Reservoir Simulation Research at BYU

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What is a Reservoir Simulator?

- Reservoir simulators are computer systems used by Petroleum Company engineers that virtually deplete petroleum containing reservoirs. Repeated simulations allow reservoir engineers to optimize production and profitability.
- Reservoir simulators calculate the underground flow of oil, gas, and water. They predict the changing pressures and saturations throughout the reservoir. Sometimes they also calculate chemical compositions and temperatures.

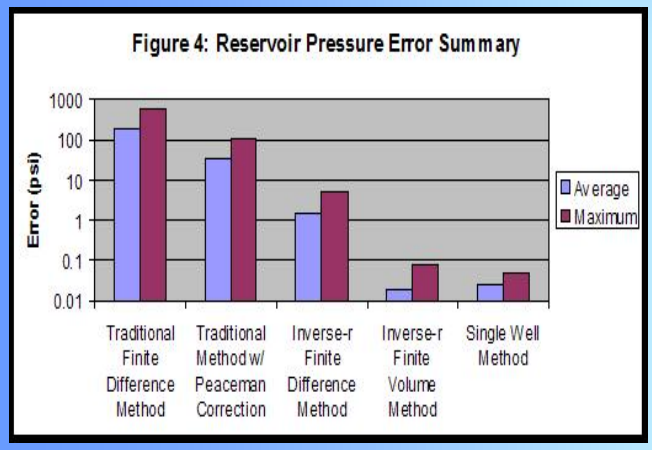
Traditional Reservoir Simulators…

Use Taylor series based, finite difference methods to simultaneously solve the partial differential equations governing reservoir pressures, saturations, and other variables. The solution of millions of simultaneous linear algebraic equations is required for each time step.

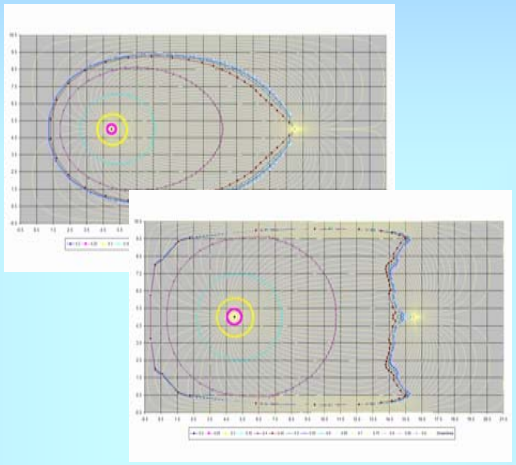
BYU Innovations:

Finite Difference Equations that Incorporate the Physics of the Flow

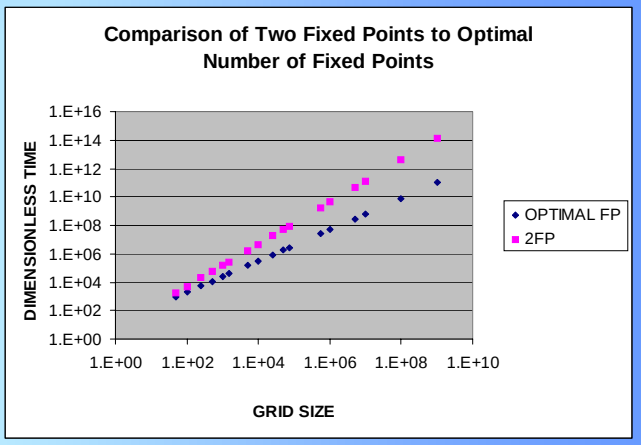
Reservoir Pressure Error Summary



Characteristic Solutions for Saturations



Improved Linear Algebra Methods



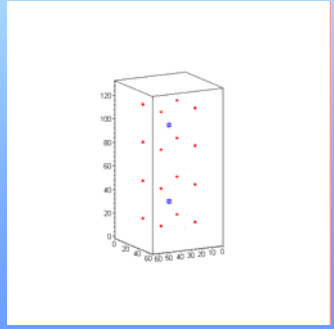
Rapid-Calculation Method for the Determination of Fine-Grid Reservoir Simulation Pressures

Grids Considered

DIMENSIONS	GRID POINTS	FIXED POINTS(FP)	PERCENT OF FP	INCLUDING WELLS
5x5x10	250	16	6.40	7.20
9x9x18	1458	16	1.10	1.23
17x17x34	9826	16	0.16	0.18
33x33x66	71874	16	0.02	0.03
65x65x130	549250	16	0.00	0.00
9x9x18	1458	128	8.78	8.92
17x17x34	9826	128	1.30	1.32
33x33x66	71874	128	0.18	0.18
65x65x130	549250	128	0.02	0.02
17x17x34	9826	1024	10.42	10.44
33x33x66	71874	1024	1.42	1.43
65x65x130	549250	1024	0.19	0.19
33x33x66	71874	8192	11.40	11.40
65x65x130	549250	8192	1.49	1.49
65x65x130	549250	65536	11.93	11.93

Fine Grid Solution

16 Fixed Points



Results

2FP	2FP TIME	OPTIMAL FIXED	TOTAL	OPTIMAL FP TIME	PERCENT FIXED	RATIO OF IMPROVEMENT
2	1.83E+03	13	50	9.18E+02	26.19	2
2	5.12E+03	22	100	1.98E+03	21.78	3
2	1.99E+04	43	250	5.44E+03	17.10	4
2	5.58E+04	71	500	1.17E+04	14.25	5
2	1.56E+05	119	1000	2.51E+04	11.89	6
2	2.73E+05	157	1458	3.80E+04	10.77	7
2	1.70E+06	390	5000	1.47E+05	7.81	12
2	4.62E+06	643	9826	3.10E+05	6.55	15
2	1.85E+07	1284	25000	8.64E+05	5.14	21
2	5.16E+07	2144	50000	1.85E+06	4.29	28
2	8.85E+07	2805	71874	2.76E+06	3.90	32
2	1.81E+09	12635	549250	2.58E+07	2.30	70
2	4.39E+09	19688	1000000	4.98E+07	1.97	88
2	4.78E+10	64813	5000000	2.92E+08	1.30	164
2	1.34E+11	108277	10000000	6.25E+08	1.08	214
2	4.06E+12	595596	100000000	7.84E+09	0.60	518
2	1.24E+14	3474824	1000000000	9.85E+10	0.35	1256