GID PRE/POST PROCESSING SYSTEM AS AN INTERFACE FOR PARALLEL RESERVOIR SIMULATOR (PARSI)

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Key words:

Abstract. *GiD pre/post processing system is used to provide a user friendly interface for our Parallel Reservoir Simulator (PaRSi), which is completely designed and programmed by the Reservoir Simulation Group at Sharif University of Technology sponsored by Pars Oil and Gas Company. PaRSi is a three dimensional parallel simulator for analysis of multiphase fluid flows in a petroleum reservoir. The simulator is based on a finite volume formulation and uses a newly developed high resolution central scheme as its underlying numerical method. The program is able to use both structured and unstructured grids along with either cell-centered or cell-vertex approach. GID provides powerful tools for both geometry modelling and mesh generation to the system as well as a well organized interface for assigning initial and boundary conditions. These are integrated as a new Problem Type. The simulation program is run by clicking an icon in the GID preprocessor. GID's postprocessing tools are also employed to visualize the computational results such as streamlines, variations of physical properties in space and time and to create relevant animations.*

1 INTRODUCTION

Numerical simulation of flows in hydrocarbon reservoirs is a powerful tool which can be used for the management of production from such systems. Well placement and operation schedule can be optimized using a fast and accurate simulator. To this end, multiple non-linear partial differential equations must be solved numerically on typically large physical domains for a long period of time, which frequently exceeds several years. [1] As the simulations are very time consuming, one must use parallel computing techniques to obtain the required solutions within a reasonable time.

PaRSi is a parallel reservoir simulator software which can simulate three dimensional multiphase flows in petroleum reservoirs based on the so-called black-oil model. The software uses facilities incorporated in GID as its pre and postprocessor. In the following, the basic features of the simulation software are briefly described and the dialogue boxes used for communication between GID and the simulator are explained.

2 SOLVER

The heart of PaRSi simulator is its solver which is based on the black-oil model. This solver uses a volume balance formulation [1,2], in contrast to the customary pressure-saturation formulation. This simplifies dealing with various under-saturation states that occur during the production history. The volume balance formulation results in a nonlinear parabolic equation for pressure and a set of non-convex degenerate hyperbolic equations for fluid compositions. The equations are split to facilitate the use of a segregated approach.

During each time-step, the pressure equation is solved implicitly from which, fluid velocities are calculated. Then, fluid compositions are calculated using the component transport equations. A novel high resolution central scheme is used for the solution of component transport equations [2,3]. The main advantage of this method is that its accuracy is comparable with the more sophisticated higher-order Godunov schemes while retaining the simplicity of the traditional central schemes [3].

Time-step size is calculated based on several conditions. The first one is the CFL condition which ensures the stability of the solution. The second condition controls the maximum change in components which limits the splitting error associated with the pressure and component transport equations. The third condition is a user specified maximum time-step size which is activated when the above two conditions give unacceptable time-step sizes.

3 GEOMETRY AND MESH GENERATION

As GID provides both structured and unstructured grids, the software was design to work with both types. Unstructured mesh can be used for more complicated geometries and enables PaRSi to resolve complex flow features more accurately especially near production or injection wells. GiD also has the capability to generate different output mesh files and assigning several conditions to elements, nodes or faces of elements [4] which is acknowledged by PaRSi’s solver.

4 PARSI PREPROCESSOR PROBLEM TYPE

All data and parameters for the PaRSi’s solver are set in the GID environment. PaRSi uses a new Problem Type in GID which enables the software to use most features of GID. A general view of GID's environment with the Problem Type used by PaRSi is shown in Figure 1. Below a brief description for each window is given.

4.1 PaRSi- Materials

Reservoirs may have different layers with material properties. The associated window in GiD can set various properties including rock compressibility, porosity, and absolute permeability in three dimensions. Also, relative permeability and capillary pressure of each layer can be defined as functions of water and gas saturations via tables, correlations, or specified data files.

4.2 PaRSi- Initial conditions

Water and gas initial saturations, assigned to either elements or nodes, can be set in the initial conditions window.

4.3 PaRSi- Boundary conditions

Boundary conditions, either an active aquifer or an impermeable wall, should be assigned to boundary faces of the volume in this window.

4.4 PaRSi- Well conditions

Well properties and production scenarios are defined through either injection or production well condition windows and then assigned to the well elements (in a cell based method), or nodes (in vertex based method).

4.5 PaRSi- PVT

General properties of reservoir fluids including gas, water, saturated oil, and under-saturated oil, are entered in this window. These properties contain density of fluid at standard conditions, compressibility of fluid and variation of some properties of fluids such as viscosity, density, formation volume factors, etc. which can be entered through table, correlations, or specified data file as a function of pressure.

4.6 PaRSi- general data

Reservoir's initial pressure, temperature and reference depth are given in this window. Also, in this window one can choose between the vertex-based or the cell-based methods.

4.7 PaRSi- stopping criteria

Constraints containing total time of production, total gas oil ratio and total oil production are defined in this window in order to determine the simulation duration.

