ADPRES V.1.1

USER MANUAL

1. Introduction

Abu Dhabi Polytechnic Reactor Simulator (ADPRES) solves static and transient diffusion equation for two or three dimensional reactor problems in Cartesian geometry. ADPRES uses fourth order Nodal Expansion Method (NEM) to spatially discretize the neutron diffusion equation where the transverse leakage moments are approximated using quadratic leakage fit. While fully-implicit method is used for temporal-discretization in the transient diffusion equation. ADPRES can handle problems with Assembly Discontinuity Factors (ADF) to imporove the accuracy. Recently, TH feedbacks module was also added that enables ADPRES to solve transient problems with TH feedbacks.

ADPRES is a great learning tool for reactor theory classes. The input is modular and it is designed to be straightforward. ADPRES' main objective is to make all nuclear engineering students have access on similar nuclear computer code. It is open and completely free, so everyone has access to the source code and modify for his/her own purposes.

2. Theory

Users who are interested in the theoretical background of NEM used in ADPRES can refer to MOSRA Manual [1].

3. Program Compilation and Execution

In UNIX environment such as GNU-LINUX or CYGWIN where the gfortran is already installed, the source codes can be compiled using command

```
gfortran mod_data.f90 mod_InpOutp.f90 mod_nodal.f90 mod_trans.f90 ADPRES.f90
-O4 -o adpres
```

This command will produce executable file called "adpres". This executable file can be run by

```
./adpres [FILE INPUT NAME]
```

for example

```
./adpres IAEA3D
```

The program then runs and produce output file. The output file name will be similar to input file name but with "`out`" extension.

4. Input Description

The input is designed to be self-explanatory for the convenient of users. The input is grouped into several cards which depend on the nature of the problems.

4.1 General Rules

Some general rules for the ADPRES inputs:

1. Comments are marked by `!`. Example:

```
! COMPOSITION 1
0.20574  0.00654  0.00415  0.00415  1.0  0.0  0.01462  !Group 1
0.68866  0.04850  0.06099  0.06099  0.0  0.0  0.00000  !Group 2
```

2. Currently ADPRES has several input cards. Cards' name shall be uppercase and marked by `%`. Example:

```
%MODE
FORWARD
%XSEC     ! Cross section card
2 4       ! Number of groups and number of materials
...
...
%GEOM     ! Geometry card
12 12 2   !nx, ny, nz
...
...
```

3. Numbers can be repeated using `*` mark. For example

`10.0 8*20.0` is equivalent to `10.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0`

4.2 Cards Description

ADPRES has 12 input cards. Each card can be placed arbitrarily in the input deck. Some cards are obligatory for any problems, while some cards are conditional depend on the problem being solved and some cards are optional. The description of input for each card is explained in this subsection. The input cards as well as their description are listed in Table 4-1.

Table 4-1. Input Card Description

No.	Cards	Description	Remark
1.	%MODE	Calculation mode	Mandatory
2.	%XSEC	Cross Sections	Mandatory
3.	%GEOM	Geometry of the problem	Mandatory
4.	%CASE	Problem case	Optional
5.	%ESRC	Extra source	Conditional
6.	%WRST	Write restart file	Optional
7.	%RRST	Read restart file	Optional
8.	%ITER	Iteration Control	Optional
9.	%PRNT	Output print control	Optional
10.	%ADF	Assembly Discontinuity Factor	Optional
11.	%CROD	Control rods	Conditional
12.	%EJCT	Control rods ejection and/or insertion	Conditional

The input for each card is described in the followings subsections

4.2.1 Calculation Mode

This card tells ADPRES the calculation mode. The calculation mode can be either forward, adjoint or fixed source.

Table 4-2. Calculation mode card

%MODE			
LINE 1	MODE	Calculation mode	`FORWARD` : Forward Calculation `ADJOINT` : Adjoint Calculation `FIXEDSRC` : Fixed Source Calculation `RODEJECT` : Rod ejection and/or insertion mode (transient problems)

4.2.2 Cross Section Data

This card describes to ADPRES the few-group cross section data as well as number of group and materials used in the problem.

Table 4-3. Cross section data card

%XSEC			
LINE 1	NG	Number of groups	`2 4 ! Number of groups and number of materials`
	NMAT	Number materials	
LINE 2	SIGTR(g)	Transport macroscopic XS for group g	Repeat LINE 2 NG times. And again repeat this input segment NMAT times. (See example in the provided sample inputs)
	SIGA(g)	Absorption macroscopic XS for group g	
	NUF(g)	Nu * Fission macroscopic XS for group g	
	SIGF(g)	Fission macroscopic XS for group g	
	CHI(g)	Fission neutron spectrum for group g	
	SIGS(g,1:NG)	Scattering macroscopic XS from group g to other groups	

4.2.3 Geometry

Geometry of the reactor core is described in this card. The coordinate system used in ADPRES is shown in Figure 4-1. The point of origin is located at the corner between west, bottom and south sides. Figure 4-2 shows the coordinate system seen from top which typically used for two-dimensional problems.

