CHAPTER IV
SIMULATION GRID MODEL

In order to observe the pressure response from wireline formation testing, reservoir simulator is used as a tool to predict reservoir pressure under different reservoir conditions. After that, analytical model or Pressure Transient Analysis (PTA) can be used to interpret the simulated transient. As a result, reservoir properties can be obtained. The work described in this report focuses on the fluid flow close to the wellbore. For this purpose, reservoir grid model is created by radial grid algorithm. The details of simulation grid will be expressed later in this chapter.

The pressure response for fluid flow in this study was obtained from commercial reservoir simulator software called ECLIPSE version 2006 developed by Schlumberger. It includes black-oil (ECLIPSE 100) and compositional modeling (ECLIPSE 300). The ECLIPSE black-oil simulator employed in this thesis is based on a fully-implicit finite-difference solution of the multi-phase fluid flow equation. Grid sizes in the radial direction are calculated using a geometrical series. The simulator yields time records of pressure and liquid rate withdrawal. After running each case, the interpretation software Weltest200, one of the modules available in ECLIPSE, is used to match the flow model with the pressure derivative plot. Then, Saphir interpretation program is used to generate the regression plot on the data. The reservoir parameters such as skin factor or permeability are obtained.

The simulation runs have been separated into 3 categories which are single layered homogeneous reservoir, single layered reservoir with invaded zone, and single layered reservoir with stimulated zone.

First of all, the simulation grid was created by paying attention to performing simulations under reservoir conditions that can be met in real life. The probe inserted into the borehole wall is open to flow from the formation, implying that the simulation grid needs to handle radial flow geometry. The grid geometry contains 20 grid blocks in the theta direction, 30 grid blocks in the radial direction, and 31 grid blocks in the z-direction. Since the pressure response changes logarithmically as a function of distance, the size of grid blocks was varied logarithmically. The initial size of the grid block closest to the well in all directions depends on the actual probe size of the tool used to conduct the test. This work considers 3 types of probe: extra-large probe size, large probe size, and standard probe size. The large probe size is mainly used for the base case.

The cross sectional area of the large probe size is 0.85 square inches; hence the initial size of the grid block for all directions can be calculated. The wellbore radius is set to be 0.25 ft. In the radial direction, the first grid block is 0.0340 ft. and the size of the following grid blocks was increased logarithmically as a function of distance. For the theta grid direction, the first grid cell is 7.8 degrees. Similar to the radial direction, the angle is increased logarithmically in the clockwise and counter clockwise directions. In the z-direction, the first grid cell size is 0.07683 ft. (0.85 sq. in.), which is the size of a large probe, and the size of the following grid cell was also increased logarithmically as shown in Table 4.1. The position of probe is set at grid number 16 which is the smallest grid size located in middle point of the reservoir formation. Figures 4.1, 4.2, and 4.3 depict the side, top and a 3D view of the single layer radial model, respectively.