5 GID AS A POSTPROCESSOR FOR PARSI

Several visualization facilities exit in GiD. These can be any or all of the followings: contours plots of different parameters, vectors, animations of variation of variables with time, viewing results on different sections of the geometry and also graphs of variation of variables with time or position. Typical results for a SPE comparative study are shown in Figure 2.

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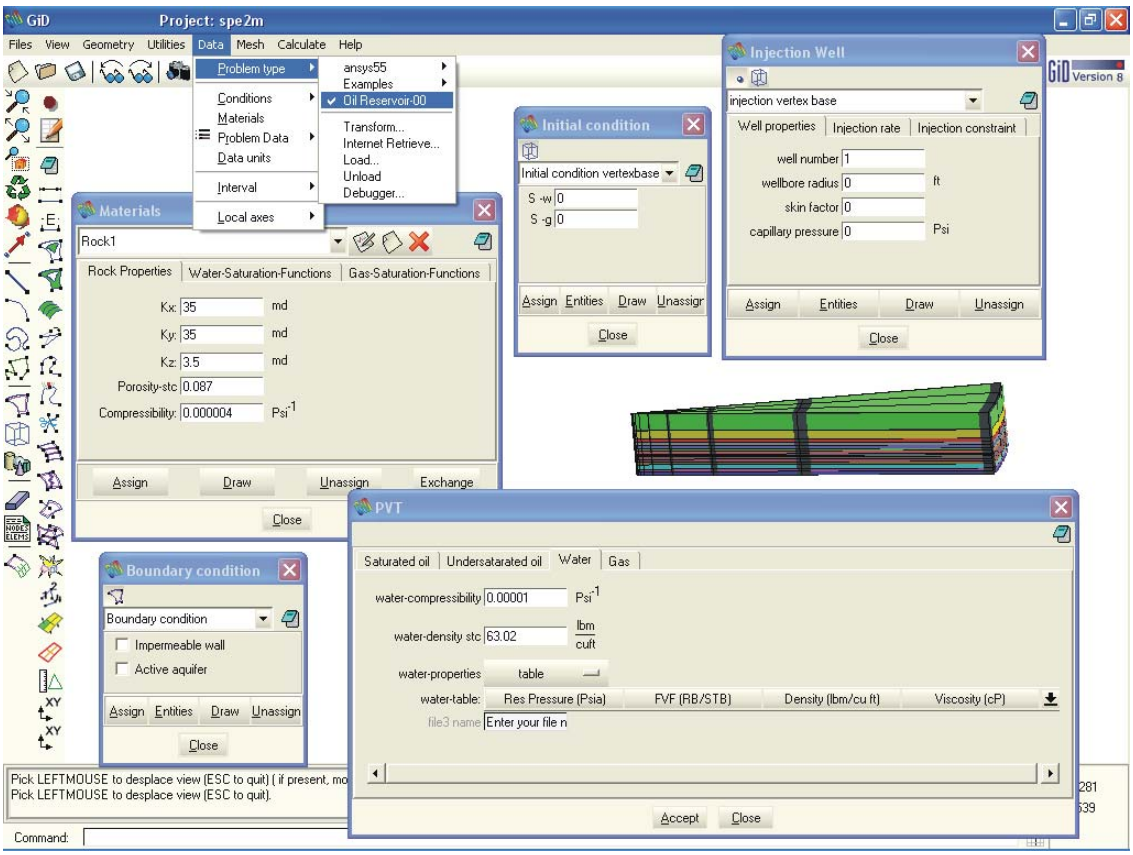

Figure 1: A view of GiD while preparing data for a problem

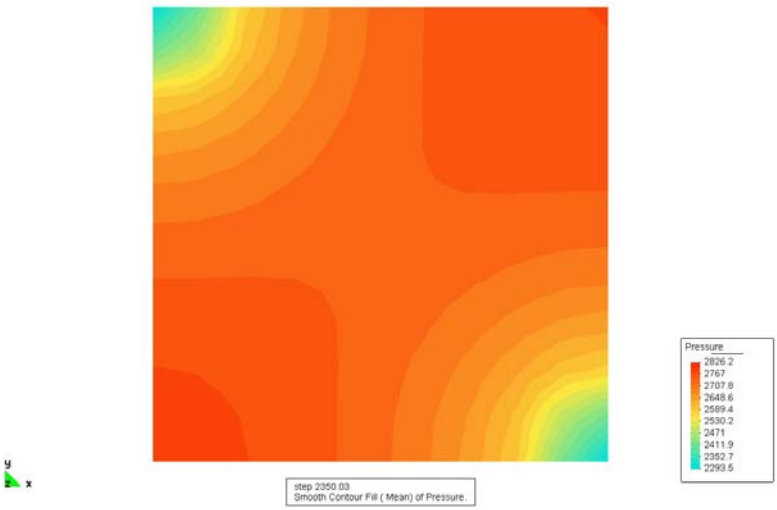

Figure 2- Pressure contour plots for the SPE test case