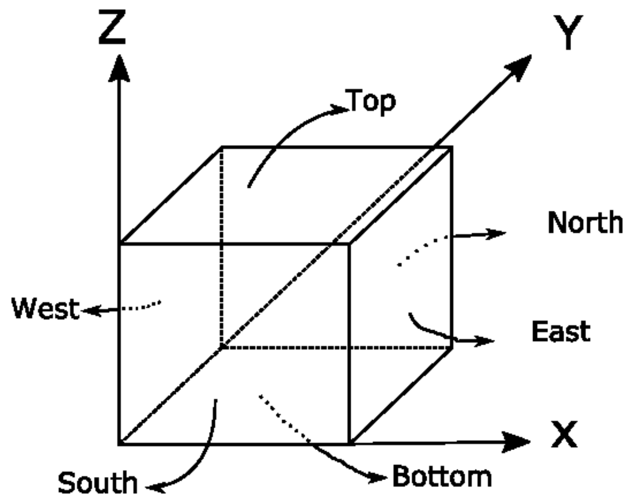

Figure 4-1. Coordinate system used in APDRES

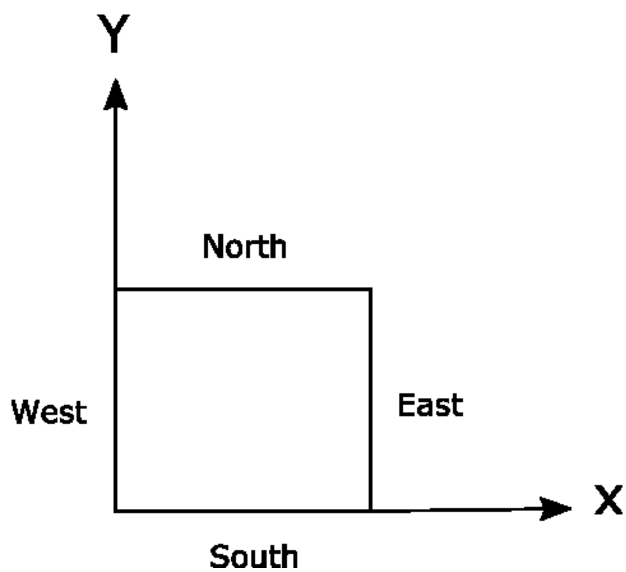

Figure 4-2. Coordinate system seen form top (typically used for two-dimensional problems)

Table 4-4. Geometry card

%GEOM			
LINE 1	NX	Number of assemblies along X-direction	Example: `9   9   19 !NX,NY,NZ`
	NY	Number of assemblies along Y-direction	
	NZ	Number of assemblies along Z-direction	
LINE 2	XSIZE(1:NX)	Assembly size along X-direction (from west to east)	Example: `10.0 8*20.0 !X-direction assembly size`

LINE 3	XDIV(1:NX)	Assembly division along X-direction (from west to east)	Example: `1 8*2 !Last 8 assemblies divided into 2 along Y-direction`
LINE 4	YSIZE(1:NY)	Assembly size along Y-direction (from south to north)	Example: `10.0 8*20.0 !Y-direction assembly size`
LINE 5	YDIV(1:NY)	Assembly division along Y-direction (from south to north)	Example: `1 8*2 !Last 8 assemblies divided into 2 along Y-direction`
LINE 6	ZSIZE(1:NZ)	Assembly size along Z-direction (from bottom to top)	Example: `19*20.0 !Uniform assembly size along Z-direction`
LINE 7	ZDIV(1:NZ)	Assembly division along Z-direction (from bottom to top)	Example: `19*1 !Assembly along Z-direction is not divided`
LINE 8	NP	Number of different core planar with different material composition	Example: `4 !There are four different planar`
LINE 9	ZPLN(1:NZ)	Planar assignment along Z-direction from bottom to top	Example: `1 13*2 4*3 4 !planar assignment (from bottom to top)`
LINE 10	DO j = NY, 1, -1 ASM(1:NX) END DO	Planar material map	Repeat this LINE NP times in order, from planar number 1 to NP. (See example in the provided sample inputs)
LINE 11	XEAST	East boundary conditions	`0` = Zero flux `1` = Zero incoming current `2` = Reflective Example: `0 2 0 2 2 2 !BC`
	XWEST	West boundary conditions	
	YNORTH	North boundary conditions	
	YSOUTH	South boundary conditions	
	ZBOTT	Bottom boundary conditions	
	ZTOP	Top boundary conditions	

4.2.4 Problem Case

This card describes the problem case if necessary.