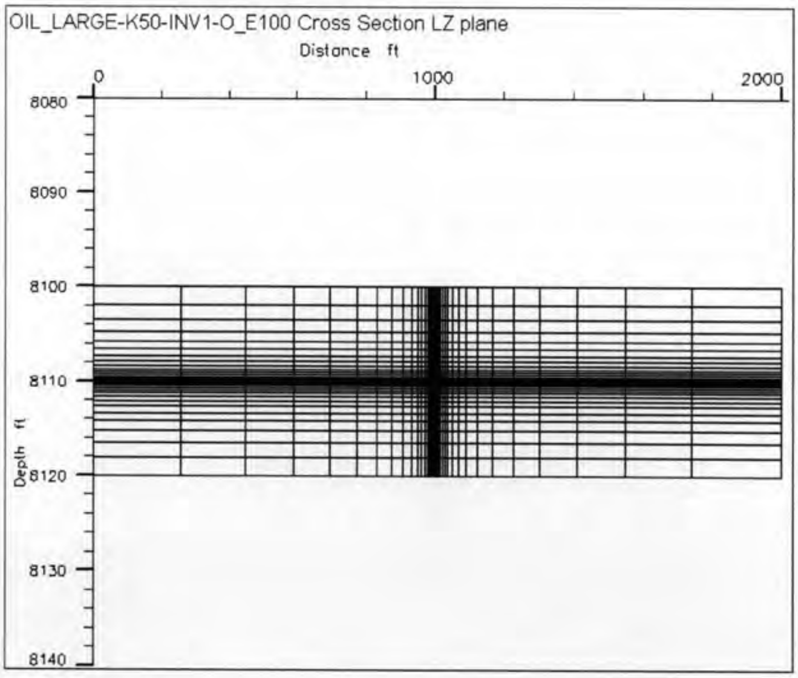

Figure 4.1 : Side view of a single layer radial model.

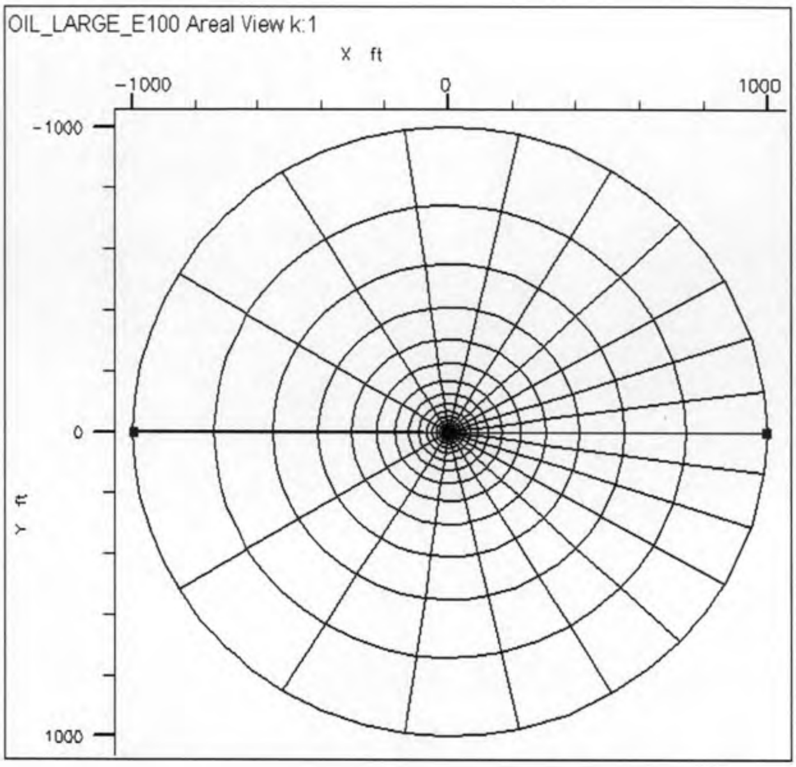

Figure 4.2 : Top view of a single layer radial model.

