Uncertainty Analysis of a Giant Oil Field in the Middle East Using Surrogate Reservoir Model

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ABSTRACT
Simulation models are routinely used as a powerful tool for reservoir management. The underlying static models are the result of integration efforts that usually includes the latest geophysical, geological and petrophysical measurements and interpretations. As such, these models carry an inherent degree of uncertainty. Typical uncertainty analysis techniques require many realizations and runs of the reservoir simulation model. In this day and age, as reservoir models are getting larger and more complicated, making hundreds or sometimes thousands of simulation runs can put considerable strain on the resources of an asset team, and most of the times are simply impractical. Analysis of these uncertainties and their effects on well performance using a new and efficient technique is the subject of this paper. The analysis has been performed on a giant oil field in the Middle East using a surrogate reservoir model.

The surrogate reservoir model that runs and provides results in real-time is developed to mimic the capabilities of a full field simulation model that includes one million grid blocks and takes 10 hours to run using a cluster of twelve 3.2 Gzh CPUs. Such a performance allows Monte Carlo simulations to be implemented on many parameters in the geologic model. Using Monte Carlo simulations, the effect of such uncertainties on the well performance can be analyzed for all the 165 horizontal wells in the field. In order to demonstrate the robustness of the surrogate reservoir models and their predictive capabilities as well as their limitations, this paper will examine the performance of the surrogate reservoir model on different geologic realizations of the static model.

INTRODUCTION
The conventional approach for uncertainty analysis in our industry is mainly based on geostatistics. One such method that is often used is Response Surfaces. Response Surfaces are statistical interpolations (based on fitting some type of pre-determined models – linear or quadratic – ) of model responses to different geological, geophysical and petro-physical realizations. Another method that has been used more in other industries is called the Reduced Model. Reduced Models are developed from full three dimensional numerical simulation models that essentially approach an analytical model for tractability.

One of the major advantages of Surrogate Reservoir Models, when compared to conventional geostatistical techniques, is the small number of simulation runs that is required for their development. For example, instead of hundreds of simulation runs that would be required to perform a limited geostatistical study, development of the Surrogate Reservoir Model that is the subject of this paper required only 10 simulation runs. On the other hand, the capabilities of the SRM for analyses are more far reaching than the alternative technique that required hundreds of runs. The reason for this efficiency in using the simulation run resources is the way Surrogate Reservoir Models represent the reservoir. The objective of this paper is to demonstrate the different approach that is taken by Surrogate Reservoir Models in representing multiple realizations within one simulation run.

METHODOLOGY
Following figure shows the location of the wells in the field along with the approximate drainage area for each well. The objective is to demonstrate that the Surrogate Reservoir Model can be developed using a certain set of realizations and be validated by another set of independent realizations. In order to do this 19 out of the 165 horizontal wells in the field were randomly selected to serve as the validation wells. These wells are called the set of blind wells. The set of 19 blind wells are identified with their potential drainage areas shaded. The validation is performed by predicting the flow behavior in these wells with a Surrogate Reservoir Model that has been developed using the realizations associated with the rest of the wells in the field.

Another capability of the Surrogate Reservoir Models is the development of full field models. Once the Surrogate Reservoir Model is developed it can be used to generate a large number of type curves for the field being studied. Development of such type curves can provide valuable insight into the general behavior of fluid flow in the field and guide future operational development efforts in the field as well as help and direct future analytical and numerical analysis using the full field model.

The type curves are developed by plotting one of the model outputs (in this study 5 year cumulative oil production or water cut) against another parameter while selecting a third parameter for the type curves. By changing the value of the third parameter from minimum to maximum in several steps a set of type curves can be generated. During this operation one can hold the values of all other involved parameters at overall average or select the minimum or the maximum from the entire data set for all the parameters. Some examples of such type curves are presented here.

CONCLUSIONS
Surrogate Reservoir Models are accurate prototypes of full field models that can run in real-time. They provide instantaneous results and respond to changes in rock, fluid and rock-fluid characteristics that are used in the model. In this article the robustness of SRMs was demonstrated by showing their capabilities to predict fluid flow behavior in several different geological realizations. Furthermore, it was demonstrated that SRMs can quickly generate a series of type curves for a reservoir that can help engineers in analysis and operational planning of the reservoir.

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RESULTS & DISCUSSIONS
The instantaneous water cut generated by the Surrogate Reservoir Model was plotted against the instantaneous water cut generated by the full filed model for comparison. These plots are shown below for several wells in the set of blind wells. These figures show that results generated by the Surrogate Reservoir Model are quite accurate and acceptable. In these figures when the water cut goes to zero after increasing for several years indicates that the well has been watered out and has been shut down. It is interesting to note that this phenomenon was predicted by SRM correctly in every case.