Table 4-5. Problem case card

%CASE			
LINE 1	CASE_ID	Case name	Example: `DVP`
LINE 2	CASE_EXP	Case Description	Example: `DVP Problem Test`

4.2.5 Extra Source

This card shall be present only if the calculation mode is fixed source.

Table 4-6. Extra source card

<table>
<tr><td colspan="4">%ESRC</td></tr>
<tr><td>LINE 1</td><td>NSRC</td><td>Number of sources</td><td>Example:
2 ! Number of extra sources</td></tr>
<tr><td>LINE 2</td><td>SDEN</td><td>Source density</td><td>Repeat LINE 2 through LINE 7 NSRC times</td></tr>
<tr><td>LINE 3</td><td>SPEC(1:NG)</td><td>Source energy spectrum (normalized to 1.0)</td><td>Example LINE 2 through LINE 3:
Example:
1.0 !Source density 1
1.0 0.0 ! Spectrum 1
...
...
2.0 !Source density 2
0.9 0.1 ! Spectrum 2
...
...</td></tr>
<tr><td>LINE 4</td><td>ZPOS</td><td>Axial position of the source (between 1 to NZ)</td><td>This line must be followed by XPOS and YPOS.
And then this input segment can be repeated as many as desired until 0 (LINE 7) is entered</td></tr>
<tr><td>LINE 5</td><td>XPOS</td><td>Radial position of the source (along X axis) for current axial position</td><td rowspan="2">Repeat this line as many as desired until 0 (LINE 6) is entered</td></tr>
<tr><td></td><td>YPOS</td><td>Radial position of the source (along Y axis) for current axial position</td></tr>
<tr><td>LINE 6</td><td>0</td><td rowspan="2">Zero numbers are entered to end XPOS and YPOS</td><td rowspan="2"></td></tr>
<tr><td></td><td>0</td></tr>
</table>

LINE 7	0	Zero number to end ZPOS	Example for LINE 4 through LINE 7 together:
			`10    !zpos of source`
			`2  9 !xpos-ypos of source`
			`2  8 !xpos-ypos of source`
			`0  0 !x-y position ends`
			`11    !zpos of the source`
			`2  9 !xpos-ypos of source`
			`2  8 !xpos-ypos of source`
			`0  0 !x-y position ends`
			`0     !z-position ends`

4.2.6 Writing Restart File

It is often useful to write restart file, which stores flux, flux moments and other parameters, to solve large problem repetitively with minor changes in the cross section data.

Table 4-7. Restart file card (writing)

%WRST			
LINE 1	FNAME	Restart file name (max. 20 characters) to be produced	Example: `IAEA3D.res`

4.2.7 Reading Restart File

In order to read the restart file this card must be present. Note that the problem being solved shall have identical geometry as the restart file.

Table 4-8. Restart file card (reading)

%RRST			
LINE 1	FNAME	Restart file name (max. 20 characters) to be read	Example: `IAEA3D.res`

4.2.8 Iteration Control

If the users wish, they can alter the iteration parameters.

Table 4-9. Iteration control card

%ITER			
LINE 1	NOUT	Maximum number of outer iteration	Default: 300
	NIN	Maximum number of inner iteration	Default: 2
	SERC	Fission source error criteria	Default: 1.0e-5

	FERC	Flux error criteria	Default: 1.0e-5
	IERC	Inner iteration error criteria	Default: 1.0e-5
	NAC	Fission source extrapolation interval	Default: 5 Example: `500 5 1.0e-6 1.0e-6 1.0e-6 3 !Iteration control`

4.2.9 Print Option

This card can be used to choose the specific output that the users want.

Table 4-10. Output print option card

%PRNT			
LINE 1	CAPRAD	Radial assembly power distribution print option	1 = YES 0 = NO Default for all = YES Example: `1 1 0 !Print output`
	CAPAXI	Axial assembly power distribution print option	
	CAFRAD	Radial Flux Power Distribution	

4.2.10 Assembly Discontinuity Factor

ADF card can be incorporated into ADPRES input, if any, to make the solution more accurate.

