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# Underground salt caverns in gas:

# modelling thermodynamics... what is a physical model?

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## Abstract

A cavern simulation software has been developed by EDF, based on a top-down driven as well as mixed physical-statistical approach. Encouraging precision in wellhead as well as cavern pressure and temperature calculation has been obtained in history matching and forecasting. Various presentations have been made on the software approach itself (basics, progress, simulation robustness) from 2014 to date in SMRI Technical Conferences. Questions were raised by the audience about the physics incorporated in that particular way of modelling, like at Galveston last April: "…what is the value of your gas-salt heat transfer coefficient?" The answer that there is no such single value in the model caused some surprise. Therefore, the aim of the present paper is to shed more light on underlying physics in NARMA modelling. The first part of the paper gives a brief look on derivation methods leading to the establishment of a physical law, here the equation of state for gases. The second part develops differences between a "classical" approach in modelling of thermodynamics using "established" laws and the here considered combined physical and statistical NARMA approach. It will be shown that NARMA models employ just another way of dealing with the same set of underlying thermodynamics as they occur in UGS assets. In fact, while classical models make thermodynamic coefficients appear mainly in form of single values (heat transfer, conduction, compressibility, …), the here considered NARMA approach allows the expression of such coefficients in an increased number of model positions by spreading such coefficients into space (well, cavern, salt rock) through the analysis approach on time series (history) of UGS gas-side process data. These parameters are also linked to an increased number of process data (pressure, temperature, flow, stored gas volume and combinations thereof). As an important consequence appears the capability of automated matching (numerical convergence) between input (recorded data) and model calculations due to reduced sensitivity of individual model parameters and increased numerical stability through the predominantly linear model structure.

**Key words:** PVT, thermodynamic modelling, salt cavern, gas storage, physics, ARMA/NARMA time series modelling

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