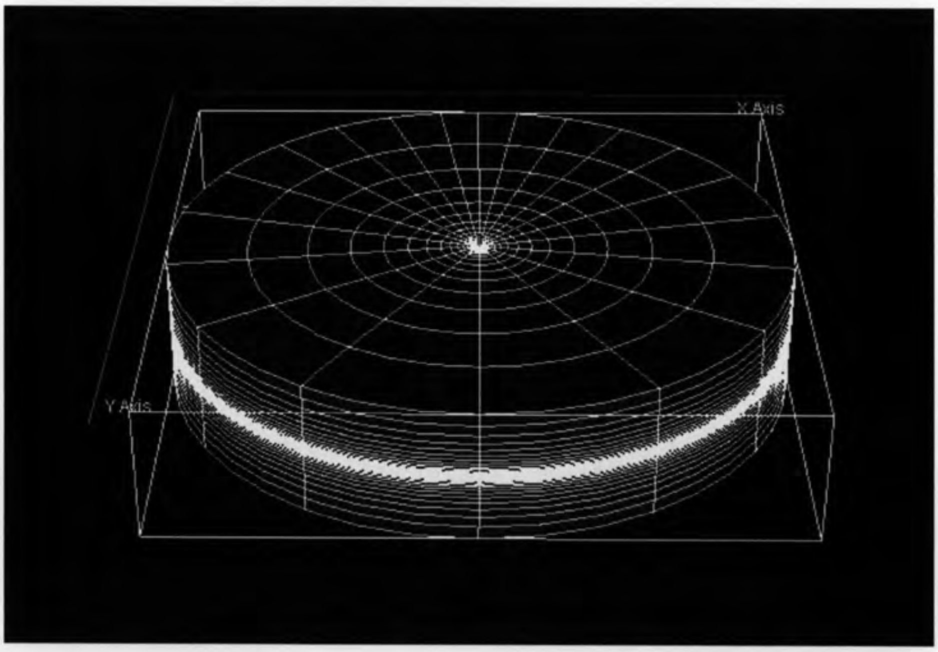

Figure 4.3 : 3D view of a single layer radial model.

Table 4.1 : Summary of grid geometry for the single layer radial model.

Theta direction		**Radial direction**		**Vertical direction**	
grid	**grid size (degree)**	**grid**	**grid size (ft)**	**grid**	**grid size (ft)**
1	7.8029	1	0.0340	1	1.9051
2	10.3016	2	0.0617	2	1.5587
3	11.8367	3	0.0831	3	1.2753
4	13.6006	4	0.1120	4	1.0434
5	15.6273	5	0.1508	5	0.8537
6	17.9560	6	0.2031	6	0.6985
7	20.6318	7	0.2735	7	0.5715
8	23.7062	8	0.3684	8	0.4676
9	27.2389	9	0.4961	9	0.3826
10	31.2979	10	0.6682	10	0.3130
11	31.2979	11	0.8999	11	0.2561
12	27.2389	12	1.2119	12	0.2095
13	23.7062	13	1.6322	13	0.1714
14	20.6318	14	2.1982	14	0.1403
15	17.9560	15	2.9605	15	0.1148
16	15.6273	16	3.9871	16	0.0768
17	13.6006	17	5.3698	17	0.1148
18	11.8367	18	7.2320	18	0.1403
19	10.3016	19	9.7399	19	0.1714
20	7.8029	20	13.1175	20	0.2095
Σ	360	21	17.6664	21	0.2561
		22	23.7928	22	0.3130
		23	32.0436	23	0.3826
		24	43.1558	24	0.4676
		25	58.1214	25	0.5715
		26	78.2768	26	0.6985
		27	105.4217	27	0.8537
		28	141.9800	28	1.0434
		29	191.2160	29	1.2753
		30	257.5261	30	1.5587
		Σ	1000	31	1.9051
				Σ	20

After the grid geometry was created, we need to specify the reservoir conditions in order to perform the reservoir simulations. The geometrical properties of the reservoir are listed in Table 4.2, and Table 4.3 summarizes the rock and fluid properties used in the simulations. The detailed simulation input data are described in Appendix A.

Table 4.2 : Summary of geometrical and numerical simulation parameters for the reservoir model.

Variable	Value	Unit
Wellbore radius (r_w)	0.25	ft
External radius (r_e)	1000	ft
Top reservoir depth	8100	ft
Bottom reservoir depth	8120	ft
Reservoir thickness	20	ft
Datum depth	8110	ft
Initial datum pressure	5000	psi
Water-oil contact	8200	ft
Number of nodes –radial direction	30	-
Number of nodes – theta direction	20	-
Number of nodes – vertical direction	31	-

Table 4.3 : Summary of reservoir rock and rock-fluid properties for the reservoir model.

Variable	Value	Unit
Porosity	0.18	fraction
Pressure at Standard condition	14.7	psi
Temperature at Standard condition	60	^oF
Oil density @STP	51.457	lbf/ft3
Oil compressibility	3.8E-6	psi-1
Oil viscosity	1.25	cp
Rock compressibility	1.048E-6	psi-1
Production flow rate	0.8	stb/day
Reservoir temperature	160	^oF