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Surrogate Reservoir Model

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Surrogate Reservoir Model (SRM) is new solution for fast track, comprehensive reservoir analysis (solving both direct and inverse problems) using existing reservoir simulation models. SRM is defined as a replica of the full field reservoir simulation model that runs and provides accurate results in real-time (one simulation run takes only a fraction of a second). SRM mimics the capabilities of a full field model with high accuracy.

Reservoir simulation is the industry standard for reservoir management. It is used in all phases of field development in the oil and gas industry. The routine of simulation studies calls for integration of static and dynamic measurements into the reservoir model. Full field reservoir simulation models have become the major source of information for analysis, prediction and decision making. Large prolific fields usually go through several versions (updates) of their model. Each new version usually is a major improvement over the previous version. The updated model includes the latest available information incorporated along with adjustments that usually are the result of single-well or multi-well history matching.

As the number of reservoir layers (thickness of the formations) increases, the number of cells representing the model approaches several millions. As the reservoir models grow in size, so does the time that is required for each run. Schemes such as grid computing and parallel processing helps to a certain degree but do not provide the required speed for tasks such as: field development strategies using comprehensive reservoir analysis, solving the inverse problem for injection/production optimization, quantifying uncertainties associated with the geological model and real-time optimization and decision making. These types of analyses require hundreds or thousands of runs. Furthermore, with the new push for smart fields in the oil/gas industry that is a natural growth of smart completion and smart wells, the need for real time reservoir modeling becomes more pronounced.

SRM is developed using the state of the art in neural computing and fuzzy pattern recognition to address the ever growing need in the oil and gas industry to perform accurate, but high speed simulation and modeling. Unlike conventional geo-statistical approaches (response surfaces, proxy models ...) that require hundreds of simulation runs for development, SRM is developed only with a few (from 10 to 30 runs) simulation runs. SRM can be developed regularly (as new versions of the full field model become available) off-line and can be put online for real-time processing to guide important decisions.

SRM has proven its value in the field. An SRM was developed for a giant oil field in the Middle East. The model included about one million grid blocks with more than 165 horizontal wells and took ten hours for a single run on 12 parallel CPUs. Using only 10 simulation runs, an SRM was developed that was able to accurately mimic the behavior of the reservoir simulation model. Performing a comprehensive reservoir analysis that included making millions of SRM runs, wells in the field were divided into five clusters. It was predicted that wells in cluster one & two are best candidates for rate relaxation with minimal, long term water production while wells in clusters four and five are susceptive to high water cuts.

Two and a half years and 20 wells later, rate relaxation results from the field proved that all the predictions made by the SRM analysis were correct. While incremental oil production increased in all wells (wells in clusters 1 produced the most followed by wells in cluster 2, 3 ...) the percent change in average monthly water cut for wells in each cluster clearly demonstrated the analytic power of SRM. As it was correctly predicted, wells in clusters 1 and 2 actually experience a reduction in water cut while a substantial increase in water cut was observed

in wells classified into clusters 4 and 5. Performing these analyses would have been impossible using the original full field simulation model.