Studies Related to Deep Waste Injection

Chin-Fu Tsang and Dmitriy B. Silin
Contact: Chin-Fu Tsang, 510/486-5782, cftsang@lbl.gov

RESEARCH OBJECTIVES

The main purpose of the Underground Waste Injection project at Berkeley Lab is to develop new scientific approaches and methods related to underground injection of liquid wastes and to advise EPA on scientific aspects of injection regulation and permit process. In 2003, under the project an international symposium on Underground Injection Science and Technology will be organized, with attendees from 15 countries. One technical development in 2003 is the demonstration of a new pressure analysis method that allows the possibility of estimating the formation's hydraulic properties using regular operations data, to replace the currently-required annual shut-in tests. It is discussed below.

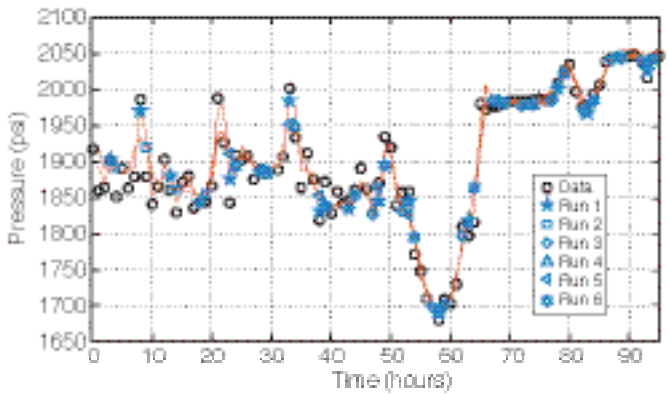

Figure 1. Hourly injection pressures from a deep injection well at an Ohio EPA site. Besides measured pressures (circles), the plot includes six matching curves obtained using ODA on different data intervals. All six curves practically collapse. Outside of the data matching intervals, the calculated curves provide accurate pressure predictions.

APPROACH

We have developed a new method, implemented in a code, ODA, to analyze the operations pumping rates and pumping pressure data (Silin and Tsang, 2002; 2003). To demonstrate its capability, first, the formation parameters are estimated from the regular injection operations data using the ODA code. Then, these results are compared with the results obtained independently from conventional analyses of fall-off tests.

RESULTS

The developed method has been applied to analyze several regular injection data sets obtained from four deep injection wells at an Ohio EPA site. The injection intervals are approximately 300 ft long and mostly consist of sandstone formations. The data fitting has been performed on various data intervals. The resulting estimates of the key hydraulic parameters are stable with respect to the selected data interval. Figure 1 shows the results of six different runs of the code on different matching intervals. In cases where the matching interval was significantly shorter than the whole data set, the extension of the calculated curve beyond this interval provides an accurate prediction of the actually measured pressures. In some cases, averaging of the data over a running time window helps to improve the quality of fitting. The smoothing of the data by such an averaging does not significantly affect the estimated values of the hydraulic parameters. Comparison of the results of analysis of conventional pressure fall-off tests obtained by our method with results obtained independently, using standard methods, shows that in most cases our estimates of the skin factor are significantly lower. We explain this by the fact that our approach rigorously accounts for the impact of pre-test pumping. Such an impact is neglected by the standard methods. The stability of our estimates makes them more credible than those of the standard methods, where the estimates strongly depend on the selection of the analyzed data interval.

SIGNIFICANCE OF FINDINGS

We have demonstrated that by applying the methods we have developed to regular operations data, we can obtain robust estimates of formation hydraulic properties. It implies that interruptions for conducting transient pressure well tests, which are required by regulations governing deep waste injection, can be significantly reduced or entirely replaced by regular data analysis. In addition to the consequent cost reduction, our method makes possible continuous monitoring of the formation properties, which means a significant safety enhancement with regard to timely detection of possible leakage or breakthrough of the liquid injectant.

RELATED PUBLICATIONS

Silin, D.B. and C.F. Tsang, Estimation of formation hydraulic properties accounting for pre-test injection or production operations. Journal of Hydrology, 265, 1–14, 2002.

Silin, D.B. and C.F. Tsang, A well-test analysis method accounting for pre-test operations. SPE Journal, 8(1), 22–30, 2003.

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