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System Identification

ASSIGNMENT 01: PAPER SKIMMING

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MEC2015 – System Identification

Assignment 01: Paper skimming

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a) Paper title, journal name, citescore and highest percentile, and the reason you chose it

- Paper title: Conceptual Framework for Using System Identification in Reservoir Production Forecasting
- Journal: Procedia Engineering.
- Citescore: 4.0, Highest Percentile: 80% (57/297) General Engineering.

The reason I have chosen this paper is that it is my professional activity to forecast a petroleum reservoir field production. Although the article refers to short term production and in my activity the focus is on long term forecasts, the procedures and ideas described in this paper can be used as a guide to implement system identification for production forecasting, which is the case of interest of my thesis.

b) Problem description: input-output data and model purpose (1 image allowed)

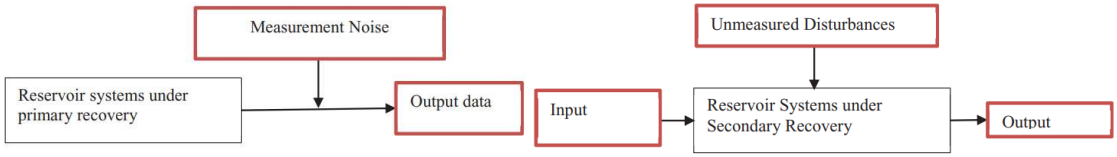
Production forecast is maybe the most important tasks of a reservoir engineer. The usual techniques to that end are decline analysis and reservoir simulation. The first is quite simple but also limited, as it supposes steady state conditions and is restricted to a small set of reservoir production mechanisms and some reservoir types. The second is very expensive and time consuming and relies on scarce data input. The paper proposes the use of system identification approaches to address that problem.

The paper proposes to study two different reservoir drive mechanisms:

- Primary drive mechanisms: No injection fluids are used as a recovery mechanism and the reservoir production is given only by its natural energy. Some of these mechanisms are rock expansion, expansion of gas dissolved in oil, water influx from aquifers and natural gas cap expansion. It is immediately obvious that since there are no injection wells, the reservoir does not have any input. Outputs from systems of this kind are called time series and identification falls under a special branch of system identification called time series analysis, or “output-only” models.
- Secondary drive mechanisms involve injection of fluids to maintain or increase the reservoir pressure in addition to displacing the reservoir fluids with the injected fluid.

In summary the used input/output variables are:

- Input signal: injection rate of fluids, except primary drive, which has no inputs
- Output signal: fluid production rate (oil or gas) or any other production parameter



The purpose of the models is to predict production and then compare it to a validation dataset. They compared the system identification models forecast to the responses provided by benchmark reservoir models. These models were modified to represent complexity and the different mechanisms. A 10-year forecast, provided by the models was used as validation data and the metric used as a measure of accuracy was the normalized root mean squared error (NRMSE).

c) Classes of model used

Polynomial models were used as an alternative to neural networks, which are the most popular models in upstream industry.

For primary drive mechanisms, several time series models were used:
(1) Autoregressive (AR)
(2) Autoregressive Integrated (ARI)
(3) Autoregressive Moving Average (ARMA)
(4) Autoregressive Integrated Moving Average (ARIMA).

For the secondary drive mechanisms, the author used:
(1) Autoregressive with exogenous inputs (ARX)
(2) Autoregressive Integrated with exogenous inputs (ARIX)
(3) Autoregressive Moving Average with exogenous inputs (ARMAX)
(4) Autoregressive Integrated Moving Average with exogenous inputs (ARIMAX)
(5) Box-Jenkins (BJ)
(6) Box Jenkins Integrated (BJI)

Tertiary drive mechanisms were not modelled as they are expected to represent nonlinear input-output behaviour.

d) Quick description of the results

An excellent accuracy was achieved in predicting the behaviour of the primary drive reservoirs and most part of the models fit with order 3 or less.

For secondary drive mechanisms, some parameters (among gas oil ratio, oil rate and water cut) are well predicted and others don't, what suggests that linear models are not suitable to all variables as the relationship between inputs and output seems to be nonlinear in those cases.

e) What are the original contributions of the paper

The paper says that the most popular technique to forecast production in upstream industry (exploration and production), in the field of SYS ID is neural network.

The main original contributions of the paper are:
1. The 1st original contribution of the paper is to use polynomials as a system identification technique with high accuracy and short time response to predict reservoir performance.
2. The 2nd original contribution is that this study describes and classifies reservoirs into distinguishable recovery mechanisms and associate system identification models to each drive mechanism, as other studies that apply SYS ID are limited to a specific reservoir mechanism.