Table 4-11. Assembly Discontinuity Factor card

%ADF			
LINE 1	DC(1)	East side discontinuity factor	Repeat LINE 2 NG times. And again repeat this input segment NMAT times. (See example in the provided sample inputs)
	DC(2)	West side discontinuity factor	
	DC(3)	North side discontinuity factor	
	DC(4)	South side discontinuity factor	
	DC(5)	Bottom side discontinuity factor	
	DC(6)	Top side discontinuity factor	
LINE 2	ROT	Direction for ADF rotation	This line is optional. Necessary if the value of discontinuity factor is not fully symmetric. Repeat this line followed by LINE 3 as many as desired until zero number (LINE 5) is entered. 1 = 90 degree counter clockwise 2 = 180 degree counter clock wise

			3 = 270 degree counter clockwise
LINE 3	X1	Start assembly position in X-direction	This line follows LINE 2 which tells the position of assembly being rotated. Repeat this line as many as desired until zero numbers (LINE 4). Followings are value limits for these line 1 <= X1 <= NX; 1 <= X2 <= NX; 1 <= Y1 <= NY; 1 <= Y2 <= NY; 1 <= Z1 <= NZ; 1 <= Z2 <= NZ; X1 <= X2; Y1 <= Y2; Z1 <= Z2
	X2	End assembly position in X-direction	
	Y1	Start assembly position in Y-direction	
	Y2	End assembly position in Y-direction	
	Z1	Start assembly position in Z-direction	
	Z2	End assembly position in Z-direction	

LINE 4	0	Zero numbers entered to end X1 through Z2	Example LINE 2 through LINE 6:
			`1 ! 90 degree counter clock-wise`
			`2 2 1 1 1 2`
			`2 2 3 3 1 2`
			`...`
			`...`
			`0 0 0 0 0 0`
			`2 ! 180 degree counter clock-wise`
			`2 2 2 2 1 2`
			`2 2 4 4 1 2`
			`...`
			`...`
			`0 0 0 0 0 0`
			`3 ! 270 degree counter clock-wise`
			`1 1 2 2 1 2`
			`1 1 4 4 1 2`
			`...`
			`...`
			`0 0 0 0 0 0`
			`0 ! ADF INPUTS END`
			`! ADF PRINT(OPTIONAL)`
			`1`

	0		
	0		
	0		
	0		
	0		
LINE 5	0	Zero number to end ROT	
LINE 6	ZP	ADF print option	This line is optional.

4.2.11 Control Rod (CR)

If the problems have control rods inserted, users can use this card. This card is mandatory of `RODEJECT` calculation mode.

Table 4-12 Control Rods Card

%CROD			
LINE 1	NB	Number of CR banks	! Number of CR bank and Max steps 2 180.
	NSTEP	Maximum number of steps	
LINE 2	POS0	Zero step pos. (cm from bottom)	! Zero Step pos. and step size 10. 0.15463
	SSIZE	step size (cm/step)	
LINE 3	BPOS(1:NB)	Control Rod Bank position (step) **0 step means full inserted**	! Bank pos. 0. 180.
LINE 4	DO j = NY, 1, -1 BMAP(1:NX) END DO	Control Rod Bank Map	See example in the inputs
LINE 5	DISGTR(g)	Macroscopic Cross Section changes due to control rods insertion	Repeat LINE 2 NG times. And again repeat this input segment NMAT times. (See example in the provided sample inputs)
	DSIGA(g)		
	DNUF(g)		
	DSIGF(g)		
	DSIGS(g,1:NG)		

4.2.12 Control Rod Ejection and/or Insertion

For transient problems due to control rods insertion or withdrawal, users can use this card. This card is mandatory if calculation mode is RODEJECT.

Table 4-13 Rod Ejection Card

%EJCT			
LINE 1	FBPOS(n)	Final bank n position after ejection and/or insertion (step)	Repeat this line NB times. Example: 60. 7.5 3.0 !Bank 1 180. 0.0 3.0! Bank 2
	TMOVE(n)	When bank n starts move (second)	
	BSPEED(n)	Bank n speed (steps/second)	
LINE 2	TTOT	Total simulation time (seconds)	Example: 60. 0.1 40.0 1.0
	TSTEP1	First time step (seconds)	
	TDIV	When to start second time step (seconds)	
	TSTEP2	Second time step (seconds)	
LINE 3	IBETA(1:6)	6-groups delayed neutron fraction	See example
LINE 4	LAMB(1:6)	6-groups precursor decay constant	See example
LINE 5	VELO(1:NG)	Neutron velocity	See example

5. References

1. Okumura K (1998) MOSRA-light: high speed three-dimensional nodal diffusion code for vector computers, JAERI-Data/Code 98-025. Japan Atomic Energy Research Institute, Tokaimura (in Japanese)