation in comparison with together case. This interaction does no effect in our research results whereas this research aim is the investigation of different core states reactivity wroth.

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